FAILURE MODE AND EFFECT ANALYSIS FOR TARHANA PROCESSING

by

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ABSTRACT

FAILURE MODE AND EFFECT ANALYSIS FOR TARHANA PROCESSING

Tarhana is a traditional fermented Turkish food. Failure mode and effect analysis (FMEA) methodology has been applied for the risk assessment of four traditional and one industrial production processes of tarhana. A detailed flow chart was created for each process to start the FMEA. Each step in the process was evaluated and potential failure modes that could effect the food safety were determined and listed on the FMEA worksheet. Based on both of the best expert opinion and epidemiological studies for similar items, a severity, occurrence and detection ranking were assigned and the risk priority numbers (RPN) were calculated for each potential failure mode. The corrective actions were proposed to minimise the possibility of failure occurrence and lower the RPN values below acceptable limit of 50. The new RPN values were calculated assuming that the actions are successfully taken. A total RPN was calculated by adding all of the RPNs and compared with the resulting total RPN. The highest total RPN level of tarhana production processes was found on industrial production related to the number of ingredients and process stages. It was seen the highest RPN values were related with the biological hazards. The FMEA study was resulted in more than 70 percent reduction in the total RPN values for all of the 5 tarhana production processes.

ÖZET

FARKLI TARHANA ÜRETİM METOTLARINA HATA TÜRÜ VE ETKİLERİ ANALİZİNİN UYGULANMASI

Geleneksel ve endüstriyel yöntemlerle gerçekleştirilen Tarhana üretiminin risk analizinin yapılabilmesi için, dört geleneksel ve bir endüstriyel tarhana üretim süreci Failure Mode and Effect Analysis (FMEA) diğer bir ifadeyle Hata Türü ve Etkileri Analiz metodu kullanılarak irdelenmiştir. Öncelikle her üretim süreci bir iş akışı şeması ile ortaya konmuştur. Sistemde oluşabilecek muhtemel hatalar tespit edilerek listelenmiş, uzman görüşü ve epidemiyolojik çalışmalar çerçevesinde hataların ortaya çıkma olasılığı, şiddeti ve saptanabilirliği sayısal değerler atanarak derecelendirilmiştir. Bu değerlerin çarpılmasıyla oluşabilecek her bir hata için bir risk öncelik sayısı (RÖS) elde edilmiştir. Risklerin en aza indirilebilmesi ve RÖS'ün 50'nin altında değer alabilmesi için üretim sürecinde uygulanabilecek düzeltici önlemler belirlenmiştir. Öngörülen önlemlerin hayata geçirilmesinin ardından hata oluşmasını etkileyebilecek faktörler tekrar derecelendirilmiş ve yeni bir RÖS sayısı oluşturulmuştur. Tarhana üretim sürecindeki RÖS değerlerinin bir araya getirilmesiyle bir "toplam RÖS" değeri hesaplanmış bu değer sistemde önlem alınmadan önceki ve sonraki risk düzeyinin karşılaştırılmasında kullanılmıştır. En yüksek toplam RÖS değerinin endüstriyel tarhana üretim sürecine ait olduğu görülmüş, bu durum endüstriyel üretimdeki aşama ve ham madde sayısının fazlalığına bağlanmıştır. Ayrıca RÖS değerinin büyük bir kısmının biyolojik tehlikelerden kaynaklanabileceği tespit edilmiştir. Çalışma sonunda beş farklı tarhana üretim sürecinin her birinde, FMEA uygulamasının toplam RÖS değerini % 70'in üzerinde düşürebileceği saptanmıştır.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF SYMBOLS / ABBREVIATIONS

ADI	Acceptable Daily Intake
B	Biological hazard
C	Chemical hazard
CP	Control point
D	Possibility of detecting the failure
FMEA	Failure mode and effect analysis
HACCP	Hazard Analysis Critical Control Point
NLV	Norwalk-like virus
O	Frequency of occurrence for each failure
P	Physical hazard
RPN	Risk priority number
S	Seriousness of the failure to the consumer
TARAL 1007	TUBITAK, Support Programme for Research Projects of Public Institutions
TUBITAK	The Scientific and Technological Research Council of Turkey

1. INTRODUCTION

Tarhana is among the traditional Turkish fermented foods which are consumed in largest quantities. It is generally produced with traditional processes in small enterprises while the industrial productions are also available. The traditional techniques vary between regions. The traditional production process may contain risks due to inadequate conditions and applications in the food operations. These process problems would be minimised by using a comprehensive quality control system like failure mode and effect analysis (FMEA).

The present study aims to apply FMEA methodology for the risk assessment of traditional and industrial tarhana production processes. Potential failure modes in the tarhana production processes were determined and risk priority number (RPN) were calculated for each of the failure mode. Corrective actions were proposed to minimise the possibility of failure and new RPNs were calculated assuming that the proposed corrective actions are successfully taken. Total RPNs were used to compare the effectiveness of FMEA methodology on the potential failure modes of the tarhana production processes.

This thesis covers the theoretical background about fermentation of cereals, survey of tarhana production, hazard control and management and FMEA methodology. Materials and methods used in FMEA process such as potential failure modes, FMEA worksheets, RPNs are discussed in detail. Then, the determined potential failure modes, their causes, corrective actions, and the RPN levels calculated before and after corrections were listed in tables. Finally, conclusions and future work for the study are reported. In the Appendix, the tarhana production processes are given in flow diagrams. Ingredients of each production method are tabulated. FMEA of five production processes and total RPNs are given in tables. The images from tarhana production stages are also presented in the Appendix.

2. THEORETICAL BACKGROUND

2.1. FERMENTATION

Fermentation is used to improve the flavour, aroma, shelf-life, texture, nutritional value of the food, and also preserve the food, decrease the cooking times, reduce the volume of the material to be transported and destroy undesirable components. The raw materials traditionally used for fermentation are diverse and contain fruits, cereals, honey, vegetables, milk, meat, and fish [1-4].

Fermentations can basically be performed either by spontaneous (natural) fermentation, addition of starter cultures (controlled fermentation) or back-slopping [5-6]. In spontaneous fermentation process the raw material, after its initial preparation, will support the growth of a natural flora. If the raw material is allowed to ferment without pre-heating, most of microorganism that were already found or added into food during processing can multiply [5-6]. Spontaneous fermentations may take a relatively long time to complete and the outcome can be a surprise [5]. Addition of starter cultures is mostly used when it is possible to inactivate the indigenous flora of the raw food by heat treatment and letting the growth of only the added starter microorganisms. The optimization of the fermentation speed involves reducing the lag phase, increasing the growth rate, and improving the metabolic activity of the cells [6]. In back-slopping, a part of a previous batch of a fermented product is used to inoculate the new batch. This method produces a larger quantity of beneficial microorganisms than found in raw material. This brings about more rapid domination and ensures a faster and more predictable quality of fermentation than occurs in spontaneous fermentation [5-6].

The currently employed food fermentations rely on only a few main metabolic pathways like anaerobic alcoholic, lactic acid, aerobic acetic acid, and glycolytic pathways which convert carbohydrates to alcohol and CO_2, carbohydrates to lactic acid and alcohol to acetic acid, respectively. The main metabolic pathways involved in food processing and preservation are shown in Figure 2.1 [6-7].

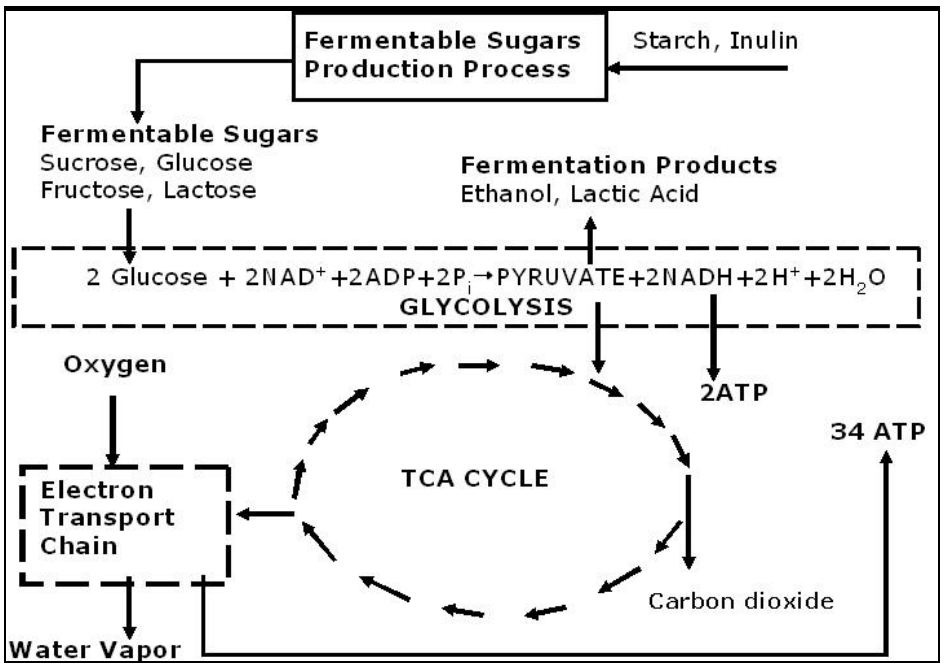

Figure 2.1. Main metabolic pathways involved in food processing and preservation [7]

A large variety of yeast, mold and bacterial species have been used in food fermentations [5-6]. Yeasts are used in both spontaneous and controlled fermentations and involved in the production of foods like bread, wine, beer and cheese. Most yeast species can grow under aerobic and anaerobic conditions [6]. Yeasts use carbohydrates as carbon sources which are converted into alcohols and CO_2 with secondary metabolites like esters, organic acids, aldehydes, and ketones. Yeasts involved in the fermentation of foods and beverages belong primarily to the ascomycetous yeasts and among these, the most well described yeast species is *Saccharomyces cerevisiae* [6].

Most fermentative preservations of vegetables and cereals occur by the action of lactic acid bacteria [5]. Lactic acid bacteria are gram-positive, non–spore forming, catalase negative, usually non-motile (utilize carbohydrates fermentatively) and fermentative anaerobes that are often aerotolerant and have extensive growth requirements. They produce most of their cellular energy as a result of the glucose fermentation and lactic acid is the major end product of these activities [4-6, 8].

Lactic acid bacteria are mostly mesophilic they can grow at temperatures from 5°C to 45°C. Lactic acid fermentations mostly require no heating or cooking either before or after fermentation. While the majority of strains grow at pH 4.0–4.5, some are active at pH 9.6 and others at pH 3.2. Strains are generally weakly proteolytic and lipolytic and needed for preformed amino acids, purine, pyrimidine bases and vitamin B for their growth [4, 8].

2.1.1. Fermentation of Cereals

Cereals are one of the important ingredients of fermented foods worldwide [3, 9]. Fermentation may be the most simple and economical way of improving the nutritional value, sensory property, and functional quality of cereal based foods. In general, natural fermentation of cereals leads to a decrease in the level of carbohydrates as well as some non-digestible poly and oligosaccharides. Certain amino acids may be synthesised and the availability of B group vitamins may be improved [4]. Phytic acid is an antinutritional agent because of its ability to bind minerals and proteins, directly or indirectly, and thus alter their solubility, functionality, digestibility and absorption [10]. However lactic acid fermentation of cereal products reduces the phytic acid content of cereal. When phytic acid is reduced, iron, zinc, and calcium levels and protein bioavailability of cereal products are increased [4, 11].

2.2. Tarhana

Tarhana is one of the fermented cereal foods eaten by Turks for centuries. It was thought that tarhana was introduced by Turkish settlers from Mid-Asia to Anatolia, Middle East, Balkans and some European countries [9, 12, 13]. There are some other traditional products in the world similar to tarhana named kishk (sour milk-wheat mixture with boiled chicken stock) in Egypt, Syria, Lebanon, and Jordan, Kushuk (milk-sour dough mixture with turnips) in Iraq, Tahonya/Talkuna in Hungary and Finland, and atole/trahana (fermented cereal-milk porridge) in Scotland and Greece [12, 14-19] .

Tarhana is main ingredient of Tarhana soup. Tarhana soup is consumed as a breakfast and appetizer prior to main meals usually along with bread and vegetables mainly during cold days [13, 20-22]. Tarhana soup is also used to feed babies and sick

people because of its nutritious and digestive properties [18]. Tarhana production methods are not standard and that's why nutritional value of tarhana vary between regions because of nutritional properties to depend heavily on the ingredients and the amounts used in the recipe [1, 18]. Tarhana is a good source of minerals, and water soluble vitamins. Tarhana also contains proteins in highly available form [9, 22, 23]. In Turkey tarhana soup is used mostly for infant and children nutrition due to its composition. Tarhana soup enriched by legumes and meat is also recommended for the children suffering from kwashiorkor and marasmus diseases [13, 24].

Tarhana soup is prepared basically by adding tarhana to water and stirring occasionally untill simmering, adding oil and seasonings at the end [22, 25, 26]. In some locations of Turkey dried thin layers of tarhana are consumed as a snack like nuggets or biscuits [1, 13]. Although tarhana is the soup which is consumed in Turkey, its consumption in instant form is quite low. Instant soup manufacturers in large quantities produce soups that are hard to cook in home; while tarhana is the one of the easiest to cook. Second reason is that in Turkey there are more than 50 different flavours of tarhana due to regional production and consumption differences. Therefore it is not easy for the manufacturers to produce tarhana that would have a standard and common taste for the consumers in all over Turkey [27].

Yoghurt and wheat/wheat flour are the most common and main ingredients of tarhana. The other ingredients vary in different places. Tarhana is enriched by vegetables, herbs, spices and other foods by the purposes of increasing its nutritional value, flavour and taste. Wheat flour, wheat and semolina are the main cereals used in tarhana production. Cereals sometimes substituted either partially or totally with legume seeds such as soybean, lentil, chickpea, and corn flour especially in the central and eastern parts of Turkey [9, 12, 20, 22]. Tomatoes, onions, green pepper, red pepper, mint, dill, tarhana herb and thyme are the other vegetables and herbs used in tarhana production. Tomatoes with smaller water content and red onions are preferred for tarhana production. Red peppers are also added into tarhana due to their dominant colour. Besides its flavour-enhancing property, salt improves fermentation and increase the shelf life. Tarhana herb (*Echinophora sibthorpiana*) which is grown in Southern Europe, and Asia (Greece, Turkey

and Syria etc.) is used to improve the flavour of tarhana [12]. Some manufacturers may use *Saccharomyces cerevisiae* (baker's yeast) in tarhana production [28, 29].

Different tarhana production methods are used in Turkey. In general tarhana production is based on 4 main steps including [1] mixing ingredients (dough formation), [2] fermentation, [3] drying, and [4] grinding [9, 29, 30].

In tarhana production, dough is prepared with mixing ingredients like yoghurt, wheat flour, yeast, minced vegetables and spices [9]. In the whole mixture, the wheat flour/ yoghurt ratio is generally 1:1 or 2:1 [13]. The yeast used in tarhana fermentation can be produced by a small quantity of sourdough from previous fermentation to be mixed into the new dough. This practice can be successfully carried out for many years to achieve reliable fermentations [5, 9].

Tarhana fermentation generally takes one day to one week depending on the desired properties [18]. In tarhana production, lactic acid bacteria and yeasts are responsible for acid formation throughout fermentation and the leavening effect. Total living microorganisms and lactic acid bacteria count increase rapidly within three days of fermentation and then decrease to the initial levels with consuming substrate level [22]. The yeast involved in tarhana production is *Saccharomyces cerevisiae*. It decreases the fermentation time and acidity, enhances amino acid profile as well as taste and flavour of final product [5, 31]. *Lactococcus lactis* and *Streptococcus thermophilus* are the main lactic acid bacteria found in tarhana. Other lactic acid bacteria determined in tarhana are; *Pediococcus acidilactici, Streptococcus thermophilus, Lactobacillus fermentum, Enterococcus faecium, Pediococcus pentosaceus, Leuconostoc pseudomesenterioides, Weissella cibaria, Lactobacillus plantarum, Lactobacillus delbrueckii spp. bulgaricus, leuconostoc citreum, Lactobacillus paraplantarum, Lactobacillus casei, Lactococcus lactis, Lactococcus diacetylactis, Lactobacillus acidophilus, Leuconostoc cremoris* [6, 20, 22]. Lactic acid bacteria and yeasts give the characteristic taste and flavour of tarhana by producing lactic acid, organic acids, ethanol, CO_2, and aromatic compounds [31]. Aromatic compounds identified from tarhana were mainly aldehydes, esters, ketones, alcohols, terpenes, furans, phenols, sulphur compounds, and acids etc [4, 32].

Tarhana is dried after fermentation to decrease the moisture content in order to prevent the growth of pathogens and spoilage microorganisms. At domestic level, tarhana is usually sundried. In industrial scale, tarhana can be dried by using modern drying techniques [4, 9, 18, 33-35].

The tarhana is formed by grinding of the dried tarhana [9]. This tarhana can be stored for 1-2 years under proper storage conditions such as low humidity and temperature without any sign of deterioration. Because tarhana is a poor medium for pathogens and spoilage organisms due to its low pH (3.5-5.0) and moisture content (6-9%) [13, 14, 22].

According to the Turkish tarhana standard, the moisture level should be under 10% [36]. In domestic level, big variations on acidity and moisture levels of tarhana were determined and it was considered to be due to production differences of tarhana like fermentation time and amount and type of yoghurt used in tarhana production [18, 21, 22].

Microbiological studies have shown that tarhana is a safe product. Beside the low pH and moisture content, another reason is the antimicrobial effects of fermentation [2, 28]. Antimicrobial effects are related to bacteriocins, ethanol, CO_2, hydrogen peroxide, diacetyl, organic acids and various low molecular weight compounds produced during fermentation [5, 28, 31, 37].

2.3. Hazards, Their Significance and Control

2.3.1. Hazards and Food Borne Illnesses

Food borne illness can be defined as: “any disease of an infectious or toxic nature thought to be caused by the consumption of food or water”. For most adults in the industrialized world, incidents of foodborne illness are unpleasant but are generally mild and self-limiting indispositions that are restricted to gastroenteritis and are not usually life-threatening. Exceptions occur with particularly susceptible individuals such as the very old or very young, pregnant women or those who are already very sick or weak for some other reason. These vulnerable groups constitute quite a large proportion of the population and for many of them diarrhoeal disease can be fatal [38].

Food illness can result from what a food contains or what it lacks and these are called hazards. Hazard is biological, chemical or physical property which may cause a food to be unsafe for human consumption. Any factor which may be present in the product that can cause harm to the consumer either through injury or illness can be considered as hazard [38, 39]. Some hazards of this kind are described as being intrinsic to the food in the sense that they are normal and natural constituents of the food. Other food borne hazards can be described as extrinsic, indicating that their presence is a result of contamination of the food. This includes contamination with industrial chemicals or pesticide residues, right through to the presence of pathogenic bacteria or parasites [38].

Biological hazards may include macrobiological and microbiological hazards. Macrobiological hazards, such as the presence of insects and flies, are considered as biological hazard, if they pose a risk by themselves to the product [39]. Microbiological hazards in food include; bacteria, their toxins, viruses, and parasites [40]. Most food processing operations will be at risk from one or more biological hazards, either from the raw materials or during the process. Pathogenic or food-poisoning microorganisms exert their effect directly or indirectly on humans. Direct effects result from an infection or invasion of body tissues and are caused by the organism itself, e.g. bacteria, viruses and protozoa. Indirect effects are caused by the formation of toxins (or poisons) that are usually preformed in the food [39].

Bacteria are the most important and well studied foodborne pathogens. A key factor is their ability to multiply in food, thus increasing the hazard they pose [38]. Bacteria cause foodborne illness by two mechanisms: infection and intoxication. Infection occurs when living bacteria are ingested with food in numbers sufficient for some to survive the acidity of the stomach, one of the body's principal protective barriers. These survivors then pass into the small intestine where they multiply and produce symptoms. Infective pathogens can be introduced into the body from a variety of sources. To cause illness, a sufficient number of cells must be consumed. This is known as the infectious dose. Intoxication is a genuine food poisoning since a poisonous substance, the toxin, is present in the food having been produced by the bacteria which have grown in the food prior to consumption [38, 41]. For example, there is a great attention on the *Escherichia coli* as a cause of many

food borne outbreaks with significant morbidity and mortality. Production of cytotoxins (Shiga toxins) is a common feature of Verocytotoxin-producing *Escherichia coli* which has low infectious dose and causes haemolytic uraemic syndrome [42].

Numerous types of viruses are found in the gut of human. However some of them can be important pathogens. The primary source of virus infection is in food-borne outbreaks must be considered as human origin. There are number of types of viruses but the greatest number of outbreaks is due to infective hepatitis, rotaviruses and small round structured viruses (SRVS) such as the norwalk virus. Virus are obligate parasites, they are very difficult to detect due to their small size and them to do not grow on culture media or in foods (food is a vector only) [38, 39, 41, 42].

A wide range of foods may be infested with animal parasites which are harmful to man and which can be readily transmitted by ingestion of the food. The larva of parasites such as pathogenic flatworms, tapeworms and flukes may infect man via the consumption of the flesh of infected pork, beef, fish and wild game. Protozoa such as *Toxoplasma gondii*, *Giardia intestinalis (lamblia)* and *Cryptosporidium parvum* produce encysted larvae which subsequently infect man on ingestion [39, 41, 43].

Chemical contamination of foodstuffs can happen at any stage of their production, from growing of the raw materials through to consumption of finalised product. The effect of chemical contamination on the consumer can be long term (chronic) such as for carcinogenic or accumulative chemicals (e.g. mercury) which can build up in the body for many years, or it can be short term (acute) such as the effect of allergenic foods. The main chemical hazard issues in food products are cleaning chemicals, pesticides, mycotoxins, allergens, toxic metals, nitrites, nitrates, N-nitroso compounds, polychlorinated biphenyls, plasticizers, packaging migration, veterinary residues and chemical additives [39, 44].

Physical hazards can enter a food product at any stage of production. There is a huge variety of physical items which can enter food as a foreign material, but only a few of these are hazards to food safety. It could be prosecuted for the presence of foreign material in a product regardless of whether or not it is a true safety hazard, but simply because the product is not of the true nature and substance demanded by the consumer. The possible

physical food safety hazards are glass fragments, metal pieces, stones, sharp splinters of wood, plastic, pests etc [39, 44].

2.3.2. Hazard Control and Management Systems

Quality control contains the control of the food process, raw materials and final products. Activities of food control provide the quality, safety and honest presentation of the food at all stages of the food process such as production, storage, marketing and consumption [41, 45]. Quality assurance involves wider aspects such as the evaluation of ingredients and final product standards, design of production area, and equipment, packaging, storage and distribution [41].

"Good Hygienic Practices" and "Good Manufacturing Practices" are the preventive actions which are applied for the safety of food productions and they show the requirements in the food production facilities [46]. Significant specific hazards are addressed by using different management systems like Hazard Analysis Critical Control Point (HACCP), Total Quality Management, Quality Assurance programmes (ISO series) and Failure Mode and Effect Analysis (FMEA) [41].

2.3.2.1. HACCP

HACCP is an approach for hygienic food production by the prevention of problems. It does not cover the quality of product and a production process is evaluated for hazards and their relative risks. In order to maintain the production of a hygienically safe product, key steps in the production process are determined and monitoring and verification procedures are established [41].

2.3.2.2. ISO 22000

ISO 22000 was developed by ISO Technical Committee 34 Working Group 8 according to the guide ISO-72. In comparison to HACCP, ISO 22000 refers not only to the food safety requirements, but also to those of the consumers. An ISO 22000 certified organisation must display its capability for auditing internally the provision of safe foods. ISO 22000 covers continuous inspection of all the points at the food process such as production process, transfer of the food, the sale of the products, and also the final product

at the points of sale. The main difference between ISO 22000 and HACCP is that all sectors in the food chain are responsible for the safety of the product [47].

2.3.2.3. FMEA (Failure Mode and Effect Analysis)

FMEA is an analysis which aims to determine and protect the product and process problems before they occur [48]. FMEA which was drawn up by the Pillsbury Company working by NASA and US army laboratories is based on the engineering system, investigated potential failures at each stage in an operation beside possible causes and the likely effect [39, 40]. The ways of process fails are determined as the failure modes. Each failure mode has a potential effect which can have different frequency to occur. There is a relative risk associated with each potential effect [48].

FMEA provides information on the subsystems and final items, list of potential failures in the production process, probability, severity and detectability of failures, and criticality rankings of all failure modes. Corrective actions which may decrease the dangerous effect of failures can be determined for failures according to previous interventions [49]. The personnel failures would also be included into the FMEA apart from food problems [48].

Three factors which are listed below can be used to determine the relative risk of a failure and its effects:

Severity; The consequence of the failure,

Occurrence; The likelihood or frequency of the failure may occur,

Detection; The probability of the failure to be detected before it may occur [48].

Each of these tree factors are rated from 1 to 10 for each potential failure mode according to the data and knowledge of the production process. A risk priority number (RPN) is calculated by multiplying the rankings of the three factors. There are two RPN values which are calculated before and after the corrections are taken for each failure [48].

In Turkey, tarhana is produced at traditional and industrial levels. In local production units and small-scale industries tarhana is produced using traditional family techniques which may vary between different regions [10, 22, 30]. Most of the traditional production

processes may contain risk factors like direct hand contact, usage of simple equipment, poor process conditions such as sun drying, and inefficient process control measurements. Therefore there is a great necessity for the assessment of these risks and application of preventative methods. Using a comprehensive quality system can be effective on minimising these process problems. In this way FMEA would be preferred as a part of quality system in tarhana production.

According to a HACCP study, the determined critical control points in Tarhana production were cooking, fermentation, drying and sieving [29]. By FMEA, a higher quantity of production steps would be taken as a control point and assessed in a more comprehensive way while FMEA detects all potential failure modes and their effects as HACCP evaluates the hazard only in the sense of product safety [39]. On the other hand, up to now FMEA method has not been applied to tarhana production in Turkey. Therefore our study was aimed to see the effectiveness of this systematic method on tarhana production in order to reduce the potential risks coming from tarhana and minimising the human health problems which may be resulted from the consumption of such a highly consumed traditional food. One of the objectives of the study was applying FMEA into different tarhana production methods which are widely used in Turkey and to look for the stages where their process can fail, and what the corrective actions are for the most critical stages of these productions.

3. MATERIALS AND METHODS

3.1. Materials

3.1.1. Tarhana Production Process

Our study was covered 4 traditional and 1 industrial tarhana production methods. Traditional tarhana production methods were gathered from Uşak, Gediz, Maraş and Beypazarı. One tarhana manufacturer was chosen from each geographic location in order to take information on the traditional food production technique. The selected manufacturers have been producing tarhana at least for 15 years and with traditional production methods which they learned from their family members. The study on production method of the 4 traditional foods was conducted under the project titled "Determination of National Food Composition and Formation of a Widespread-Sustainable System" which was funded by The Scientific and Technological Research Council of Turkey-TUBITAK, Support Programme for Research Projects of Public Institutions (TARAL 1007) [50]. A visit was scheduled on Uşak, Gediz, Maraş, and Beypazarı distinct by different project personnel. At the study in production area, the tarhana production process was monitored, process conditions like temperature were measured, and comprehensive information on production stages was recorded. Other local traditional tarhana manufacturers in the same distinct were also visited and information on tarhana production technique was collected.

Industrial tarhana production method was taken from a production area which was located in Keşan by telephone interview. The ingredients of tarhanas are given in Table 3.1. The process flow diagrams of Beypazarı, Maraş, Uşak, Gediz and industrial tarhana productions were given in Figure A.1, A.2, A.3, A.4, A.5 respectively. The images of main production processes can also be seen in Figure B.1, B.2, B.3, B.4, B.5, and B.6.

Table 3.1. Ingredients of tarhana and their quantity (%) in different formulations

Tarhana Production Processes									
Beypazarı tarhana		Maraş tarhana		Uşak tarhana		Gediz tarhana		Industrial tarhana	
Ingredient	%	Ingredient	%	Ingredient	%	Ingredient	%	Ingredient	%
Salt	0.1	Salt	2.0	Salt	1	Salt	1.2	Salt	3.0
Yeast source	0.5	Thyme	1.0	Yeast source	0.2	Yeast source	0.04	Yeast source	0.5
Yoghurt	16.1	Yoghurt	65	Yoghurt	6.6	Yoghurt	4.0	Yoghurt	4.5
Onion	1.3	Wheat	32	Onion	13.4	Onion	4.9	Onion	0.5
Wheat flour	65			Wheat flour	35.5	Wheat flour	56.4	Wheat flour	2.5
Tomato	13			Tomato	13.3	Red pepper	33	Tomato paste	3.0
Green pepper	1.3			Green pepper	17.6	Mint, dried	0.5	Red pepper paste	1.5
Chickpea	1.3			Red pepper	8.9			Chickpea flour	2.5
Lentil	0.7			Mint, raw	3.5			Rye flour	7.5
Dill	0.7							Durum clear flour	72
								Semolina	2.5

In Beypazarı tarhana production process vegetables were mixed with wheat flour and yoghurt, as shown in Figure A.1. Different than Uşak, Gediz and Maraş tarhana productions, Beypazarı tarhana was enriched by legumes like chickpea and green lentils. Yeast source used as ingredient in Beypazarı tarhana like in Uşak, Gediz, and industrial tarhana as shown in Figure A.1, A.3 and A.4 was a piece of sourdough which was kept from previous fermented tarhana dough. In Beypazarı, yoghurt was produced from raw milk like in industrial tarhana production process. In Beypazarı tarhana production method, firstly the mixture of vegetables, legumes and yoghurt was fermented for 3 days. Then, yeast source, wheat flour and salt were added into the mixture which was fermented for 3 days more. The dough pieces were taken by hand from fermented tarhana dough and spread on platforms wrapped with sheets. Beypazarı tarhana was dried in indoor environment like in Uşak and Gediz tarhana productions. In Beypazarı tarhana production dried tarhana was milled, sieved and dried again like those of Gediz tarhana production process, as shown in Figure A.1 and A.4.

Gediz and Uşak tarhana productions were typical and involving dough formation, fermentation, drying and milling operations, as shown in Figure A.3, A.4. However in Uşak tarhana, the dough was kneaded by hand for 30 min each day throughout the fermentation process while other tarhana productions were not involving any kneading operations.

In Maraş tarhana no vegetables and yeast source used, which was different than those of the other tarhana production processes. Wheat was processed and mixed with yoghurt. The mixture was fermented for a very short time (approximately 15 hours). Maraş tarhana was exposed to direct sun light for drying operation. Maraş tarhana production is given as a flow chart in Figure A.2.

In industrial tarhana production process different grains and grain products like buckwheat, buckwheat semolina, wheat flour, rye, and chickpea were used. Tomato and red pepper paste were also used which was a different application than the other tarhana production processes. In industrial tarhana production process there were storage operations applied to store some ingredients and the final product as a result of the large production capacity. In the industrial tarhana production process tarhana batches were transferred by carriages between the main processes equipment. Fermentation was conducted in fermentation silos which had capacity of 1.5 tonne and equipped with mixer. Different than traditional tarhanas, industrial tarhana was dried in industrial driers. In industrial driers tarhana was slowly heated by steam until temperature reaches to 80°C, then the tarhana was cooled by ventilation. Total drying procedure was taking 6-9 hours, and the final moisture content of the tarhana was falling to %7. In industrial tarhana production, tarhana was produced at any time of the year and it was stored before selling. However traditional tarhanas were produced only in the summer between August to October and the product would not be stored. In industrial tarhana production, application of tests to provide the quality control of process was reported. Industrial tarhana production is showed in Figure A.5.

3.2. Methods

3.2.1. FMEA methodology

A detailed flow chart was created for each tarhana production processes to use for FMEA work. Each failure mode of tarhana production processes were determined and defined as a control point (CP) in the process flow charts, as shown in Figure A.1, A.2, A.3, A.4 and A.5. Potential hazards and possible causes for the hazards were identified for each possible failure mode of 5 tarhanas and shown in Table A.1, A.2, A.3, A.4, and A.5. The possible causes were grouped as biological, chemical and physical hazards. Epidemiological studies and the best expert opinion about the similar ingredients or processes were taken as a base for the hazard analysis. The risk level of each potential failure was identified by calculating a risk priority number (RPN) from three variables: frequency of occurrence for each failure (O), seriousness of the failure to the consumer (S), and possibility of detecting the failures (D) [48, 51]. A numerical ranking for variables O, S, and D of failures was established. Each failure mode was identified whether or not the failure is likely to occur on a scale of 1-10. The highest ranking indicated the greatest probability of the failure to occur. The possibility for detecting the failure prior to occurring and the seriousness of the failure to the consumer were also rated on a scale of 1-10, where 10 was the least likely chance of detecting the failure and high severity effect of the failure, respectively. The RPNs were calculated by multiplying the values of the variables O, S, and D. The RPN (which will range from 1 to 1000 for each failure mode) is used to rank the need for corrective actions to eliminate or reduce the potential failure modes. The RPNs higher than 50 were considered as the potential failures which corrective actions were required on them. The number of 50 was selected due to the aim of reducing the system risk level. The maximum value of a possible RPN is 1000 (10x10x10) while statistically 50 is equal to the 5% of 1000 with a statistical confidence of 95%. Possible corrective actions were suggested for each potential failure mode and can be found in Table A.1, A.2, A.3, A.4 and A.5. A new RPN (resulting RPN) is determined by assuming that the proposed corrective actions are successfully taken and re-evaluating the S, O, and D rankings. For each tarhana production process, an original total RPN was calculated by taking sum of the RPNs which were calculated before the corrections. And with the same way, a total resulting RPN was calculated by using RPNs calculated after the corrections.

Both original and resulting RPN values were used to compare the effectiveness of FMEA on the safety of each production processes which can be found in Table A.1, A.2, A.3, A.4 and A.5 [48, 51-54].

4. RESULTS AND DISCUSSION

Heavy metal contamination is an important chemical hazard in food processing [44]. As a result of environmental pollution, heavy metal contamination threats human health via food chain [55]. Metal contamination can take place during the handling and processing of foods, from the farm to the point of consumption and can be of concern in high levels [56]. Heavy metal residues in the final food product should be under tolerance levels, since it can be harmful to humans even at low concentrations [57-58]. For example, nickel is carcinogenic and can cause also respiratory problems. Cadmium may accumulate in the human body and induce kidney dysfunction, skeletal damage, learning disability and reproductive deficiencies. High intake of copper and zinc can also cause liver and kidney damage even if these metals are essential for good health. Lead can increase blood pressure and cardiovascular disease risk in adults. Different than adults, children more readily absorb lead, and lead can have more hazardous effects like reduced cognitive development and intellectual performance [57, 59, 60].

Heavy metals can get into the vegetables through water used for the irrigation, and soil by mineralization of crops. The levels of these metals increase as a result of natural weathering of rocks, disposal of wastes like batteries, metallic household appliances, application of sewage sludge, use of fertilizers, pesticides, herbicides, industrial effluents, soil pH and type, soluble content of metal in soil, and plant species [57, 61-64]. Heavy metals taken into the plants may also redistributed with the soil enriched by the pollutants of decayed and dead plants. Especially leafy vegetables accumulate higher amounts of heavy metals due to their leaves which absorb the metals [57].

Receiving onion is the most critical stage in tarhana production due to its heavy metal contamination risk, as shown in Table A.1, A.3, A.4, A.5 (RPN=240). Receiving heavy metal contaminated onion is of major concern since onion is most common vegetable used in tarhana production methods, and it has higher metal transfer factors and the ability to accumulate more heavy metals than the leafy vegetables [57, 62]. The other vegetables, tomato and peppers, received in tarhana production, would also contain heavy

metal, as shown in Table A.1, A.3, A.4 (RPN=90). Heavy metals can also be found in the grains, wheat, rye, buckwheat and processed grains, wheat flour, durum clear flour, buckwheat semolina, used in tarhana productions which can be seen in Table A.1, A.2, A.3, A.4, A.5 (RPN= 120-108). In one of the recent studies high heavy metal contamination level was observed in vegetable like onion, pepper and tomatoes cropped in Turkey [57]. Therefore it is important for the tarhana manufacturer to consider whether the supplier applied the effective agricultural approaches and countermeasures to reduce the accumulation of heavy metals in edible part of crops. Effective agriculture methods like crop rotation and the application of zinc fertilizers would reduce the metal transfer into food chain. Additionally use of organic and inorganic amendments would decrease the bioavailability of heavy metals in soils [62]. Tarhana manufacturer should consider whether the land used to produce crops have been treated with lead containing pesticides, sewage sludge, irrigated waters and/ or soil. The certificates of the vegetables need to be reviewed for the presence of heavy metals according to the specifications given by Turkish Food Codex [58]. Very soiled vegetables, especially onions should not be purchased by tarhana producers.

Receiving milk brings heavy metal contamination risk to the tarhana production, as shown in Table A.1, A.5 (RPN=160). Yoghurt can also contain the risk of heavy metal which is resulted from the usage of milk with high heavy metal concentration which is shown in Table A.2, A.3, A.4 (RPN= 100). The animal feed can be contaminated with heavy metals and it can lead to bioaccumulation of metal in animal tissues and milk. Feed contamination can be linked to local industrial activities, and farming practices as mentioned before, like application of irrigated water and/or soil on agricultural land [55, 65]. In tarhana production processes, the received milk should come with the certificates reporting its heavy metal content compared with the specifications of Turkish food codex [58]. Also it must be considered whether the lactating animals were grown far away from potentially emitting industries. In general monitoring the environmental load of the industrial areas in Turkey would be possible by animal sentinel systems which include applications like verification of ecological risks and exposure of contaminants on animal tissues [65-66].

Heavy metal contamination of food can also arise during food processing because of the contact between food and metal [56, 67]. In different tarhana production processes, heavy metal contamination resulted from metal surfaces in contact with food can be a potential failure in the milling and sieving processing such as milling and cracking wheat, milling tarhana, chickpeas and onions, sieving tarhana, wheat flour and milled chickpeas, as shown in Table A.1, A.3, A.4, A.5 (RPN=72). Stainless steel equipments can contaminate the food by free iron found on their surface [56, 68]. Free iron can be detected by a variety of tests such as copper sulphate and ferroxyl tests. Moving parts of equipment can also cause damage on the metal surface of instruments [69]. Applications like using lead solder to repair broken equipment or substituting non-food-grade equipment with food-grade equipment in food processing facility would also cause heavy metal contamination. Therefore in tarhana production it must be avoided to use non food-grade metals for metal surfaces, lead solders for instruments which are in contact with food [67]. However iron contamination in the food process can be removed by certain chemical and mechanical methods like pickling, and abrasive blasting. As it is a sign of iron contamination, presence of rust in the equipment should also be checked constantly [68]. Moving parts of the instruments also require daily checks to ensure that they have not become loose or out of adjustment [69]. The number of stages contain heavy metal contamination risk due to equipment surfaces is highest in the industrial tarhana production while Maraş tarhana is the lowest. Because food, come into contact with instruments more frequently in the industrial processes. However, number of instruments used in Maraş tarhana production is low due to the traditional production method.

Even if in low levels, packaging process in tarhana production can also have the heavy metal risk due to the packaging material used and this is shown in Table A.1, A.2, A.3, A.4, A.5 (RPN≤50). Packaging items like colored plastic bags or lead containing dyes, and foil capsules used for packaging can cause this risk [67]. The canned products used in tarhana production can also contain the heavy metal risk from packaging material since lead soldered cans have been identified as important source of food contamination with lead, as shown in Table A.5 (RPN≤50).

Water used in industrial tarhana production may have heavy metal contamination, as shown in Table A.5 (RPN=63). Heavy metals like lead and other metals can slowly

dissolve into the tap water from the plumbing, fixtures and pipes as a result of corrosion. Additionally heavy metals can get into drinking water from nearby industrial waste facilities or municipal landfills, if water is supplied from a private well [70]. It is recommended to have corrosivity and heavy metal content of the tap water to be tested periodically. The corrosive pipes and plumbing materials also need to be changed. Corrosion control devices like calcide filters would be used to reduce the tendency of water to dissolve lead from indoor plumbing materials. Leaving water to run for 15 to 30 seconds would also reduce the metal contamination of water. Water needs to be supplied from a public water system because it is regularly monitored by municipalities. It must be considered whether lead free materials are used in drinking water plumbing. Using any water treatment devices like distillers and reverse osmosis is a big help for distilling water [70, 71].

While heavy metals enter into the environment in a variety of ways, dust can be another way where heavy metals find their route into soils and subsequently on the surfaces like tissues of plants. Therefore in tarhana production processes, drying in outdoor environment would have heavy metal contamination risk which may be transferred by air or dust on to the surface of tarhana and this risk was shown in Table A.2 (RPN=54,). The non-ferrous industry, fossil fuel combustion, waste and traffic, are the main sources of atmospheric heavy metals [72, 73]. Maraş tarhana is dried under direct sun-light. If applicable, maintaining the drying process of Maraş tarhana in an indoor environment, or covering the tarhana with a shelter and placing it on a platform would help in minimising the heavy metal contamination risk arising from dust and air pollutants.

In general, the maintaining efficiently the production steps like; washing wheat, rye, and buckwheat and peeling onions would help to lower the residue of heavy metal in the final product [56].

Potential microbiological biological hazards in tarhana include bacteria, their toxins, viruses, and parasites. Bacteria are one of the most important microbiological hazards while they cause a large proportion of all food borne illnesses. However these microorganisms can have different effects on the consumers. Therefore in order to take this effect into account, in our study, the bacteria and virus were grouped due to their severity

as severe and moderate hazards and their seriousness of failure were ranked as 10 and 7 respectively [40].

Escherichia coli are gram-negative, facultative anaerobic, non-spore forming bacilli. A wide variety of foods has been implicated in outbreaks of illness attributed to particularly *Escherichia coli* O157 which attach to mucosal cells, produce toxin and cause typically haemorrhagic colitis. This is characterised by sudden onset of severe crampy abdominal pain, grossly bloody diarrhoea and vomiting. Approximately 10% of cases usually develop into a serious illness called haemolytic uraemic syndrome, which consist of symptoms: acute renal failure, thrombocytopaenia, microangiopathic haemolytic anaemia [42, 74]. *Salmonella* are gram-negative, facultatively anaerobic, non-spore forming bacilli [74]**.** *Salmonella typhimurium* and *Salmonella enteridis* are mostly isolated serotypes in food outbreaks [75]. A wide range of contaminated raw materials has been implicated in outbreaks of salmonellosis, although initial contamination is often trace back to human or animal sources. A variety of wild animals including rodents and birds can carry salmonella [42]. Typical incubation period of *Salmonella* is 12-36 hours. Usually the patient has fever with abdominal pain and diarrhoea and patients mostly recover within 7 days [74]. The bacterium *Salmonella typhi* causes typhoid fever which is a life-threatening illness and characterized by fever, headache, constipation, malaise, chills, and myalgia with few clinical features that reliably distinguish it from a variety of other infectious diseases. Confusion, delirium, intestinal perforation, and death may occur in severe cases. Without therapy, the illness may last for 3 to 4 weeks and death rates range between 12% and 30% [76].

Listeria monocytogenes are gram-positive, facultative anaerobic, non-spore forming bacilli or cocco-bacilli. Mostly healthy persons whose gastrointestinal tract is contaminated with *Listeria* are probably symptomless or suffer only mild symptoms that may well go unnoticed [42, 74]. Campylobacters are gram-negative, micro-aerophilic, non-sporing, small vibroid cells. *Campylobacter jejuni* is the most significant *Campylobacter* species [42]. *Campylobacter* infection, Campylobacteriosis, is usually characterised by an acute, self-limiting enterocolitis, lasting up to a week and clinical illness is often preceded by fever, headache, myalgia and malaise. A small proportion of affected individuals suffer relapses [42, 74]. The family micrococcaceae includes two genera of significance,

micrococcus and *staphylococcus*. Micrococci are non-motile aerobes growing best between 25 and 37°C whereas staphylococci are facultatively anaerobic and grow best between 35 and 40°C. The genus *staphylococcus* contains one species, *Staphylococcus aerous*, which is an important food poisioning organism. They may be present as part of the normal microflora of humans and other animals, *Staphylococcus aerous*, being carried out on skin and nasal cavities of the healthy population. *Staphylococcus aerous* is the species almost invariably involved, although enterotoxin production by several other species has been reported [42]. This type of food poisoning is characterised by nausea, vomiting, abdominal pain and prostration, often with diarrhoea, approximately 1-6 hours after ingestion of contaminated food. One of the major problems associated with the control of *Staphylococcus aerous* food poisoning is the high carriage rate of the organism in humans [74]. The genus *Yersinia enterocolitica* comprises gram-negative, facultatively anaerobic, non-spore-forming or coccobacilli bacterias which are psychrotrophic. *Yersinia enterocolitica* is not uncommon in the environment or in food and was found to be in 3.5% of faecal specimens. Infection by *Yersinia enterocolitica* can involve many symptoms as the most common are gastrointestinal, characterised by abdominal pain and diarrhoea, but rarely by nausea and vomiting [42, 74]. Shigella species are gram-negative, facultatively-anaerobic, non-spore-forming bacilli that do not ferment lactose and are non-motile [74]. It was found that, *Shigella dysenteriae* type 1, may cause deadly epidemics [77]. Classic *Shigella (bacillary) dysentery* is characterised by frequent passing of liquid stools, which contain blood, mucus and inflammatory cells. In healthy adults death is rare but, *Shigella dysentery* is a major cause of death among infants in countries where hygiene is poor. Bacteraemia is an unusual symptom, being most common amongst persons aged less than 16 years, but also occurring in compromised persons, the death rate approaching 50% [42]. The genus Aeromonas comprises gram-negative, oxidase-positive, facultatively anaerobic rods. The most common type of illness associated with *Aeromonas* is similar to cholera, characterised by watery stools, i.e. diarrhoea and mild fever and vomiting in young children. Less common is an illness similar to dysentery, characterised by diarrhoea and the presence of blood and mucus in stools. Patients with *Aeromonas*-related enteric illness usually produce diarrhoea which is mild and self limiting [42, 74].

Clostridia are gram-positive, obligately anaerobic, endspore-forming bacilli. *Clostridium botulinum* may be found in the intestines of humans and other animals, and in

soil and mud, from where it can contaminate vegetables. Botulism is a serious disease of *Clostridium botulinum*. In food-borne botulism the food item becomes contaminated with spores from environment, which are not destroyed by the initial cooking or processing. Symptoms of *Clostridium botulinum* type differ and include dizziness, difficulty in swallowing, slurred speech, weakness of limbs and blurred or double vision. Breathing problems are caused by respiratory paralysis which may lead to death by asphyxiation [74]. Certain *Clostridia,* particularly *Clostridium pasteurianum* and *C. butyricum*, are grow well in low pH and cause spoilage, with gas production, of canned tomatoes [41]. *Clostridium perfringens* is commonly found in the intestines of humans and animals and in the soil, resulting in the contamination of meats and vegetables respectively. The disease of *Clostridium perfringens* which has symptoms like abdominal pain and diarrhoea is usually self-limiting, only supportive therapy is needed [74].

Bacillus cereus is a large, motile, gram-positive, facultative aerobic, rod-shaped bacillus, sporulating readily only the presence of oxygen, and is widely distributed in the environment. The resistance of the spores to adverse environmental conditions, and ability to produce a range of food-degrading enzymes enable *Bacillus cereus* to survive and grow well in many different conditions [42]. Staphylococcal food poisoning symptoms are rapid onset of nausea, vomiting and malaise and recovery is usually complete within 24 hours [42, 74]. The bacteria of the genus *Brucella* is primarily passed among animals, and they cause disease (Brucellosis) in many different vertebrates. Humans become infected by coming in contact with animals or animal products that are contaminated with these bacteria. In humans brucellosis can cause a range of symptoms that are similar to the flu and may include fever, sweats, headaches, back pains, and physical weakness. Severe infections of the central nervous systems or lining of the heart may occur. Brucellosis can also cause long-lasting or chronic symptoms that include recurrent fevers, joint pain, and fatigue [78]. *Mycobacterium tuberculosis* is the causative organism of tuberculosis [65]. Another member of the mycobacteria group, *Mycobacterium avium* ssp., *Mycobacterium paratuberculosis* is the cause of chronic enteritis in cattle known as John's disease. It is suspected this organism to be associated with the human Chron's disease. It is a lifelong disease and a highly debilitating chronic inflammation of gastro intestinal tract in humans [42].

Dill received in tarhana have high risk of *Salmonella, Bacillus cereus, Listeria monocytogenes, Shigella* spp., *Aeromonas,* and *Clostridium perfringens* contamination which can be seen in Table A.1 (RPN=210). These bacteria's were also risk due to tomato, green and red pepper which were received in different tarhana productions, as shown in Table A.1, A.3, A.4 (RPN=175). Dill was considered to have higher risk than the other vegetables in tarhana, because of its leafy shape to have larger surface, and involving more handling stages during harvest [79].

Contamination of *Escherichia coli* O157:H7 and *Clostridium botulinum* can be found on tomato, green and red pepper, as shown in Table A.1, A.3, A.4 (RPN=100). This risk would be higher in dill which is shown in Table A.1 due to its leafy structure (RPN=150). Contamination of vegetables can occur mainly because of inappropriate agricultural applications at any point throughout the production system. Potential pre-harvest sources of contamination of vegetables include soil, animal faeces, insects, fly eggs, larvae wild and domestic animals, human handling, irrigation of water supplies by seepage of untreated sewage, or fomites which have suffered faecal soiling in agricultural applications [42, 74, 80-82]. During post harvest, some fly eggs and larvae can also transfer pathogens and contaminate the vegetables [81]. For example small flies of the species *Drosophila* deposit their eggs on fresh growth cracks in sound tomatoes and the eggs which are secured to the tomato by an adhesive substance, are very difficult to remove [83]. Although flies are rarely the direct cause of disease, some fly species can be a natural vector of a particular pathogen and cause food-borne disease [81]. Handling of vegetables is an important stage. Vegetables must come along with certificates which report the microorganism content of food and comparison with the upper approved standards. When determining the vegetable supplier, it would be useful information to know whether the field of crops have been treated with sewage sludge and unsafe water. Avoiding supply of defective vegetables would also prevent the production process from pathogen contaminations.

Recontamination of foods through contaminated equipment surfaces is of major concern in tarhana production. Contaminated equipment can be source of *Listeria monocytogenes* and *Staphylococcus aureus* pathogens, as shown in Table A.1, A.2, A.3, A.4, A.5 (RPN=196). Equipment can also be source of *Escherichia coli* O157:H7, as given

in Table A.1, A.2, A.3, A.4, A.5 (RPN=60). These pathogens can be transferred into food by the equipment at the tarhana production stages like; removing inedible parts of vegetables, milling ingredients, chickpeas, rye, onions, and tarhana, cracking and shelling wheat, fermentation, mixing ingredients, tarhana dough, tomato and red pepper paste, transferring the wet and dried tarhana, dough, and the mixture and peeling the top layer and cutting the base of onions, and sieving tarhana. The presence of pathogens on equipment can occur as the consequence of ineffective or inadequate cleaning and disinfection of equipment pieces and the poor hygienic design of equipment [29, 31, 42, 46, 84]. In tarhana production it is necessary to apply efficient cleaning, disinfection and prevention procedures on the equipment. Disinfection of equipment and cleaning utensils (sponges, brushers etc.) is also necessary to apply after cleaning and before a process run. Correct design and proper maintenance of the equipment is also a factor increasing the efficiency of cleaning. During disinfection all equipment should be routinely dismantled or parts should be loosened. Using tests like “coliform test” can be practical to monitor the cleaning efficiency of the equipment surfaces. Limitation of the movements of personnel and goods is a long help in minimising the failure arising from environmental factors. Using automatic washing equipment and UV disinfection cabinets would be effective for disinfection of tools like knifes [39, 41, 42, 85].

Escherichia coli, Clostridium botulinum, Shigella can be a significant risk at possible stages of tarhana like; in receiving and storing durum clear flour, wheat flour, and buckwheat semolina (RPN=120). Pathogens like *Bacillus cereus, Sallmonella spp., Clostridium perfringens, Micrococcus, Alcaligenes* can be also found in these stages shown in Table A.1, A.2, A.3, A.4, A.5 (RPN=84). Flours are generally regarded as microbiologically safe product due its low moisture content. However the proliferation of microorganisms on cereal grains can occur due to improper storage properties. Additionally the pathogens which have ability to contaminate the flour can survive in extended storage periods [86, 87]. Equipment contamination used in milling would also be a cause of microorganisms in flours [88]. *Bacillus cereus* is a specific hazard for cereals and cereal products and *Bacillus* spp. can occur when the moisture content and water activity is high [41, 89]. The pathogens can also be transmitted to the cereals by rodent excreta and diseased seeds [81, 90]. Indicator parameters of microbial safety like total mesophilic bacteria or coliform count should be indicated for grains and their products by

the grain manufacturers. Monitoring the moisture and microbial content of grains by quick tests at any stage of process is a great help in minimising their contamination risk. The hygiene of the equipment surfaces coming in contact with grains like storage silos is also important to avoid recontamination of foods. Providing cool, well-aerated and low-humidity place for storing cereals is also important [41, 89].

Transfer of pathogens by food handlers, in particular from hands, is of major concern in the food productions. Hands are considered very important in the transfer of infectious organisms like *Shigella disentariae*, *Listeria monocytogenes and Staphylococcus aureus* [42, 46, 91]. The contamination risk of these bacteria would differ due to the time duration and frequency of hand touch in the process. Therefore the microbiological risks were ranked different for handling stages of tarhana production process in our study. Kneading the tarhana by hands during fermentation and spreading the wet tarhana on mats and removing them from mats, can have significantly contamination risk of *Shigella disentariae* due to contaminated hands, as shown in Table A.2, A.3 (RPN=120). This risk would also be found in other handling operations in tarhana production processes such as; spreading the wet tarhana dough on sieve trays by hand, and dividing the tarhana dough which are shown in Table A.1, A.3, A.4, A.5 (RPN=80).

Listeria monocytogenes, *Staphylococcus aureus* and *Shigella* ssp. contamination also can be a potential risk when kneading the tarhana and spreading the wet tarhana on mats and removing them from mats, because duration of handling operation is high in these process, as shown in Table A.2, A.3 (RPN=112). Other sources of these bacteria can be the processes like, spreading by hand the wet tarhana dough on sieve trays, and dividing the tarhana dough which are shown in Table A.1, A.3, A.4, A.5 (RPN=84). This bacteria can also contaminate the vegetables if they are chopped by a knife, as shown in Table A.1 (RPN=56). Poor personnel hygiene of the food handlers working at these stages with dirty finger nails, unclean dresses, and unwashed hands can cause the contamination of the food. Inefficiency or absence of hand washing is the main causative mode of transmission of the pathogens [42, 46, 91]. Personnel working on these stages should be trained on understanding the risk associated with cross-contamination and good standards of personnel hygiene should be ensured. Appropriate facilities in the production area needs to be provided to operate good hygienic practice e.g. presence of hand basin and bactericidal

soaps, adequate toilet facilities, strong toilet paper. Table ledges, the underside of tables, door handlers, overhead pipes and many other areas of the process should be routinely and properly cleaned and disinfected. Minimising hands-on operations in tarhana production is also necessary [39, 41, 42, 46].

Listeria monocytogenes, *Staphylococcus aureus* and *Shigella* ssp. contamination can also occur during packaging tarhana due to poor personnel applications, as shown in Table A.1, A.2, A.3, A.4, A.5 (RPN=56). In order to avoid this, bare hand contact with the product must be limited. Personnel should comply with the Good Manufacturing Practice and avoid entry of the extraneous materials into the final product. Efficient lighting and temperature would be helpful to avoid personnel failures.

Antibacterial factors that appear in fermentation may affect and inhibit the survival of bacterial pathogens that are come from raw material or process failures. Survival of pathogens, especially acid-tolerant bacteria is a potential failure in tarhana production [5, 28, 29, 74, 92]. Survival of *Clostridium botulinum* is a potential failure in Maraş tarhana as shown in Table A.2 due to short duration of fermentation (RPN=120). *Staphylococcus aureus, Salmonella*, *Listeria monocytogenes* and *Staphylococcus aureus* toxin (RPN=84) and *Escherichia coli O157:H7* (RPN=80) are also risk in Maraş tarhana fermentation. In the other tarhana processes, the fermentation time is longer and therefore the survival rate of microorganisms is low. The survival of *Escherichia coli O157:H7, Clostridium botulinum* (RPN=60), *Staphylococcus aureus , Salmonella*, *Listeria monocytogenes* (RPN=56) and *Staphylococcus aureus* toxins (RPN=56) in other tarhana fermentations would occur, although in low frequencies which can be seen in Table A.1, A.3, A.4, A.5. Outbreaks occurring in fermented products have usually involved deficiencies in fermentation. Pathogen growth in fermented products is mainly based on deficiencies in the fermentation process, like slow acid production, or post process non-sanitary conditions [42]. *Escherichia coli* O157:H7 is relatively acid resistant and can survive in the fermentation stage [5, 42]. *Listeria monocytogenes* is not particularly acid tolerant, but increased pH in the product due to mold growth can occasionally promote survival of *Listeria* [5]. *Clostridium botulinum* is also acid tolerant and can be found in fermented foods after inadequate processing [38, 74]. The sources of pathogenic bacteria in fermented tarhana can be the contaminated ingredients or production of tarhana which can be easily

contaminated due to absence of pasteurisation during or after the production [28, 74]. Process challenge tests can play an important role in detecting the success of fermentation on reduction of the acid-resistant pathogens. According to test results, modifications on the fermentation conditions can be done. For the quality fermentation, enhancing appropriate conditions (time, temperature, and pH) is important. Usage of starter culture in adequate quantity is also important to ensure rapid fermentation. The activity of starter culture increase in the optimum pH and temperature and its activity level can be measured by pH changes during the fermentation. The sanitary condition of environment is also critical for the efficiency of fermentation [5, 42].

Raw milk is susceptible to many pathogens [65, 93-96]. The potentially pathogenic bacteria of milk are *Escherichia coli O157:H7, Brucella* ssp*., Clostridium botulinum*, *Salmonella typhi, paratyphi* and *dublin, Shigella dysenteriae, Mycobacterium avium* (RPN=100), *Listeria monocytogenes, Salmonella spp.,* Enterotoxigenic *Escherichia coli, Enteroinvasive Escherichia coli*, *Bacillus cereus, Clostridium perfringens, Staphylococcus aerous*, *Campylobacter jejuni* and other species, *Aeromonas spp*., and *Yersinia enterocolitica*, as shown in Table A.1 and A.5 (RPN=70). Microbial contamination of milk may occur during and after milking. Raw milk may expose to contamination with faecal pathogens from the faeces attached to the exterior of teats of cow during milking. Contamination may also occur due to mastitis organisms which enter the teat canal and infect the interior tissues of the teats and cause mastitis. During milking these organisms may also contaminate the milk. Poor milk storage (bulk tank) and transfer equipment may also infect milk. Additionally microbial growth in raw milk may occur, if milk is not collected daily, or not cooled immediately, or no chill chain is provided [42, 65]. Tarhana manufacturer should obtain the results of microbial analysis of milk from dairy suppliers. Besides, he should test the milk for its bacterial load with methylene blue or by some other tests at the point of delivery. Just then milk temperature can be measured by a probe to detect the milk samples which are not in the range of optimum temperatures. It is also important to supply daily and cooled milk (≤8°C) within chill chain [65].

Most pathogenic and gram-negative psychrotrophic bacteria are eliminated at the pasteurisation temperatures of the milk (72-75°C). However a number of heat-resistant bacteria can survive and promote spoilage of the milk. *Clostridium perfringens, Bacillus*

cereus and *Mycobacterium avium* are heat-resistant and can be found in pasteurised milk occasionally. Staphylococcal organisms are susceptible to the pasteurisation temperatures while their toxins are not eliminated at these temperatures. Heating may not destroy the enterotoxin produced by *Staphylococcus aureus* since it is formed in the milk [65, 94]. Therefore *mycobacterium avium (RPN=50)*, and spores of *Bacillus cereus* and *Clostridium perfringens* and enterotoxins produced by *Staphylococcus aureus (RPN=63)* can be risk at boiling milk as shown in Table A.1, A.5 due to their heat resistant character. Efficient pasteurisation conditions of milk should be applied (63°C for 30 min., 72°C for 15 s) to the raw milk received into the tarhana production. Testing the pasteurised milk with sterilization test kits would be a big help in determining the effectiveness of heat-treatment. The kits are examined the presence of phosphatase and peroxidase enzymes which are naturally occur in raw milk and denaturated by pasteurisation. Therefore it is expected for adequately pasteurised milk to test negative for these enzymes [65].

In tarhana productions, boiled milk is cooled before fermentation. During cooling *Bacillus licheniformis* and *Staphylococcus thermophilus* can multiply in milk and this is shown as a potential failure in Table A.1 and A.5 (RPN=56). Bacteria grows slowly until 8-9 h of cooling, and then they grow rapidly if the temperature of the environment is high. Cooling periods of heated milk provides the reduction of this bacterial growth. It is favorable to achieve rapid cooling of milk by using chilled water or glycol [65].

Yoghurt is a dairy product which is susceptible to some pathogens [65, 80, 93, 97]. Yoghurt contains the risk of *Yersinia enterocolitica, Staphylococcus aureus* and *Listeria monocytogenes* (RPN=63) and *Escherichia coli O157:H7* (RPN=60), as shown in Table A.2, A.3, A.4. Although lactic acid bacteria in yoghurt have inhibitory effect on pathogens like *Salmonella* spp. and *Listeria monocytogenes*, acid tolerant pathogens can survive in the yoghurt [65, 97]. Also using yoghurt which are not produced in modern facilities by officially approved suppliers (like families) may be unsafe [93]. Inefficient fermentation conditions like improper active starter cultures, fermentation temperature and time are the main cause of yoghurt spoilage [97]. In tarhana production it is important to supply yoghurt at low temperatures (2-3°C), with certificates and from manufacturers with production permit.

During milk fermentation of tarhana production processes, *Escherichia coli O157:H7* (RPN=60), *Yersinia enterocolitica, Staphylococcus aureus* and *Listeria monocytogenes* (RPN=63) would survive and this was shown as a potential failure in Table A.1 and A.5. Monitoring and controlling all the factors inhibiting the quality of milk fermentation has critical importance in tarhana productions.

Bacterial pathogens may contaminate the raw foods at any point of production system. Failure on washing and rinsing some types of vegetables is of major concern because they can cause survival of microorganisms on the surfaces of raw food material [75, 82, 98-101]. Inefficient washing of vegetables may cause survival of *Escherichia coli O157:H7* (RPN=90) and *Listeria monocytogenes*, and this is a potential hazard for tarhana production process as shown in Table A.1, A.3, A.4 (RPN=84). The contaminating bacteria can attach to inaccessible locations, incorporated into biofilms, or even internalized within the vegetable. This contamination can be mainly be a consequence of contaminated irrigation or spray make-up water, windblown dust from a nearby pasture or feedlot, insects or birds which are vectors of human pathogens. The moist environment and nutrient availability in the inaccessible sites of vegetables can also favour the formation of biofilms by bacteria. Bacteria in these locations escape contact with washing or sanitizing agents and can preclude the effectiveness of washing the vegetables [99]. Applying an efficient washing procedure may play important role in reducing microbial populations on vegetables. The procedure includes 3 steps; firstly washing with water, secondly with sanitizer and thirdly rinsing with water. Water used for washing and rinsing should be cool (preferably <5°C) and in efficient quantity. It is important to remove water from the product after washing and this may be done by centrifugation for appropriate duration at appropriate speed. Favorable results may be obtained in reducing microbial numbers and retarding enzymatic activity of the vegetables by using a chemical sanitizer. Hydrogen peroxide is a highly effective sanitizing agent. It is also generally recognized as safe for some food applications and produces no residue since it is decomposed by catalase [82, 98, 99, 102].

Water may induce pathogen microorganisms into the food process [42, 74-76, 98]. These pathogens in wash water can be *Salmonella thyphimurium, Escherichia coli*, *Vibrio cholera* (RPN=90), *Shigella* and *Aeromonas* (RPN=84). Washing vegetables, washing

wheat and soaking chickpeas in tarhana production are the critical points, as shown in Table A.1, A.2, A.3, and A.4.

Water used as ingredient in tarhana production may contaminate the tarhana with *Campylobacters, Arcobacter* spp., *Shigella* spp., *Aeromonas* and *Salmonella* spp. (RPN=84), *Salmonella thyphi, Shigella dysenteriae, Vibrio cholerae* (RPN=80), *Escherichia coli O157:H7*, as shown in Table A.5 (RPN=60). Infectious microorganisms may come to water from human or animal waste. Wells and other drinking water sources can be contaminated by storm water, run-off from roadways, farms and livestock operations, seepage of untreated sewage, or fomites [42, 74, 103]. Total coliform test is a good indicator on microbial count of water and it can be easily used by tarhana producer. Favorable results on water safety can be obtained by distillation of water with water treatment devices like distillers and reverse osmosis [103]. Additionally usage of water containers in order to avoid water cut and inefficient control and sanitisation of these tanks can cause contamination of the tanks and so tap water [57].

Improper conditions of drying can induce contamination of the process by *Escherichia coli* O157:H7*, Salmonella (RPN=80)* and *Staphylococcus aureus (RPN=60)* and this was shown as potential hazard for tarhana production process in Table A.1, A.2, A.3, A.4. In traditional Gediz, Uşak, and Beypazarı tarhana production processes, tarhana is dried by placing on platforms, in a room at approximately 10-25°C, for 1-5 days while simple sun drying is applied to Maraş tarhana. The risk of Maraş tarhana is the same with other traditional tarhanas even if it is dried outside because of its short drying period (8-10 h). Flies, rodents and cockroaches can be a vehicle of pathogen contamination in traditional drying techniques. Although flies are rarely the direct cause of disease, some pests are potential contributing factors to the spread of the pathogens that cause food-borne disease [81]. Clean, dry and closed area is necessary for drying tarhana to avoid growth of pathogens and access of environmental factors like pests. This can be achieved by extra applications such as zoning, and avoiding personnel entry into the drying area with outdoor shoes.

In industrial production process tarhana is dried in industrial driers which are working by steam and providing ventilation by airflow. Driers heat the tarhana first

progressively until the temperature to reach at about 80°C by using steam and then cooled by ventilation. This procedure takes approximately 6-9 h and the final moisture content of tarhana decreases to 7 %. Due to controlled drying; risk of *Escherichia coli* O157:H7, *Salmonella* (RPN=60) and *Staphylococcus aureus* (RPN=63) in industrial tarhana are lower than that of the traditional tarhana production methods. Although drying process reduces the level of contaminants, deficiencies in drying procedure like applying too short drying period, or low hygiene conditions can cause growth or recontamination of organisms [42]. Discolouration and poor rehydration performance may also arise as a result of incorrect drying procedure. Shorter residence time of drying is better for the rehydration quality of tarhana [33]. Process challenge test studies should be undertaken especially for the drying procedure of industrial tarhana. Prior to introduction of a new product, drying validation needs to be able to identify the conditions that will consistently produce a safe product. Monitoring and stabilizing drying time, temperature and final moisture content is critical for drying operations in tarhana productions [5, 104].

The pesticides are among the chemical hazards in the food systems. Not all the pesticides are safe for use in food production and even safe encountered pesticide residues would be harmful in high concentrations [39]. Foods contaminated with toxic pesticides are associated with severe effects on the human health [105]. Toxicity of pesticides on humans includes acute and long-term effects. Acute effects are functional and biochemical disorders in the central and peripheral nervous system. Chronic effects are chronic diseases, including cancer caused by long-term exposure to some pesticides [106]. Additionally certain pesticides may exert greater toxicity in the health of children and infants than adults in low-dose exposure. Pesticides originating from foods may find their way in milk and may pass to breastfed infants upon ingestion [107-108]. Therefore, pesticide risk in tarhana gain importance while it is mostly consumed by children, lactating mother, sick and/or old people in Turkey [30].

Pesticide residues on the vegetables are mainly the result of agricultural applications. In agriculture, pesticides are used to protect crops, improve their yield, and post harvest shelf life. However, after being released to the market, pesticides may remain on foods as pesticide residues [39, 109]. Presence of pesticide residues in buckwheat, rye and wheat were critical in the tarhana production processes, as shown in Table A.1, A.2, A.5 (RPN=

192). Grains are mostly stored in bulk silos around a year in post harvest period and released to the food industry and exports upon request. Grains may be treated with insecticides or fumigated in order to be protected them from pest manifestation during the storage period. Therefore the pesticide residues may be present in the outer parts of the grains [105, 110]. In tarhana production to avoid the pesticide risk, grains may be provided from storages which do not apply insecticides or fumigants. The pesticide risk resulting from the stored grains may be less in traditionally produced tarhana, because traditional tarhana is produced only in autumn and it is possible for the producers to use newly harvested grains. The pests are also problem during the storage of legumes and pesticide application on storage is also possible for legumes [111]. Therefore same measures as explained for grains should also be taken to avoid the risk of pesticide residue on chickpeas and lentils, as shown in Table A.1, A.5 (RPN=144). Processed cereals, durum clear flour and wheat flour, contain pesticide risk less than whole grains, as shown in Table A.1, A.3, A.4, A.5 (RPN= 144). Because pesticide residues are persistent on the outer shells of grains and their level decrease upon milling [105]. In general, handling of cereals, legumes and cereal products in tarhana production process have great importance. The supplier must always provide the documents certifying the pesticide residue levels of these food materials compared to specifications. The pesticide residue levels of received products should always be in the range of legal limits defined by Turkish Food Codex [112]. The methods that are used in most of food testing laboratories may analyse about 200 different residues at a time. These multi-residue methods make it possible to test many foods for several hundred residues at the same time and make the foods safer [109].

In the tarhana production, pesticides may come into the food also from the raw vegetables, onions, green peppers, red peppers, and tomatoes and this was shown as a potential failure in Table A.1, A.3, A.4, A.5 (RPN=144). Pesticide applications and residues on vegetables are shown by many studies [83, 113-115]. The pesticide application in the field should be done to assure safe ingredients and must be controlled at the national level [116]. There are estimated acceptable daily intakes (ADIs), acute reference doses, maximum, median and highest residue levels for the estimation of the dietary intake of pesticide residues, set through expert toxicological studies [39, 117]. In order to prevent excessive residue levels in the vegetables, farmers should be trained on pesticide applications and ideally pesticide should be applied under the supervision of agricultural

engineers in the field. Quality equipment should be used for the pesticide application and the working condition of the equipment should be regularly checked. [116]. Tarhana producers should ask for the certificates of the vegetables and review them carefully.

Washing procedures may have efficient role in removal of the pesticide residues from the contaminated foods [105, 118, 119]. Therefore inefficient washing of vegetables and wheat were determined as a potential failure in Table A.1, A.2, A.3, A.4 (RPN=144-72) in different tarhana production processes. Washing vegetables properly by acetic acid solution may improve reducing the pesticide content. Washing vegetables in water tanks agitated with compressed air, followed by rinsing with high-pressure water sprays may also contribute to minimising pesticide residues [119]. Besides the actions taken, some processes in tarhana production chain such as fermentation, milling, peeling vegetables, washing may decrease the pesticide residue and have a sanitary impact on tarhana [105].

Animals can take pesticides mostly from the environment and animal feeds. However some kind pesticides tend to accumulate in fatty animal tissues or in milk and this causes occurrence of high concentrations of pesticides in milk [65, 120, 121]. Therefore receiving milk with high pesticide residue is a risk in tarhana production processes, as shown in Table A.1 and A.5 (RPN=144). Effective monitoring of the pesticide levels in animal feed by the dairy producers is very important to manage the risk [65]. Tarhana producers should monitor the certificates of milk and dairy suppliers.

Yoghurt used in tarhana production may also contain pesticides and this is determined as a potential failure in Table A.2, A.3, and A.4 (RPN=80). Yoghurt should be supplied from manufacturers with food production permit. Their certificates should report the pesticide content of yoghurt indicating comparison with the upper approved standards.

Water used as ingredient in industrial tarhana production may contain pesticide and this is determined as a potential failure in Table A.5 (RPN=56). As some pesticides are no longer used but may still survive in the environment [106, 109]. Surface water runoff, snow and rain can carry these pesticides from the agricultural field, reservoirs, lakes and underground drinking water supplies [105, 122]. Water used in tarhana production should

be tested periodically for pesticide residue and supplied from public system as water is regularly monitored by municipalities to comply with the safety standards.

Virus contamination of food is a biological hazard. A relatively small number of different viruses like Norwalk-like virus (NLV), rotavirus, astrovirus and other viruses have been frequently associated with food poisonings. NLV and hepatitis A virus are the most common cause of illness by food transmission through virus [42]. The main symptoms of viral gastroenteritis are watery diarrhoea and vomiting. The affected person may also have headache, fever, and stomach ache [123]. Rotavirus mostly effects children and its main transmission way is faecal-oral [74, 124]. The NLVs cause outbreaks of gastroenteritis and are transmitted primarily through the fecal-oral route [125]. Hepatitis A is a contagious liver disease and occurs due to the Hepatitis A virus infection. Hepatitis A begins with symptoms such as fever, anorexia, nausea, vomiting, diarrhea, myalgia, and malaise. For most persons, hepatitis A lasts for several weeks. Persons with chronic liver disease can even have risk of death [126]. Hepatitis A is usually spread when a person ingests fecal matter, even in microscopic amounts, by contact with objects, food, or drinks contaminated by the faeces or stool of an infected person [127]. The hepatitis E virus causes hepatitis E which is a serious liver disease. The outbreaks are usually associated with contaminated water supply in countries with poor sanitation [128].

Food can be contaminated with virus mostly because of infected food handlers and/ or failures on personal hygiene [125-127]. These viruses are mostly rotavirus, hepatitis A (RPN=160) and NLV (RPN=80). In tarhana production process, the procedures susceptible to these organisms are like removing the tarhana and spreading them on mats, spreading the dough on sieve trays, kneading tarhana during fermentation, dividing dough, chopping vegetables and packaging and these are shown in Table A.1, A.2, A.3, A.4, and A.5. These viruses are transmitted by faecal oral route. Faecal material can come into contact with food by infected persons during manual handling in combination with minimal processing of foods afterward [42, 126]. The introduction of viruses into the food process needs to be prevented by stringent hygienic control. Increasing the awareness of all food handlers about transmission of viruses is needed. Availability of appropriate facilities including hand basins, bactericidal soaps, and adequate toilet facilities are big help in operating good hygienic practice. It is also critical to disinfect table ledges, door handlers, overhead pipes

and many other areas by cleaners including concentrations of ammonium and/or HCl which are effective in inactivating viruses like hepatitis A. In tarhana production most favorable would be minimising hands-on operations and also offering Hepatitis A vaccination for all the food handlers [42, 126].

Vegetables received in tarhana production should be free of hepatitis A contamination which is sourced from poor agricultural applications. Hepatitis A contaminated dry onions is a high potential risk in tarhana production, as shown in Table A.1, A.3, A.4, and A.5 (RPN=160). There are many reported hepatitis A outbreaks associated with consumption of fresh green onions [126, 129]. Hepatitis A contamination can also be risk for receiving tomato, as shown in Table A.1, A.3 (RPN=112). The presence of children in agricultural fields increases the potential for contamination of food during harvesting or processing since children are important source of hepatitis A. Factors contributing the contamination of vegetables may include unsanitary agricultural applications like contamination of sewage and using fecally contaminated water [126]. Upon the delivery it is necessary to do not supply soiled vegetables in reducing the risk of faecal contamination.

Hepatitis A virus is resistant to some organic solvents and low pH [126]. Therefore hepatitis A can remain on vegetables due to inefficient washing and this is determined as a potential failure in Table A.2, A.3, A.4 (RPN=112). Disinfection methods like chlorinated water are effective in reducing and eliminating hepatitis A from vegetables. It is determined that disinfecting foods with 1:100 dilution of household bleach and water rinsing alone also reduces the amount of Hepatitis A [126].

When water is used just as an ingredient or for soaking the chickpeas in tarhana production, water may induce viruses like hepatitis A, rotavirus (RPN=180), NLV and hepatitis E (RPN=126) into food and this is shown as risk for tarhana production in Table A.1 and A.4. The indicators for water quality are insufficient as predictors of viral contamination and this makes water a potential risk. Water should be supplied from public water system because water treatment processes of municipal water systems are possibly sufficient to make hepatitis A non-infectious. However using water filtrates in the production area is also favorable [42, 126].

It is likely for viruses, especially rotaviruses and hepatitis A to survive during fermentation of foods and this is indicated as a potential hazard in Table A.1, A.2, A.3, A.4, A.5 (RPN=80). Rotavirus and hepatitis A are highly resistant to acidic conditions and may be able to survive over pH range of 3.0 to 9.0 [126]. Disinfection of fermentation tanks gains importance due to hepatitis A contamination risk. Providing efficient acidification on fermentation is also important for contributing the inhibition of hepatitis A.

Dioxins are chemicals with toxic potential and can be found in yoghurt and milk used in tarhana production process, as shown in Table A.1, A.2, A.3, A.4, A.5 (RPN= 144). Dioxins are released into the air from combustion processes, such as commercial or municipal waste incineration, burning fuels, industrial processes or natural processes like volcanic eruptions. Soil can be polluted by dioxin due to atmospheric deposition, sewage sludge, erosion etc. They are found throughout the world in the environment. Exposure to dioxins may result in a variety of adverse health effects like carcinogenesis. Dioxins find their way into the food chain via air or water once they are released into the environment. They accumulate in the fat tissue of animals where their estimated half life is approximately seven years. They can be absorbed by free-range grazing animals like sheep and cattle via dust deposits on vegetables, and natural animal feed [130-133]. Dioxin can be found in the fatty products like milk and yoghurt produced by animals [65, 132-135]. Dioxin concentration of these food products need to be under the legal limits determined by Turkish Food Codex [58]. The routine dioxin test on the animal feed and milk should be made by the dairy producer. Tarhana producer must be aware of this component and its hazards and carefully monitor the analysis results of the yoghurt and milk in this way.

Human zoonitic parasites in foods are of major concern since they are responsible from diseases like giardiasis, cryptosporidiosis, blastocystis, toxoplasmosis and microsporidiosis . Zoonotic parasitic diseases are transmitted from animals to humans. They can transmit to humans by ingesting environmentally robust transmissive stages, spores, cysts, oocysts, ova, larval and encysted stages, and humans can be final, intermediate, paratenic or accidental hosts. While the transmissive stages of some of these zoonoses can be transmitted directly, they can also be transmitted through contaminated water and food [136]. *Cryptosporidium* is a genus of protozoa and may cause a diarrheal

disease, cryptosporidiosis, which has symptoms like diarhea. Immunocompromised persons may develop more serious and even fatal illnesses [74, 137]. The genus giardia consists of five species and *Giardia duedonalis* [also known as *Giardia lamblia* or *Giardia intestinalis*) type parasites [42]. Giardia infection can cause a variety of intestinal signs or symptoms [138]. *Blastocystis hominis* is a common microscopic parasitic organism and its infection is called blastocystosis which is a common infection with symptoms like watery or loose stools, diarrhea, as many people have no symptoms at all [139]. *Toxoplasma gondii* is a coccidian and its infection often do not have symptoms in healthy people while it can have serous effects on immune compromised persons [43, 140]. *Microsporida* parasite causes microsporidiosis which has symptoms like diarrhoea and effect mostly immunocompromised persons [141].

Fermentation alone without applications like heating can be insufficient to prevent the transmission of many food-borne parasites [5]. That is why survival of *Cryptosporidium* and *Giardia lamblia* during Maraş tarhana fermentation is determined as a potential hazard in Table A.2 (RPN=140). This risk is less potential for the other tarhana fermentations, as shown in Table A.1, A.3, A.4, and A.5 (RPN=105). Because Maraş tarhana is fermented in a very short time and it may be consumed as a snack without any heating application while other tarhanas are consumed only in the soup form. The main source of parasites in fermentation is the use of raw ingredients [42]. Therefore efficient handling of raw foods like; pasteurisation of raw milk, sanitisation of vegetables are important to avoid this risk. Use of industrial driers which contains heating of tarhana (80°C) can eliminate the active parasites in industrial tarhana production process. It can be considered that a fully fermented traditional tarhana is unlikely to contain viable parasites. Maintaining efficient acidity levels in tarhana fermentation would also lower the risk in the final product.

Parasites can come into tarhana with vegetables contaminated with parasites (RPN=64). Potential parasites in onions, tomatos, dill, mint, green and red peppers are Protozoa- *Cryptosporidium parvum, Giardia duodenalis, Toxoplasma gondii, Blastocystis hominis,* Nematodes- *Toxocara canis, Toxascaris leonina, Toxocara cati, Lagochilascaris minor*, Pentastomids-*Armillifer armillatus* and these are indicated as potential hazard in Table A.1, A.3, A.4, A.5. Vegetables can be irrigated by poor agricultural applications

like; using animal manure, and wastewater, pasturing infected livestock near crops and direct contamination of foods contaminated with faeces transmitted by birds and insects, aerosolisation of contaminated water used for pesticide sprays and mists [42, 74, 136]. Special attention should be given supply vegetables which had grown under good agricultural practices. Avoiding delivery of soiled or dirty vegetables would also be good in minimising parasite risk.

Parasites which can be transmitted by water into the food process are Microspora- *Enterocytozooan bieneusi, Encephalitozoon cuniculi,* and Protozoa- *Cryptosporidium parvum, Giardia duodenalis, Toxoplasma gondii, Blastocystis hominis* Pentastomids- *Armillifer armillatus* [43, 136]. Contamination can also occur when foods are processed with potable water. Therefore receiving water, soaking chickpeas, washing wheat and vegetables are critical stages for tarhana production processes, as shown in Table A.1, A.2, A.3, A.4 and A.5 (RPN=64). Deficient agricultural practices like spread of farmyard manure, and slurry, pasturing of livestock in land adjoining water sources can contaminate the water by parasites. That is why periodical testing the parasite content of water has great importance in the tarhana production. A special filter system constructed for filtration of the water would be useful to reduce the parasite risk [136].

Dirty equipment surfaces can also be a source of food parasites [136]. The transmission route of parasites, mainly *Cryptosporidium parvum* may come from the equipment like chopping boards and knifes used in tarhana production process, as shown in Table A.1 (RPN=63). Efficient sanitisation of these equipments is important for safety of tarhana production process.

Transfer of parasites by food handlers, in particular from hands, is a potential failure in food productions [136]. Hands are potential transmission route of Protozoa- *Cryptosporidium parvum, Giardia duodenalis* and *Blastocystis hominis*. The stages containing parasite risk due to personal handling are kneading the tarhana dough during fermentation, spreading the wet tarhana on mats and removing them from mats, spreading the wet tarhana dough on sieve trays by hand, cutting the base of onions, dividing the tarhana dough and removing inedible parts of vegetables, as shown in Table A.1, A.2, A.3, A.4 and A.5 (RPN=64). Direct contamination of food by faecal materials of infected food

handlers causes the contamination of food. Parasite infections in people are mainly results of zoonotic transmission like contact with infected farm animals [43]. Only maintaining effective personal hygiene would prevent this risk from tarhana production.

Cryptosporidium spp. and *Giardia* spp. were the major parasites which are possible to be found in the raw milk (RPN=56). The parasites can be transmitted into milk with faeces of infected animal during milking [65]. It must take into account whether milk was collected daily, not mixed with the previously collected and stored milks, immediately cooled to ≤8°C after milking and transferred in chill chain by the manufacturer. When accepting the milk for tarhana production, its temperature should be measured by a probe thermometer and milk must be rejected if its temperature is over 6°C.

Mold and fungi found in food are considered as a biological hazard. Although molds are usually inhibited by some tarhana processing techniques such as oven drying and milling, special care also should be taken at production stages which are susceptible to growth of mold, fungi and yeasts [86, 142]. Molds are microscopic fungi and live on plant or animal matter [143]. Mold in food is often considered as a natural or unavoidable defect [81]. Apart from producing mycotoxins, some molds can cause allergic reactions and respiratory problems [143].

In tarhana production, mold coming from machinery was taken as a high risk for all stages and indicated in Table A.1, A.3, A.4, A.5 (RPN=135). These stages in different tarhana productions are milling ingredients, milling and cracking wheat, milling chickpeas, onion, and tarhana, mixing ingredients, mixing the dough, sieving tarhana and milled chickpeas, transferring the wet and dried tarhana, dough, and mixture. Machinery mold, *Geotrichum candidum*, is not a natural or unavoidable defect because it is found on dirty food processing equipment. Contamination with machinery mold is recognized as a true indication of insanitation [81]. *Geotrichum candidum* may cause geotrichosis disease which has effects like bronchial, oral, vaginal, cutaneous and alimentary infections, and pulmonary involvement [81, 144]. Therefore application of good equipment cleaning procedures on the instruments is important in tarhana productions to avoid the risk of the *Geotrichum candidum* growth.

Receiving onion with rot disease and storage of onion is a potential failure in tarhana production due to mold contamination risk, as shown in Table A.1, A.3, A.4 and A.5 (RPN=70). Usage of other diseased vegetables, tomato, green and red pepper is also undesired in tarhana productions and indicated as a risk in Table A.1, A.3 and A.4 (RPN=50). Molds are commonly isolated from a wide variety of decaying vegetable materials. Among the molds associated with vegetable spoilage, *Botrytis, Alternaria, Aspergillus, Geothrichum* are the most common [145]. Black mold of onion is caused by the fungus *Aspergillus niger* and is primarily a postharvest disorder which can increase under inconvenient storage conditions such as high temperature and humidity [146]. Species of *Alternaria* cause dry and soft black rots of a range of commercially important crops, fruits and vegetables. The most common species of *Alternaria*, *Alternaria alternata,* can produce a number of toxic metabolites. It is unlikely *Alternaria* toxins to have any significance for human health from fermented foods. However there is no information about the effects of food processing on the survival of *Alternaria* toxins into fermented foods [5]. Culling out by manual selection the wounded, bruised and soiled onion bulbs, contaminated, damaged and discoloured vegetables received in tarhana processes would contribute in minimising mold growth. Storing onions in low temperatures (0°C) would also be favorable [145]. Mold and yeast growth can also be found in tomato and red pepper paste received in tarhana production, as shown in Table A.5 (RPN≤50). There are studies that *Alternaria* toxins are detected in tomato products [5]. This is resulted from the insufficient care which has been taken by the tomato paste manufacturer who should maintain the equipment in a clean condition or reject, sort, and trim moldy raw material [83]. Yeast growth is rarely involved in spoilage of canned foods due to their extreme heat-sensitivity [41]. Therefore receiving tomato and red pepper paste was not determined as critical stages in tarhana production, but if the tomato paste is stored after opening the tin it may be a pattern.

While yoghurt can inhibit the growth of bacteria due to its acidity, mold and yeast can survive in high acidity and cause deterioration of the yoghurt which is received in Tarhana production processes, so mold and yeast grown in yoghurt are indicated as risk in Table A.1, A.2 and A.3 (RPN=60). Also according to some studies, yoghurt with mold and yeast counts over the limits of Turkish standards common in Turkey [93]. Therefore it is important yoghurt to be used in the tarhana production to be a manufactured with

production permit (not homemade). Its receipt should be accompanied with certificates of quality control which should report the mold count of yoghurt, and its comparison with the upper approved standards. Yoghurt should be transported at low temperatures (2-3°C).

Chickpeas used in tarhana production and their storage can contain mold contamination risk which is indicated in Table A.1 and A.5 (RPN=70). Chickpeas can have mold growth due to poor storage conditions as mentioned before [111]. Wheat flour, buckwheat semolina and durum clear flour used in tarhana production and storage of wheat flour, buckwheat semolina, durum clear flour, rye and buckwheat can pose contamination risk with mold and fungi, as shown in Table A.1, A.2, A.3, A.4, A.5 (RPN=56). Wheat flour can have large amount of mold spores due to the inappropriate storage conditions and careless handling operations [86, 87, 142]. Receiving rye, wheat, and buckwheat and storing rye can lead to the risk of fungi growth in tarhana production, as shown in Table A.2 and A.5 (RPN≤50). A fungus *Claviceps purpurea* cause a disease of rye which is called as ergot disease and produce natural toxic alkaloids. These toxins cause serious poisoning on the people who ate the infected grains. This type of poisonings can lead to psychotic delusions, nervous spasms, abortion, convulsions, gangrene, and even death [147, 148]. The accurate control of grain and grain products upon receiving has great importance to avoid the transfer of mold species into the food process. Certificate of the products needs to report their mold count and moisture content compared to the upper-approved standards. Beside visual control, the moisture content of grains and grain products needs to be checked upon their delivery and during storage by grain moisture tester. Newly harvested grains would have less mold contamination risk. Therefore tarhana manufacturer should have information about post harvest applications of the grains such as their storage duration and condition [89]. While grains are going to be stored before usage in the tarhana production, cleaning the dirt of grains and the store is necessary. The store may be fumigated before storage. For the long term storage to mixing the grains with non-toxic chemicals like vegetable oil would also reduce the attachment of the pests on grain surface and avoid pest multiplication and so minimise the mold growth [111]. During storage period temperature, humidity, pest situation in the environment should be recorded and corrective actions should be taken when deviations are observed. Reducing moisture in the environment by regular aeration can be used to avoid mold growth. It is also preferred to store the grains for short periods [89, 111, 149-151].

Veterinary drug residues found in animal derived foods can be risk in food processing [152]. Raw milk used in tarhana productions may contain drug residue (RPN=128) and this is indicated as a risk in Table A.1 and A.5. Animals are regularly examined by veterinarians and antibiotics are given if an animal is unhealthy. Inappropriate applications of dairy producers, like milk collection in the first 70 h of antibiotic intake, could lead in increasing level of antibiotic residue in the milk of lactating animal [95, 152]. Veterinary drug residues are unhealthy for human and they can have a number of possible adverse health effects like allergic reactions and reduced bacteria in intestine. Prolonged exposure to veterinary antibiotics can also lead to chronic toxic effects, and antibiotic resistance [152]. Although drug residue concentration may decrease by some tarhana preparation and processing techniques such as heating and fermentation, special care should be taken at handling of the raw milk to minimise the risk of veterinary drug residuals [153, 154]. Antibiotic residues come into the tarhana production may inhibit the microorganisms and cause inefficient fermentation of tarhana [153]. The dairy supplier must provide the documents certifying the safety of yoghurt and milk. The certificates should report the drug residue content of yoghurt and milk, comparison with the upper approved standards. The laboratory analysis should be carried out when necessary.

Mycotoxins are toxins which are produced as secondary metabolites by commonly occurring fungi growing in foods and feeds. The most important mycotoxins are aflatoxins, ochratoxin A, fumonisins, trichothecenes and zearalenone which are appear to have no role in the normal metabolism involving growth of the fungus [155]. Aflatoxins are produced by a small number species of *Aspergillus* like *Aspergillus flavus*, and *Aspergillus parasiticus*. [42]. Mycotoxins can cause variety of harmful effects on humans and diverse symptoms. In acute poisoning of mycotoxin, deterioration of liver or kidney function and even death may occur. In prolonged exposure they can have effect on induction of cancer or mutagenic effects by effecting DNA replication. While some symptoms show few symptoms some others may elicit severe symptoms like skin necrosis, leucopenia and immunosuppression [155]. Aflatoxins are classified as Group 1 carcinogens while deoxynilvalenol classsifed as Group 3 by the International Agency for Research on Cancer [156, 157]. Ochratoxin A is also a probable carcinogen, and may have harmful effects like immunosuppression, embryonic, and kidney damage [155]. Mycotoxins may mainly come in to the tarhana production process by ingredients such as; buckwheat, buckwheat

semolina, durum clear flour, wheat, and wheat flour which are shown in Table A.1, A.2, A.3, A.4, A.5 (RPN=128). Wheat is one of the major foods in Turkey with aflatoxin problem [158]. Mycotoxins normally contaminate crops at the growing or storage periods. During the growth period of environmental conditions like insect damage, drought, and climatic conditions may increase the mycotoxin contamination risk. Poor storage conditions like moisture and humidity may also increase the mold growth and contamination of mycotoxins [39, 87, 159]. Mycotoxins may come into the tarhana production process also by chickpeas and lentils which may have high mycotoxin content and this risk is indicated in Table A.1 and A.5 (RPN=96). The chickpeas entering into storage after harvest carry 'field' and 'storage' fungi. Pests like Bruchids bettle, can increase the growth of these fungi by producing additional moisture and heat in the environment respiration. Aflatoxin may increase in chickpea seeds during prolonged storage periods by the growth of these fungi while some types of lentils were also reported to be susceptible to *Aspergillus flavus* [111, 149, 160]. Visual control of the grains by tarhana producers would be useful to detect high humidity, undesirable odours and defective grains which may be indicators of aflatoxins. It is needed to detect moisture content of grains by a grain moisture tester upon delivery at the production site. It is favourable to supply newly harvested grains which are stored not more than 3 months. Washing grains prior to processing with distilled water or sodium carbonate solution may help to minimise the failure arising from mycotoxin. Removal of the defective grains is preferred for reducing mycotoxin content and can be done by physical methods like density, air blowing, specific gravity tables and dry cleaning [89, 111, 150, 151, 160, 161]. The tarhana producers may get information on the new sources of mycotoxins and their preventive actions from related governmental bodies or news/ journals etc. [42].

Mycotoxin contamination may also occur because of the raw vegetables, used in tarhana production. Receiving tomatoes is a critical stage (RPN=128), as showed in Table A.1 and A.3. Red pepper is susceptible to aflatoxin contamination depending on its storage conditions like humidity and atmospheric temperature, so mycotoxin was also determined as a risk in Table A.3 and A.4 [163]. The spores of mold contaminate the pollens of red pepper flowers, take their position and grow in the peppers. Therefore mycotoxins may be found inside the red peppers even through the outside of the peppers seem healthy [164]. Mycotoxins may also be found in the red pepper and tomato paste and they were indicated

as risk in Table A.5 (RPN=64). Tomato and tomato products have also been considered as a likely source of aflatoxins due to *Alternaria* molds which are commonly found in spoiled tomatoes [165]. In tarhana production process, the moldy, damaged, discoloured vegetables must be removed physically by manual selection upon the delivery. Supplying only newly harvested vegetables may help to minimise the failure arising from mycotoxins [5].

Some processes employed in production chain of tarhana, such as fermentation, milling, and washing the grains may minimize the residues and may have sanitary impact on tarhana [151, 156, 161, 162]. Although these processes in food production chain are expected to reduce the mycotoxin content, there are recommended actions to take for reducing the mycotoxin risk in tarhana [89, 111, 150, 151, 161]. In order to control mycotoxins in the food processing, risk associated with each raw material should be understood [39]. In tarhana production process it is preferred to supply the ingredients from suppliers who maintain integrated management programme to avoid aflatoxin contamination at the field and storage environment. Tarhana producers need to see the quality certificates of ingredients reporting the mycotoxin and moisture content and insect and fungi colony counts. Mycotoxin content of the ingredients should be in the range of mycotoxin safety limits [58, 157].

Drying of tarhana may help to minimise mycotoxins by reducing the water activity of the product and inhibiting the mold growth. However poor drying may result in colonisation of mycotoxigenic molds and increase the mycotoxins [42]. Therefore drying tarhana in tarhana production processes is regarded as a critical stage, as showed in Table A.1, A.2, A.3, A.4 (RPN= 112). In tarhana production, drying temperature and humidity should be optimised and monitored periodically. It is also necessary that the drying area should be free of insect pests, moldy material and dust [42, 166]. Avoiding personnel access into the drying area with outdoor shoes would even minimise the dust and mold entry into the drying processes.

In terms of mycotoxin risk, poor storage of chickpea, rye and buckwheat would be a potential failure in tarhana production, as showed in Table A.5 (RPN=112). High moisture and heat in the storage environment may result from respiration of microorganisms and

grains, and causes further mold and so mycotoxin production [111, 166]. Therefore good storage conditions should be maintained in tarhana production to avoid the mold growth [5, 111, 150, 151].

Mycotoxin contamination due to contaminated raw milk was also regarded as one of the potential failures in the tarhana production processes, as showed in Table A.1 and A.5 (RPN= 72). Because of that the milk is susceptible to aflatoxins such as aflatoxin B1 and B2 which may be ingested by animals with aflatoxin contaminated feed, and their metabolites, aflatoxin M1 and M2, can be excreted into the milk. These metabolites are less harmful than their precursors, so in our study the severity of milk contamination in Tarhana was assigned low rank [5, 39, 155]. In tarhana production process, milk must come from approved suppliers who have facilities to control the mycotoxin content of animal feed and its products. It is also necessary certificates of the milk should report its aflatoxin content.

Survival of aflatoxins is a risk during fermentation [5]. Poor fermentation of tarhana and milk may have this risk, as showed in Table A.1, A.2, A.3, A.4 and A.5 (RPN≤50). Providing appropriate fermentation conditions are important for protecting the food from such contaminations.

Foreign materials in a product should be considered as a hazard even if it is not directly harmful to the people [39]. While visible contaminants are objectionable to consumers, objects like intrinsic components of ingredients e.g., bones, food boluses, may be ingested and can cause choking and gag reflex in humans. Hard or sharp foreign objects in tarhana may cause more traumatic injuries like laceration and perforation of tissues of the mouth, tongue, throat, stomach, intestine and damage of teeth and gums [167].

Metal pieces may come into the product during production and may cause injuries or choking [29, 89, 167, 168]. Metal pieces and machinery parts may come into the product due to usage of old or expired equipment mostly during sieving tarhana, wheat flour, milled chickpeas and rye and they were indicated as risk in Table A.1, A.3, A.4, A.5 (RPN= 84). Metal pieces may also come from old equipment during milling tarhana, and ingredients, and cracking wheat, milling chickpeas and onions and mixing the dough,

mixing tomato and red pepper paste, multiplying the yeast, peeling the top layer of onions, receiving buckwheat semolina, and durum clear flour, mixing ingredients, receiving wheat flour, mixing and kneading, as shown in Table A.1, A.2, A.3, A.4 and A.5 (RPN≤50). Metal pieces may also come into the tarhana with processed grains like buckwheat semolina, durum clear flour, and wheat flour (RPN≤50). Metal contamination of processed grains may occur during post harvest applications like milling. For example, a metal bolt falling into a mill can cause serious damage to the grinding surfaces and metal filings from worn parts may contaminate the processed grain [69]. Metal swarf may also fall into the tarhana with tomato and red pepper paste and it was indicated as potential hazard in Table A.5 (RPN≤50) [39]. Using metal detectors is critical for avoiding the presence of metals in the final product. Detectors should be carefully chosen and calibrated efficiently to pick up the smallest metal pieces. The moving parts of equipment require a daily check and broken or loosened parts needs to be changed directly [29, 39, 69].

Pebbles may be found in the product and cause injury of the consumers [111, 169-171]. Pebbles may come into tarhana production process mostly by grains like chickpeas, lentil, rye, buckwheat and wheat and pellets shown as a potential failure in Table A.1, A.2 and A.5 (RPN=80). Insufficient cleaning of wheat may also cause remaining of the pebbles, as indicated in Table A.2 (RPN≤50). Shale, coal, hard earth pellets and fertiliser pellets are almost likely to originate in raw materials of plant origin. They may come within the plant, between leaves or be picked up during harvesting [39, 169, 170]. They may cause the consumer dental damage, choking, cuts to consumer's mouth and more serious consequences if swallowed [39]. Ingredients should not be accepted if they are dirty. Washing them and drilling out by manual selection may contribute to minimise the presence of pebbles.

Pests may be physical hazard as their presence in foodstuffs may cause injury or choking [39]. Additionally ingestion of larvae, body fragments of beetles may possibly cause illness and allergy on the consumers [81]. Pests may come in to the process mostly by ingredients like buckwheat, rye, chickpeas, lentil, wheat and their storage processes (RPN=84). A group of insects and mites are known as stored-product pest and they exhibit a form of commensalism known as inquilinism, or sharing of another species' home or nest for the specific purpose of stealing the host terms [81]. Storage pests may be found in the

raw material which is stored for long terms [111, 172, 173]. The grains received in tarhana production should be inspected visually for the existence of the pests. Storage period of the grains should be minimised. Old grains from previous storage period should not be supplied. Moisture, temperature and humidity of the storage environment should be monitored and stabilised. Periodic visits of the store facility should be scheduled for any pest situation. Store should be cleaned periodically. Before storage, seeds should be mixed with non-toxic chemicals such as vegetable oil which pests to attach on the surface of grain.

Foreign materials like hairs, feather, false finger nails, button, aprons, glove pieces, and jewellery may be found in foods due to personal negligence [167]. Presence of these personal items is considered as a potential hazard in personnel handling procedures of tarhana production during; chopping vegetables, dividing the dough, packaging, spreading the dough on sieve trays, transferring the wet and dried tarhana and dough by carriages, spacing the sieve trays on carriages of drier and kneading the fermented tarhana by hands, as shown in Table A.1, A.2, A.3, A.4, A.5 (RPN≤50). Foreign objects including personal items are source of careless employee practices [174]. Handlers in tarhana production areas should be instructed about physical hazards which may come to the process by personal failures. Lighting at the production process should be sufficient and the temperature of the environment where food handlers are working should be efficient to avoid the personnel failures and stargazing.

Foreign objects may also come into the foods due to material degradation and defects of water pipeline [175, 176]. These objects may transfer into the food when contaminated water is used as an ingredient and also in the stages like soaking, washing wheat and vegetables, and boiling wheat and they are indicated as hazard in Table A.1, A.2, A.3, A.4 and A.5 (RPN≤50). Therefore water pipelines and associated equipment of the production area should be monitored periodically.

The presence of wild plants (specks of *Lolium perenne, Vicia sativa L.*) in wheat may bring risk to production (RPN≤50). The presence of specks of plants may affect the cereal badly, because they may contain temperature resistant toxic substance (saponin). The specks of *Lolium perenne* are hazardous due to their toxic substances (temulin) with

narcotic effect. The specks of the *Vicia sativa L*. may cause black spots on cereal. All these extraneous materials should be excluded from wheat before grinding [89].

Foreign objects found in milk like leucocytes, animal hair etc. are undesired foreign objects [65]. They may come in to tarhana during inefficient handling and filtering of milk and indicated as physical hazard in Table A.1, A.5 (RPN≤50). Foreign materials like soil, sand, egg and larve of insects, insects and filth may also be physical hazards [83, 87, 89, 142, 146, 168, 177]. These materials may be found in many stages of tarhana production process, as shown in Table A.1, A.2, A.3, A.4 and A.5 (RPN≤50). Filth includes "rat, mouse or other animal hairs and excreta, whole insects, insect parts and excreta, parasitic worms, pollution from the excrement of humans and animals, as well as other extraneous materials which, because of their repulsiveness, would not knowingly be eaten or used. Public tolerance of visible insect filth is generally low [81]. Therefore the number of these materials in the process should be eliminated as much as possible.

Disinfectant and detergent residues used for the cleaning of instruments were determined as a potential failure in the different tarhana production processes, as shown in Table A.1, A.2, A.3, A.4, A.5 (RPN=60). The detergent residues would contaminate tarhana during; boiling of milk and wheat, fermentation of milk and tarhana, yeast multiplication (mixing water, wheat flour and yeast), spreading the dough onto trays, transferring tarhana and mixing ingredients. Sometimes trace levels of disinfectant residues may be inevitable on the surfaces of equipment. The disinfectant residues may transfer into the foods when they remain on equipment or if they splash into the food during the cleaning of adjacent items [39, 178, 179]. The side effects of detergent residues during intake by the humans would be acute and chronic toxicity, irritation, carcinogenicity and neurotoxicity [178]. Presence of detergent residues risk is higher in the industrial tarhana production process when compared with the others. Therefore the cleaning procedures are very important in the tarhana production processes. Adequate rinsing, using non-toxic, rinsable and biodegradable chemicals as disinfectants, training personnel, inspecting the detergent residues after the cleaning and convenient equipment design will minimise the detergent contamination risk. Validation of cleaning procedures in tarhana production processes would be also preferable [39, 180].

Presence of chlorine residual is undesirable in food [181, 182]. However chlorine residue risk may be found in the washing vegetable stage in tarhana production as shown in Table A.1, A.3, A.4 since the washing water is chlorinated and the chlorine level may exceed the permitted level (RPN=60). If the chlorine level of public water is high, the tap water used in tarhana production may transfer chlorine into the product, and this is indicated as a risk in Table A.5 (RPN=60). The most common method of disinfection of municipal water is through the addition of chlorine. The chlorine is destroyed, in the process but there will still be some residue left in the water which is called free chlorine. Chlorinated water is also used as a common sanitation method for washing vegetables by the food processors [181, 182]. Chlorine residue may be risk for human health in the case of long term intake. Long term consumption of chlorinated drinking water was found to be associated with bladder cancer. Therefore it is important to use less harmful sanitizers then chlorinated water for washing the vegetables. If chlorinated water is used for sanitising vegetables, the proportion of chlorine in the wash water and its contact time with the food should be arranged well and the sanitized vegetables should be rinsed efficiently [183].

Presence of prohibited plant growth regulators or plant hormones over the legal limits in vegetables is of concern since they have carcinogenic effects on human health [121, 184]. Tomato, red and green peppers used in tarhana production contain the hormon risk, as shown in Table A.1, A.3, A.4 and A.5 (RPN=60). Plants synthesize a diverse array of plant hormones which are biologically active within the plant and influence physiological processes such as growth, differentiation, and development. Some synthetic forms of plant hormones are used in agriculture and named as plant growth regulators [184-186]. However usage of some plant growth regulators is limited or prohibited due to the carcinogenic effect of their components or themselves [39, 187]. If its use is necessary, farmers should use only registered and in permitted amounts only. While the proportion of vegetables is high in tarhana, plant growth hormone quantities in vegetables should be monitored and certificated [184].

Some plasticizers and plastic additives may migrate into the foods [39] Migration of bisphenol A, a low molecular weight substance migrating from the packaging material into the foods is of major concern since its toxic effects on humans, so it is determined in Table A.1, A.2, A.3, A.4, A.5 that bisphenol A may be a risk for tarhana production process

(RPN=54). Bisphenol A is an industrial chemical used to make polycarbonate plastics which are used in food packages. If the packaging material is not safe for contact with foods, then possible low molecular weight substances like bisphenol A may migrate into the food from the packaging material and this can have harmful effects on human. Bisphenol A has reported to effect brain, and prostate grand in fetuses, infants, and children [89, 188]. While tarhana is used mostly to feed children due to its nutritious effect and this group is highly susceptible to the effects of biosphenol A, the safety of packaging material used for sealing tarhana should be important for the tarhana producer.

Toxins and allergens, maintained from the body fluids or tissues of some insects and pests may go into tarhana with ingredients like buckwheat, wheat, buckwheat semolina, rye, durum clear flour, wheat flour and during the production stages like storing rye, buckwheat, durum clear flour, and buckwheat semolina, drying tarhana, and holding the tarhana dough at room temperature, as shown in Table A.1, A.2, A.3, A.4, A.5 (RPN≤50). Some of commensal pests like cockroaches, flies, ants, rats, and mice, adventive pests, birds, bats, lizards, spiders, nuisance flies, mites and other pests are indicators of insanitation [81]. Some of them known as storage pests may be found in the raw material like wheat, buckwheat, rye, chickpea stored for long durations [111, 172, 173]. Ingestion of larvae and body fragments of beetles may be possible cause of illness and allergy on consumers. Some insects may be toxigenic and maintain toxin substances or allergic on people. Components like benzoquinones may also be released by insects and they are suspected of being carcinogenic or mutagenic on human subjects. Allergens may also be produced by food-contaminating pests, mites, cockroache or come into the food by filth or extraneous materials of pests. Allergens of mites are reported to cause allergic reactions in people who ate mite-infested food [81]. In every production step great effort needs to be made in minimising the access of these living bodies into the food.

Additives, magnesium carbonate, calcium phosphate, calcium carbonate, magnesium oxide, found in salt over the legal limits were determined as a possible risk in tarhana production, as shown in Table A.1, A.2, A.3, A.4, A.5 (RPN≤50). Food additives are defined as "any substance not normally consumed as a food in itself and not normally used as a characteristic ingredient of food whether or not it has nutritive value, the intentional addition of which to food for a technological purpose … results ... in it or its

by-products becoming directly or indirectly a component of such foods" in Directive 89/107/EEC [189]. This directive does classify additives, and also lays down guidelines and limitations for their use in foodstuffs. This testing procedure is also used for the European ‘E’ number system of classification and also the ADI levels of materials. Unnecessary or careless use of food additives in the food processes may pose potential hazard [39]. Therefore it is important that the salt used in tarhana production should come from a manufacturer with production permit.

Usage of diseased lentils and chickpeas are undesirable in tarhana production and they are indicated as hazard in Table A.1 and A.5 (RPN≤50). Pea seed borne mosaic virus is disease agent of chickpea and lentils. Rust is also an important disease on lentil and chickpeas. These diseases cause malformations of the seeds, in addition to nutrient and yield looses [190, 191].

The details of four traditional and one industrial tarhana production processes are given in Appendix A1. The details of the FMEA analysis of these processes are presented in Appendix 2. The total RPN levels of these processes are given in Table A.1. The most high total RPN value was seen in the industrial tarhana production process related to its highest number of CPs (n=49). The lowest total RPN value was found in Maraş tarhana production as parallel to its lowest number of CPs (n=15). It was estimated that after the corrections taken the total RPNs of Beypazarı, Maraş, Uşak, Gediz, and industrial tarhana productions would be decreased by 74%, 73%, 74%, 74%, and 77%, respectively. It was seen that the biological hazards had higher risk than chemical and physical hazards in the production process while the risk of physical hazards were lowest. However chemical hazards are also very important for tarhana production, because in long term intake, they would cause serious health problems such as cancer, and neurodegenerative diseases.

Table 4.1 The total RPN levels of different tarhana production processes

		Tarhana production processes				
RPN*	Corrections	Beypazarı tarhana	Maraş tarhana	Uşak tarhana	Gediz tarhana	Industrial tarhana
The total RPN	Before corrections	13603	5481	10577	8750	20817
	After corrections	3600	1473	2788	2248	4719
The total RPN of biological hazards	Before corrections	8093	3449	6287	5443	12982
	After corrections	2587	1176	1981	1669	3352
The total RPN of chemical hazards	Before corrections	4614	1576	3860	2857	5997
	After corrections	907	263	779	523	1085
The total RPN of physical hazards	Before corrections	896	456	430	450	1838
	After corrections	106	34	28	56	282

* *RPN* Risk priority number

5. CONCLUSION AND RECOMMENDATIONS

5.1. CONCLUSION

In the present study, the effects of FMEA methodology for the risk assessment of traditional and industrial production processes of tarhana were investigated. Flow charts of tarhana production processes were created to use for the FMEA process. Potential failure modes in the process were determined and their possible causes were grouped as biological, chemical and physical hazards. Rankings which are used to determine the frequency of occurrence for each failure, seriousness of the failure to the consumer, and possibility of detecting the failure were assigned for each potential failure mode based on both the best expert opinion and epidemiological studies for similar potential risks. The rankings were on a scale ranging from 1 to 10, low to high. By multiplying the ranking for severity, occurrence and detection factors, a risk priority number (RPN) which would range from 1 to 1000 was calculated for each potential failure mode. In the present study, it was decided, any RPN above 50 to be treated as an unacceptable risk. Therefore corrective actions were proposed to minimise the possibility of failure occurrence and lower RPN levels below 50. A new RPN, called as resulting RPN was determined by revaluating the rankings and assuming that the action is successfully taken. Both of the total original and resulting RPN levels were gathered for each tarhana production process by taking sum of all of the RPNs which were calculated before and after the actions are taken. The highest total RPN level was found on industrial production. While the total RPN of other tarhana production processes were compared, it was seen that the number of ingredients and process stages used in tarhana production were affecting the total RPN in direct proportion. When the FMEA tables were investigated, it was observed that the most of the total RPN was related with the possible causes of biological hazards in the tarhana production process. FMEA study was resulted in more than 70 percent reduction in the total resulting RPN from the original total RPN for all of the studied tarhana production processes. And most of the resulted RPN of the potential failure modes were at or below the target of 50 points. According to the study, it can be concluded that FMEA would be effective for assessing and minimising the risks of tarhana production process.

5.2. RECOMMENDATIONS

For the present study, tarhana from five production areas were investigated. Four of them were using traditional production techniques while one was producing tarhana on industrial scale. For a more precise study, the number of these tarhana manufacturers may be increased and the effectiveness of the FMEA may be assessed by using statistical methods.

In Turkey, there are also other production techniques that vary from region to region. However, in the present study the investigated traditional tarhana productions were only the well-known ones like; Uşak, Gediz, Beypazarı and Maraş tarhana. So in the future, the FMEA study can be repeated on the traditional tarhana production processes of different regions in Turkey.

In the present study, only one visit was scheduled to the tarhana production place just for observing the production process. In the future it would be better to apply the FMEA process into a tarhana production area and monitor the results and efficiency of the application in time. An FMEA team can be created just for the FMEA work. Beside FMEA researchers, the team could have consisted of the own personnel of the manufacturer like food engineers. This FMEA work would be more effective if the work was defined with a budget and time period. The effect of study would be observed by recording the occurred failures and it would be good to revise the preventative measures by the time.

APPENDIX A: TARHANA PRODUCTION PROCESSES

A.1. FLOW CHART

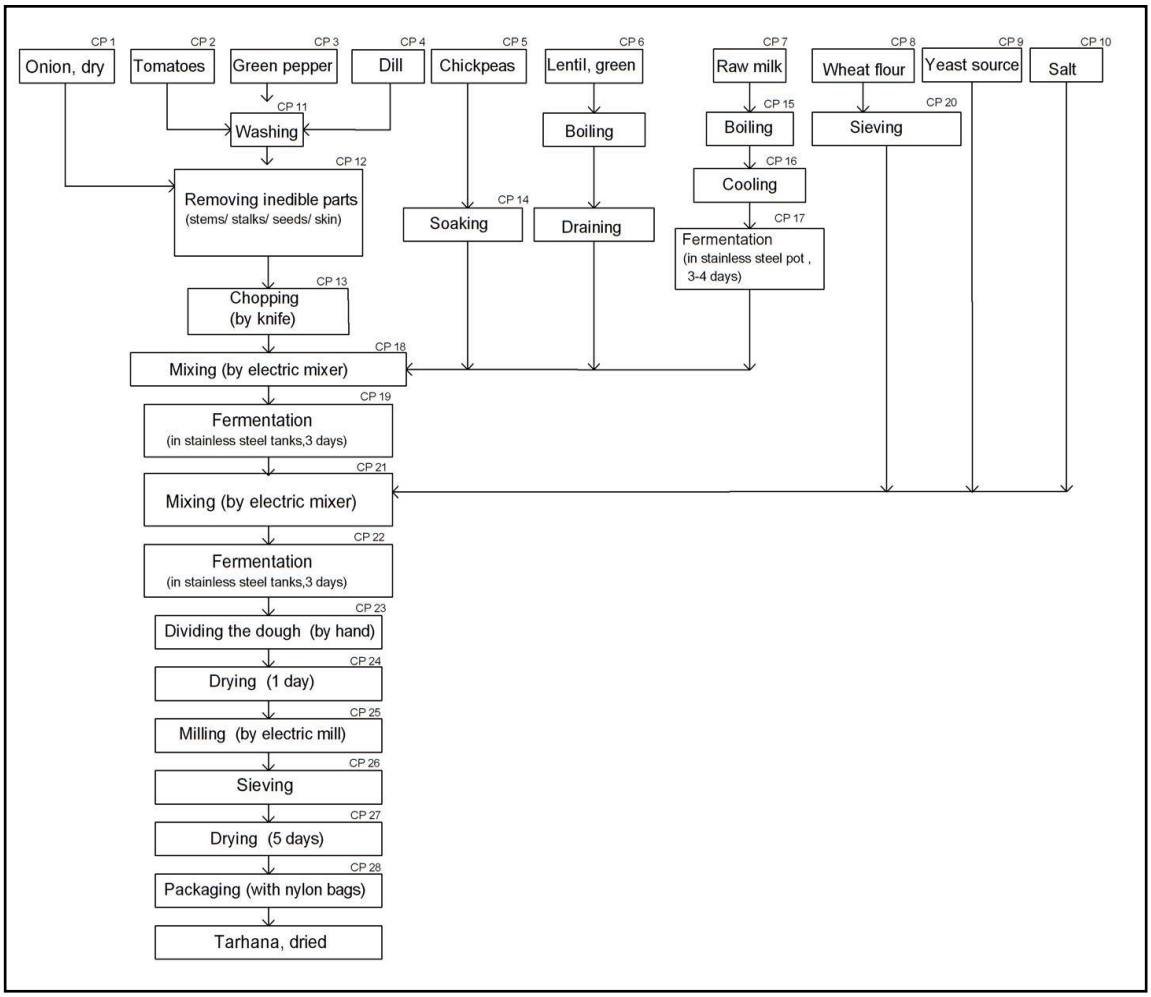

Figure A.1. Flow chart of Beypazarı tarhana production

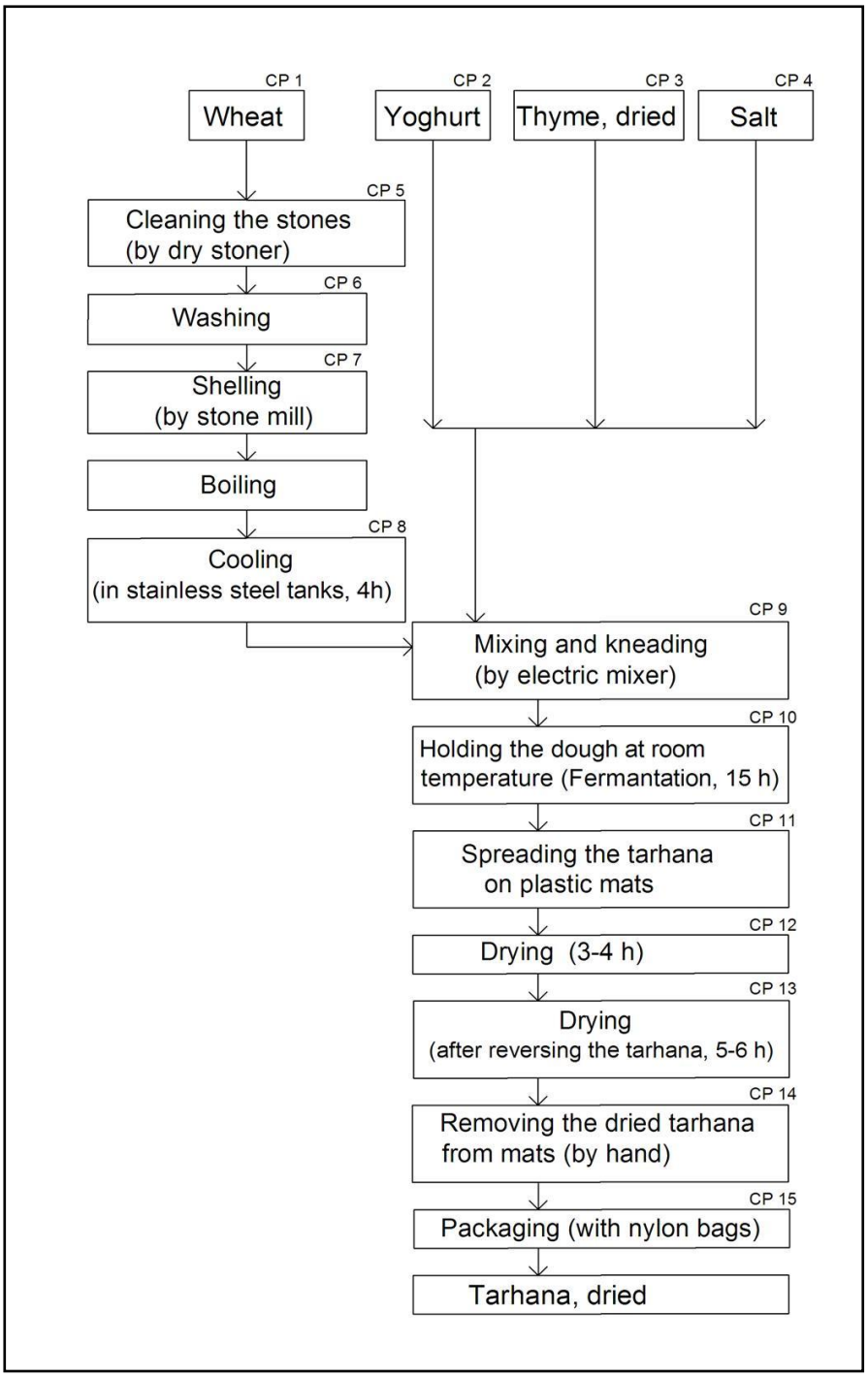

Figure A.2. Flow chart of Maraş tarhana production

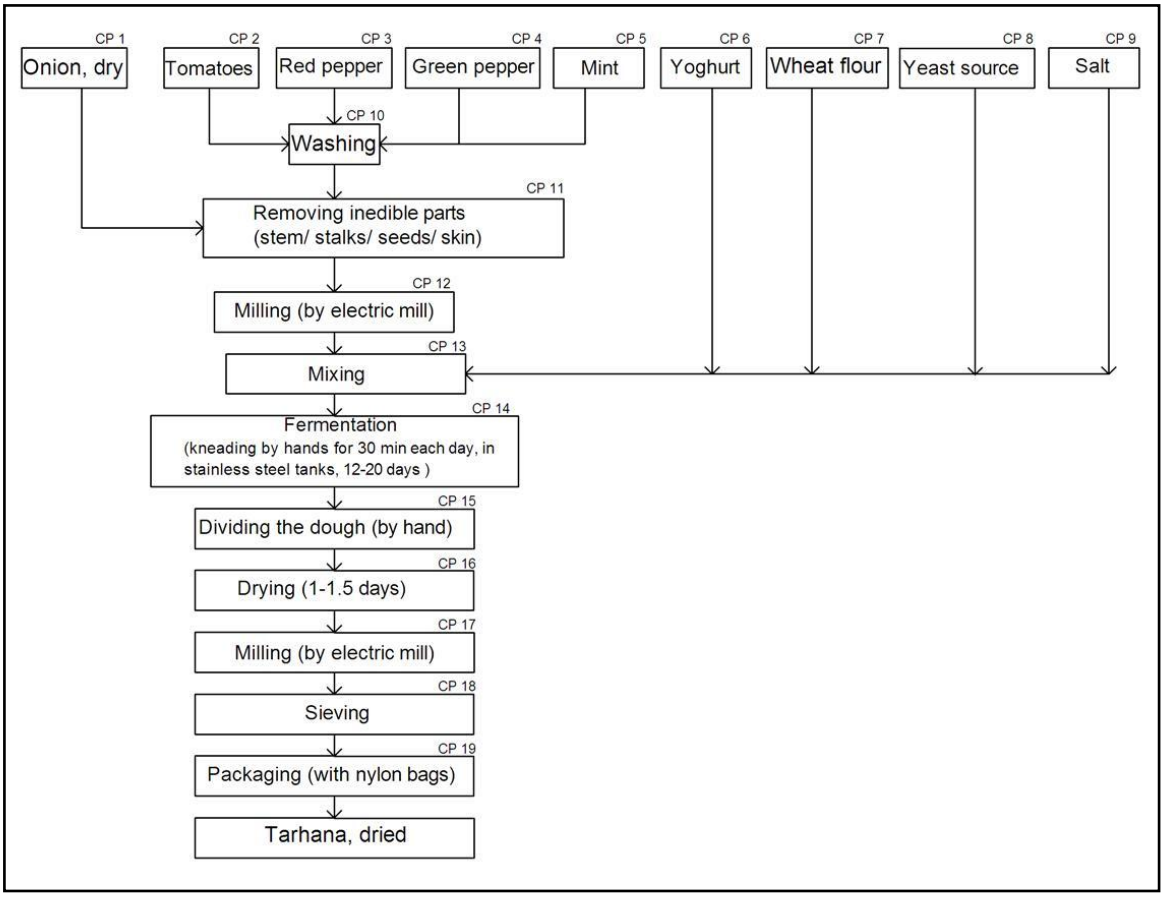

Figure A.3. Flow chart of Uşak tarhana production

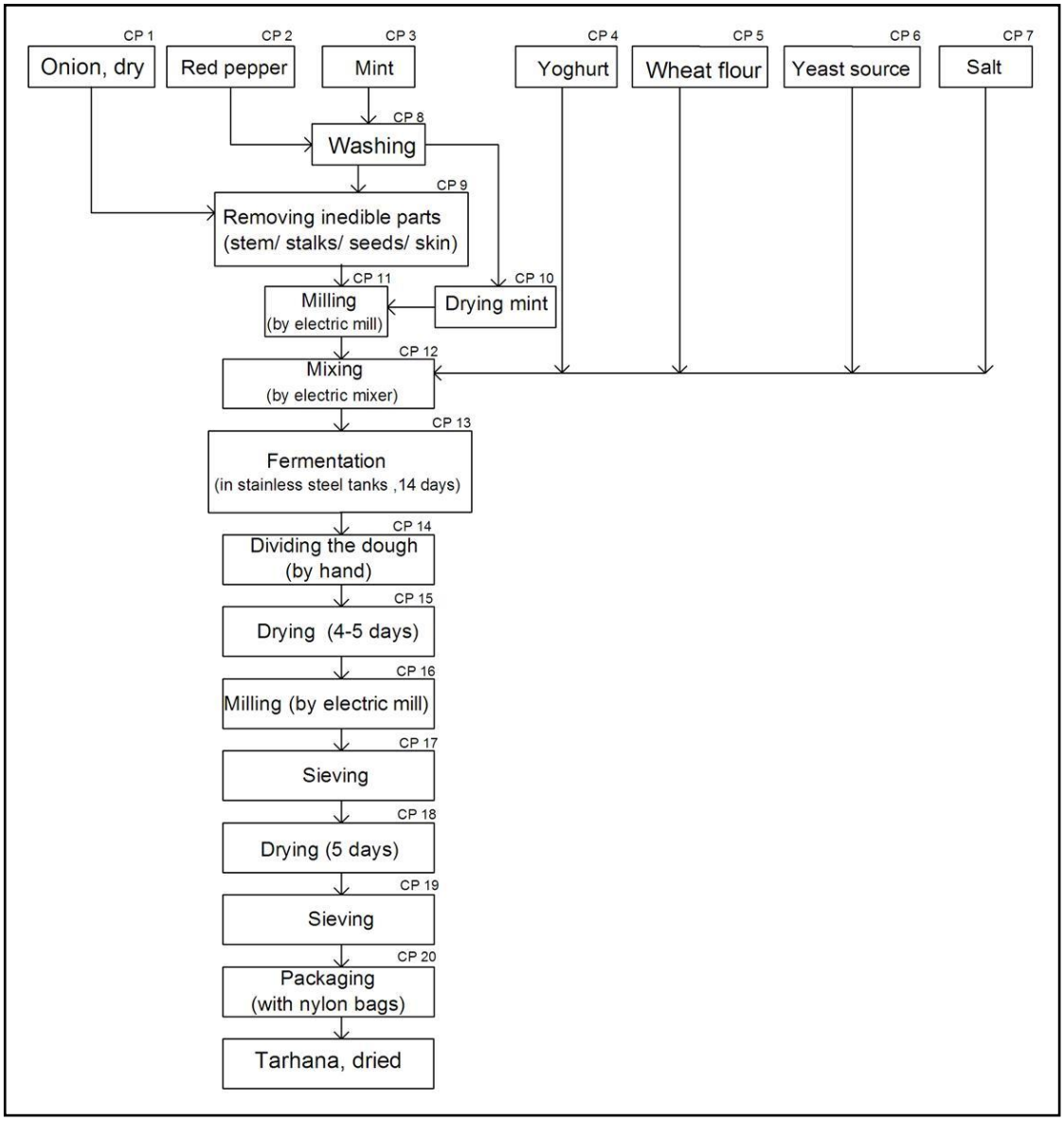

Figure A.4. Flow chart of Gediz Tarhana Production

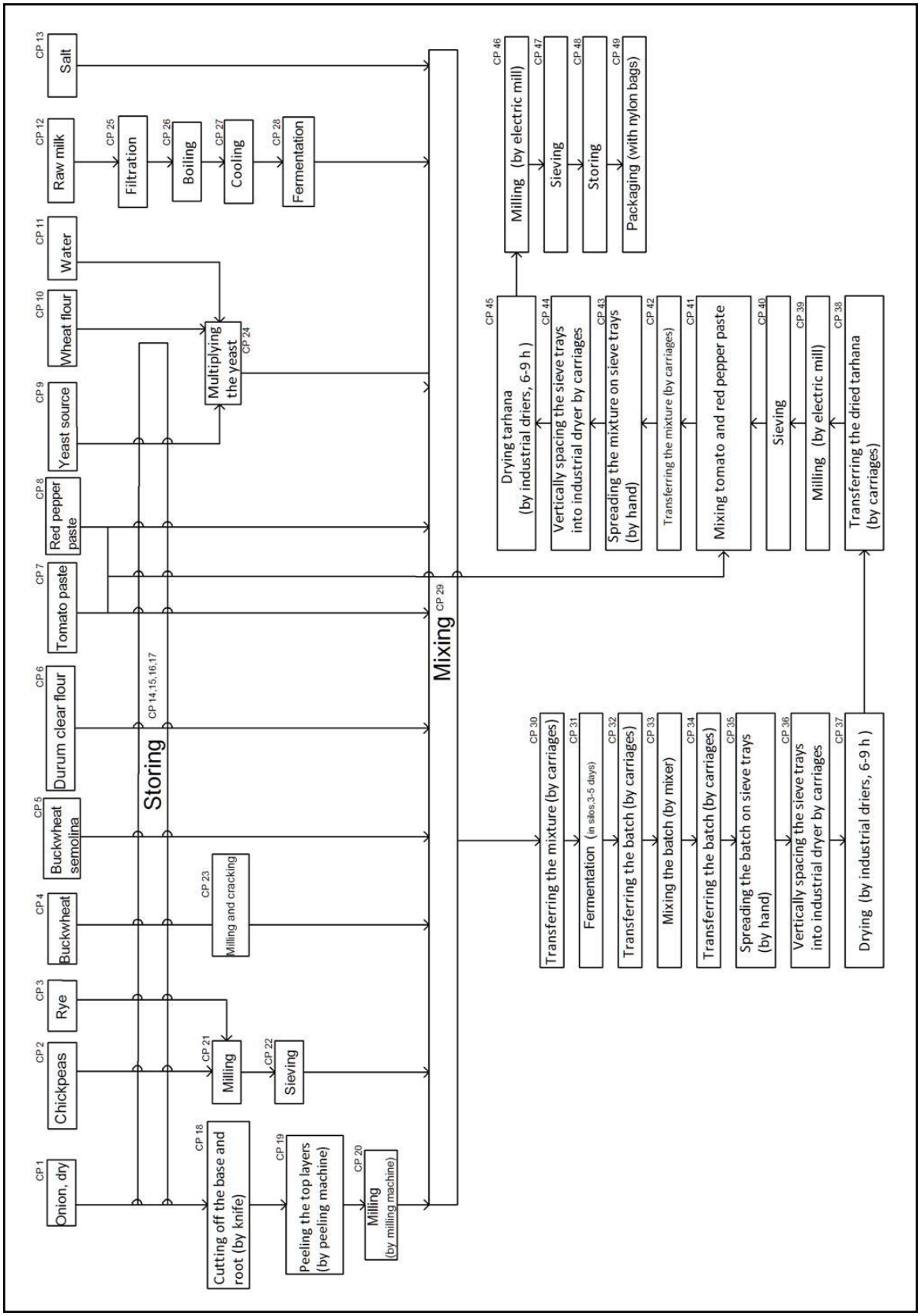

Figure A.5. Flow chart of industrial tarhana production

A.2. FMEA TABLES

Table A.1. Failure mode and effect analysis table for the Beypazarı tarhana production

CP	Processing stage	Risk number	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections
CP1	Receiving onion, dry	1	B: Virus (*Hepatitis A*) due to unsanitary agricultural applications	2	10	8	160*	Vegetables must come from approved suppliers. It must be considered whether the land used to produce crops have been treated with sewage sludge and fecally treated water and if the sanitary facilities are provided for field workers. Very soiled vegetables should not be purchased.	1	10	6	60
		2	B: Moulds, transferred by diseased onions (Bacterial soft rot, black mold rot, botrytis neck rot, blue mold rot, fusarium bulb rot caused by *Erwinia carotovora, Aspergillus alliaceus, Aspergillus niger, Botrytis allii, Fusarium spp.*)	7	5	2	70*	Onions must come from approved suppliers. Wounded, bruised and soiled bulbs should be excluded.	3	5	1	15
		3	B: Parasite zoones (Protozoa- *Cryptosporidium parvum, Giardia duodenalis, Toxoplasma gondii, Blastocystis hominis,* Nematodes- *Toxocara canis, Toxascaris leonina, Toxocara cati, Lagochilascaris minor,* Pentastomids-*Armillifer armillatus*) due to poor agricultural applications	4	8	2	64*	Vegetables should be handled carefully and supplied from reliable wholesalers/ producers. Handling of soiled and dirty vegetables should be avoided.	2	8	1	16
		4	C: Heavy metal contamination (lead, cadmium) due to usage of contaminated soil and/or water in the agricultural land.	8	10	3	240*	Vegetables must come from approved suppliers. It must be considered whether the agricultural land of crops was treated with lead containing pesticides, sewage sludge, irrigated water and/ or soil and effective agricultural approaches were applied to reduce metal accumulation on the soil. Very soiled vegetables should not be purchased.	2	10	2	40
		5	C: Pesticide residue due to deficient pesticide applications in the agricultural land.	6	8	3	144*	Vegetables must come from approved suppliers. The supplier must provide the documents certifying the safety of vegetables.	2	8	2	32
		6	C: Nitrate contamination due to environmental factors (soil, water) or fertilisers containing nitrate	5	7	3	105*	The supplier should report the nitrate concentration of vegetables by documents. The results should be in limits.	2	7	2	28
		7	P: Foreign objects (soil, sand) due to improper harvesting practices	8	1	1	8	None				
CP2	Receiving tomatoes	8	B: Microorganisms (*salmonella, B. cereus, L. monocytogenes, shigella* spp., *aeromonas, Cl. perfringens*) due to inappropriate agricultural applications, irrigation of water and soil by faecal materials, and environmental factors like pests, and flies	5	7	5	175*	Vegetables must come from approved suppliers. It must be considered whether the land used to produce crops have been treated with sewage sludge. Defective vegetables shouldn't be supplied.	2	7	3	42

CP	Processing stage	Risk number	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections
		9	B: Virus (*Hepatitis A*) due to unsanitary agricultural applications	2	7	8	112*	Vegetables must come from approved suppliers. It must be considered whether the land used to produce crops have been treated with sewage sludge and fecally treated water and if the sanitary facilities are provided for field workers. Very soiled vegetables should not be purchased.	1	7	6	42
		10	B: Microorganisms (*E. coli O157:H7, Cl. botulinum*) due to inappropriate agricultural applications, irrigation of water and soil by faecal materials, and environmental factors like pests, and flies	2	10	5	100*	Vegetables must come from approved suppliers. It must be considered whether the land used to produce crops have been treated with sewage sludge. Defective vegetables shouldn't be supplied.	1	10	3	30
		11	B: Parasite zoones (Protozoa- *Cryptosporidium parvum, Giardia duodenalis, Toxoplasma gondii, Blastocystis hominis*, Nematodes- *Toxocara canis, Toxascaris leonina, Toxocara cati, Lagochilascaris minor*, Pentastomids-*Armillifer armillatus*) due to poor agricultural applications	4	8	2	64*	Vegetables should be handled carefully and supplied from reliable wholesalers/ producers. Handling of soiled and dirty vegetables should be avoided.	2	8	1	16
		12	B: Moulds, transferred by diseased and decaying tomatoes (Alternaria rot, soft rot, bacterial canker)	5	5	2	50*	Tomatoes must come from approved suppliers. Contaminated, damaged and discoloured tomatoes should be excluded by manual selection.	1	5	1	5
		13	C: Pesticide, herbicide, insecticide, and spray residues due to deficient pesticide applications in the agricultural land.	6	8	3	144*	Vegetables must come from approved suppliers. The supplier must provide the documents certifying the safety of vegetables.	2	8	2	32
		14	C: Mycotoxins produced by moulds *(Alternaria spp.)* which present due to environmental conditions in growing period of the crop	8	8	2	128*	The moldy, damaged, discoloured tomatoes must be removed physically by manual selection. The supplier must provide the documents certifying the mycotoxin content of vegetables.	2	8	1	16
		15	C: Nitrate contamination due to environmental factors (soil, water) or fertilisers containing nitrate	5	7	3	105*	The supplier should report the nitrate concentration of vegetables by documents. The results should be in limits.	2	7	2	28
		16	C: Heavy metal contamination (lead, cadmium) due to usage of contaminated soil and/or water in the agricultural land.	3	10	3	90*	Vegetables must come from approved suppliers. It must be considered whether the agricultural land of crops was treated with lead containing pesticides, sewage sludge, irrigated water and/ or soil and effective agricultural approaches were applied to reduce metal accumulation on the soil. Very soiled vegetables should not be purchased.	1	10	1	10
		17	C: Plant growth regulators (Oxins, Etilen, 2,4 D) due to poor agricultural applications	4	5	3	60*	Vegetables must come from approved suppliers.	2	5	2	20
		18	P: Foreign objects (eggs and larvae of small flies adhered to the food)	8	1	6	48	None				
		19	P: Foreign objects (soil, sand, dirt) due to improper harvesting practices	8	1	1	8	None				
CP3	Receiving green pepper	20	B: Microorganisms (*salmonella, L. monocytogenes, shigella spp., aeromonas, Cl. perfringens*) due to inappropriate agricultural applications, irrigation of water and soil by faecal materials, and environmental factors like pests, and flies	5	7	5	175*	Vegetables must come from approved suppliers. It must be considered whether the land used to produce crops have been treated with sewage sludge. Defective vegetables shouldn't be supplied.	2	7	4	56

CP	Processing stage	Risk number	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections
		21	B: Microorganisms (*E. coli O157:H7, Cl. botulinum*) due to inappropriate agricultural applications, irrigation of water and soil by faecal materials, and environmental factors like pests, and flies	2	10	5	100*	Vegetables must come from approved suppliers. It must be considered whether the land used to produce crops have been treated with sewage sludge. Defective vegetables shouldn't be supplied.	1	10	4	40
		22	B: Parasite zoones (Protozoa- *Cryptosporidium parvum, Giardia duodenalis, Toxoplasma gondii, Blastocystis hominis*, Nematodes- *Toxocara canis, Toxascaris leonina, Toxocara cati, Lagochilascaris minor,* Pentastomids-*Armillifer armillatus*) due to poor agricultural applications	4	8	2	64*	Vegetables should be handled carefully and supplied from reliable wholesalers/ producers. Handling of soiled and dirty vegetables should be avoided.	2	8	1	16
		23	B: Moulds (Bacterial soft rot, gray mold rot, alternaria rot diseases of green pepper) produced by mold which present due to environmental conditions in growing period or transferred by diseased green peppers	5	5	2	50*	Peppers must come from approved suppliers. Injured peppers should be culled out.	3	5	1	15
		24	C: Pesticide residue due to deficient pesticide applications in the agricultural land.	6	8	3	144*	Vegetables must come from approved suppliers. The supplier must provide the documents certifying the safety of vegetables.	2	8	2	32
		25	C: Nitrate contamination due to environmental factors (soil, water) or fertilisers containing nitrate	5	7	3	105*	The supplier should report the nitrate concentration of vegetables by documents. The results should be in limits.	2	7	2	28
		26	C: Heavy metal contamination (lead, cadmium) due to usage of contaminated soil and/or water in the agricultural land.	3	10	3	90*	Vegetables must come from approved suppliers. It must be considered whether the agricultural land of crops was treated with lead containing pesticides, sewage sludge, irrigated water and/ or soil and effective agricultural approaches were applied to reduce metal accumulation on the soil. Very soiled vegetables should not be purchased.	1	10	1	10
		27	C: Plant growth regulators (2,4 D) due to poor agricultural applications	4	5	3	60*	Vegetables must come from approved suppliers.	2	5	2	20
		28	P: Foreign objects (soil, sand) due to improper harvesting practices	8	1	3	24	None				
CP4	Receiving dill	29	B: Microorganisms (*salmonella, L. monocytogenes, shigella spp., aeromonas, Cl. perfringens*) due to inappropriate agricultural applications, irrigation of water and soil by faecal materials, and environmental factors like pests, and flies	6	7	5	210*	Vegetables must come from approved suppliers. It must be considered whether the land used to produce crops have been treated with sewage sludge. Defective vegetables shouldn't be supplied.	2	7	4	56
		30	B: Microorganisms (*E. coli O157:H7, Cl. botulinum*) due to inappropriate agricultural applications, irrigation of water and soil by faecal materials, and environmental factors like pests, and flies	3	10	5	150*	Vegetables must come from approved suppliers. It must be considered whether the land used to produce crops have been treated with sewage sludge. Defective vegetables shouldn't be supplied.	1	10	4	40
		31	B: Parasite zoones (Protozoa- *Cryptosporidium parvum, Giardia duodenalis, Toxoplasma gondii, Blastocystis hominis*, Nematodes- *Toxocara canis, Toxascaris leonina, Toxocara cati, Lagochilascaris minor*, Pentastomids-*Armillifer armillatus*) due to poor agricultural applications	4	8	2	64*	Vegetables should be handled carefully and supplied from reliable wholesalers/ producers. Handling of soiled and dirty vegetables should be avoided.	2	8	1	16

CP	Processing stage	Risk number	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections
		32	C: Pesticide residue due to deficient pesticide applications in the agricultural land.	6	8	3	144*	Vegetables must come from approved suppliers. The supplier must provide the documents certifying the safety of vegetables.	2	8	2	48
		33	C: Nitrate contamination due to environmental factors (soil, water) or fertilisers containing nitrate	5	7	3	105*	The supplier should report the nitrate concentration of vegetables by documents. The results should be in limits.	2	7	2	28
		34	P: Foreign objects (insect fragments, filth, soil, sand) due to agricultural applications	6	1	2	12	None				
CP5	Receiving chickpeas	35	B: Molds due to poor post-harvest operations like inefficient storage conditions	7	5	2	70*	Chickpeas must come from approved suppliers. It must come along with quality certificates. The certificates should report the moisture content of chickpea, the number/ colonies of insects, fungi and mold that appear compared with the upper-approved standards. Visual control of the chickpea must be carried out in order to detect the high humidity, undesirable odours, defective and moldy grains. Moisture content of chickpeas must be measured by a grain moisture tester. It must avoid to supply chickpeas which were stored in long duration (more than 3 months).	3	5	1	15
		36	B: Diseased chickpeas (Chickpea rust, *U.ciceris-arietini*, infection with pea seed-borne mosaic virus) due to inefficient agricultural applications	5	1	1	5	None				
		37	C: Pesticide, Insecticide residues due to post harvest pesticides, applied to protect the stored food from pests	6	8	3	144*	Chickpeas must come from approved suppliers. It must come along with quality certificates and pesticide analysis. It must be considered whether chickpeas stored with insecticide application.	2	8	2	32
		38	C: Mycotoxins (Aflatoxin) produced by mold which present due to environmental conditions in growing period of the crop and poor storage during the post-harvest period	6	8	2	96*	Chickpeas must come from approved suppliers. It must come along with quality certificates and a mycotoxin analysis. The certificates should report the moisture content of chickpea, the average of the occurring mycotoxins, the number/ colonies of insects and fungi that appear compared with the upper-approved standards. Visual control of the chickpea must be carried out in order to detect the high humidity, undesirable odours and defective grains. Moisture content of chickpeas must be measured by a grain moisture tester. It must avoid to supply chickpeas which were stored in long duration (more than 3 months). Chickpeas should wash efficiently with distilled water or sodium carbonate solution just before using.	3	8	2	48
		39	P: Pests (bruchidis-Callosobruchus chinesis L.) due to poor post-harvest operations like inefficient storage conditions	7	3	4	84*	The chickpeas should be inspected visually. It must be avoided to supply chickpeas which were stored in more than 3 months. The chickpeas, damaged, cracked and with holes, shouldn't be supplied . Moisture level of chickpeas should be measured by a tester and grains moisture content must be under 7%.	2	3	3	18
		40	P: Hard foreign objects (stone pieces) due to poor post-harvest operations	8	5	2	80*	Dirty chickpeas shouldn't be supplied, the chickpeas should wash efficiently and the stones should remove physically	2	5	1	10
CP6	Receiving lentil, green	41	B: Diseased lentils (Rust, Uromyces viviae-fabae, infection with pea seed-borne mosaic virus) due to inefficient agricultural applications	6	1	1	6	None				

CP	Processing stage	Risk number	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections
		42	C: Pesticide residue due to post harvest pesticides, applied to protect the stored food from pests	6	8	3	144*	Lentils must come from approved suppliers. It must come along with quality certificates and pesticide analysis. It must be considered whether lentils stored with insecticide application.	2	8	2	32
		43	C: Mycotoxins (Aflatoxin) produced by mold which present due to environmental conditions in growing period of the crop and poor storage during the post-harvest period	4	8	2	64*	Lentils must come from approved suppliers. It must come along with quality certificates. The certificates should report the moisture content of lentils, the number/ colonies of insects, fungi and mold that appear compared with the upper-approved standards. Visual control of the lentils must be carried out in order to detect the high humidity, undesirable odours, defective and moldy lentils. The lentils should be efficiently washed with distilled water or sodium carbonate solution just before using.	2	8	1	16
		44	P: Pests (bruchidis-Coleoptera: Bruchidae) due to poor post-harvest operations like inefficient storage conditions	7	3	4	84*	The lentils should be inspected visually. It must be avoided to supply lentils which were stored in more than 3 months. The lentils, damaged, cracked and with holes, shouldn't be supplied . Moisture level of lentils should be measured by a tester and lentils moisture content must be under 7%.	2	2	3	12
		45	P: Hard foreign objects (stone) due to poor post-harvest operations	8	5	2	80*	The stones of lentils should be removed physically.	2	5	1	10
CP7	Receiving raw milk (cow)	46	B: Microorganisms (Severe) (*E. coli O157:H7*) due to poor milking, milk processing and transferring conditions	5	10	2	100*	Milk must come from reliable suppliers. It must be considered if milk was collected at the day of receiving, immediately cooled to ≤8° after collection and transferred with chill chain. The temperature of milk should be measured by a probe and supply only the product below 6°C. The milk should be tested for its bacterial load with methylene blue or by some other tests.	1	10	1	10
		47	B: Microorganisms (Severe) (*Brucella ssp., Cl. botulinum, Salmonella typhi, paratyphi and dublin, Shigella dysenteriae, Mycobacterium avium*) due to poor milking, milk processing and transferring conditions	2	10	5	100*	Milk must come from reliable suppliers. It must be considered if milk was collected at the day of Receiving, immediately cooled to ≤8° after collection and transferred with chill chain. The temperature of milk should be measured by a probe and supply only the product below 6°C. The milk should be tested for its bacterial load with methylene blue or by some other tests.	1	10	4	40
		48	B: Spoilage micro-organisms (Moderate) (*Listeria monocytogenes, Salmonella spp., Enterotoxigenic Escherichia coli, Enteroinvasive Escherichia coli, Bacillus cereus, Clostridium perfringens, Staphylococcus aerous, Campylobacter jejuni and other species, Aeromonas spp., Yersinia enterocolitica*) due to poor milking, milk processing and transferring conditions	5	7	2	70*	Milk must come from reliable suppliers. It must be considered if milk was collected at the day of receiving, immediately cooled to ≤8° after collection and transferred with chill chain. The temperature of milk should be measured by a probe and supply only the product below 6°C. The milk should be tested for its bacterial load with methylene blue or by some other tests.	2	7	1	14
		49	B: Parasites (Protozoa- *Crytosporidium spp., Giardia spp.*) due to poor milking, milk processing and transferring conditions	4	7	2	56*	Milk should come from reliable suppliers. It must be sure that milk was collected at the day of receiving and it was immediately cooled to ≤8° after collection and transferred with chill chain. The temperature of the milk should be below 6°C and must be measured by a probe.	2	7	1	14

CP	Processing stage	Risk number	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections
		50	C: Heavy metal contamination (lead, copper, cadmium, mercury) due to contaminated animal feed	8	10	2	160*	Milk should come with the certificates reporting its metal content compared with the specifications. It must be considered whether the lactating animals were grown far away from potential emitting industries.	3	10	1	30
		51	C: Pesticide residues (Organo-phosphates, Fumigants, Carbamates) due to contaminated animal feed of lactating animal	6	8	3	144*	Milk must come from approved suppliers. The milk should be tested periodically by a laboratory. The supplier must provide the documents certifying the safety of animal feeds and milk.	2	8	2	32
		52	C: Dioxin due to accumulation of the pollutants into the fatty tissues and products of animals.	6	8	3	144*	Milk should be supplied from producers who maintain the routine tests of animal feed and milk. Tarhana producer should give importance to the dioxin and review the analyze results and certificates carefully.	2	8	2	32
		53	C: Veterinary drug residues due to drugs given into unhealthy animal	8	8	2	128*	Milk must come from approved suppliers. The milk should be tested periodically by a laboratory.	2	8	1	16
		54	C: Mycotoxins (Ochratoxin, Aflatoxin, Thyro-toxicosis) due to contaminated animal feed	6	6	2	72*	Milk must come from approved suppliers. The milk should be tested periodically by a laboratory. The supplier must provide the documents certifying the mycotoxin content of milk.	3	6	1	18
		55	P: Foreign objects (soil, sand, animal leucocyte cells, hair, chaff, insects, glass fragments, wood slivers, metal fragments) due to inefficient filtration of milk	6	1	1	6	None				
CP8	Receiving wheat flour	56	B: Microorganisms (*E. coli, Cl.botulinum, Shigella*) due to equipment contamination or improper storage properties	6	10	2	120*	Flour must be purchased from approved suppliers. Its receipt should be accompanied with certificates of quality control and microbiological analysis. The certificates should report the humidity of flour and regarding microorganisms, their content and comparison with the upper approved standards.	3	10	1	30
		57	B: Microorganisms (*B. Cereus, Sallmonella* spp., *C. perfringens, Micrococcus, Alcaligenes*) due to equipment contamination or improper storage properties	6	7	2	84*	Flour must be purchased from approved suppliers. Its receipt should be accompanied with certificates of quality control and microbiological analysis. The certificates should report the humidity of flour and regarding microorganisms, their content and comparison with the upper approved standards.	3	7	1	21
		58	B: Molds, fungi due to inappropriate storage conditions and careless handling	7	4	2	56*	Flour must be purchased from approved suppliers. Its receipt should be accompanied with certificates of quality control. The certificates should report the moisture, mold, and mold spore count of flour, and their comparison with the upper approved standards. Moisture content of flour should be measured by a grain moisture tester.	4	4	1	16
		59	C: Pesticide, Insecticide residues due to post harvest pesticides, applied to protect the stored food from pests	6	8	3	144*	Flour must be purchased from approved suppliers. Its receipt should be accompanied with certificates of quality control. The certificates should report the pesticides of flour, their content and comparison with the upper approved standards.	2	8	2	32

CP	Processing stage	Risk number	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections
		60	C: Mycotoxins (Trichothencene pruced by *Fusarium spp.*, Aflatoxins, deoksinivalenol, zearalenon, citrinin, achratoxin, cyclopiazonic acid, viomellein, xanthomegnin, patulin) produced by mold which present due to environmental conditions in growing period of the crop and poor storage during the post-harvest period	8	8	2	128*	Flour must be purchased from approved suppliers. Its receipt should be accompanied with certificates of quality control. The certificates should report the mycotoxins of flour, their content and comparison with the upper approved standards.	2	8	1	16
		61	C: Heavy metal contamination (lead, cadmium) due to usage of contaminated soil and/or water in the agricultural land.	6	9	2	108*	Flour must be purchased from approved suppliers. Its receipt should be accompanied with certificates of quality control which should report the pieces of metals and heavy metal, their content and comparison with the upper approved standards.	3	9	1	27
		62	C: Quinones (benzoquinones), allergens, maintained from some pests (flour beetles-*Alphitobius spp.*, *Tribolium spp.*, *Tenebrio spp.*, mites, cockroaches).	4	3	3	36	None				
		63	P: Hard foreign objects (wire from sieving) due to old-expired equipment	6	6	1	36	None				
		64	P: Foreign objects (insect fragments and larvae of small flies adhered to the food)	3	1	3	9	None				
CP9	Receiving yeast source (fermented tarhana dough which is kept from previous production)	65	B: Survival of microorganisms during fermentation (*S. aureus*) due to contamination in previous production	2	7	2	28	None				
		66	B: Survival of microorganisms (*Vero-cytotoxigenic E. coli*) due to contamination in previous production	2	10	1	20	None				
		67	C: Mycotoxins (*ochratoxin A, type B trichothecenes*) transferred by the previous dough	1	8	2	16	None				
		68	P: Foreign objects due to improper handling and storage	1	3	2	6	None				
CP10	Receiving salt	69	C: Additives, magnesium carbonate, calcium phosphate, calcium carbonate, magnesium oxide, added over the legal limits	1	5	1	5	None				
		70	P: Foreign objects due to failure in processing	3	5	1	15	None				
CP11	Washing vegetables	71	B: Survival of Virus (*Hepatitis A*) due to inefficient washing procedure	2	7	8	112*	Vegetables should be treated with sanitizers and rinsed efficiently.	1	7	6	42
		72	B: Survival of microorganisms (*E. coli O157:H7*) due to inefficient washing. Contamination with *Salmonella Thyphimurium, E. coli* and *V. cholerae* due to contaminated water used for washing	3	10	3	90*	Efficient washing procedure should be applied to vegetables: washing vegetables min 3 times, 1st with water, 2nd with effective sanitizer (hydrogen peroxide), 3rd with water (rinsing). Wash water should be clean and cool. Wash water must be removed by centrifugation.	2	10	2	40
		73	B: Survival of microorganisms (*L. monocytogenes*) due to inefficient washing. Contamination with Shigella and Aeromonas due to contaminated water used for washing	6	7	2	84*	Efficient washing procedure should be applied to vegetables: washing vegetables min 3 times, 1st with water, 2nd with effective sanitizer (hydrogen peroxide), 3rd with water (rinsing). Wash water should be clean and cool. Wash water must be removed by centrifugation.	3	7	1	21

CP	Processing stage	Risk number	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections
		74	B: Parasite zoones (Microspora- *Enterocytozooan bieneusi, Encephalitozoon cuniculi,* Protozoa- *Cryptosporidium parvum, Giardia duodenalis, Toxoplasma gondii, Blastocystis hominis,* Pentastomids- *Armillifer armillatus*) transmitted by water	4	8	2	64*	Vegetables should be rinsed with clean water. The water should be tested periodically by a laboratory. Used water should be supplied from a public water system which is regularly monitored and usage of contaminated water should be avoided. Water should be filtrated by a specially constructed filter system.	2	9	1	18
		75	C: Pesticide and spray residues left on the vegetables due to inappropriate washing	6	8	3	144*	Vegetables must be washed appropriately using water and preferably by acetic acid solutions. Tomatoes and peppers must be washed in water tanks agitated with compressed air, followed by rinsing with high-pressure water sprays.	2	8	2	32
		76	C: Nitrate contamination due to inefficient washing	3	7	5	105*	Vegetables must be washed appropriately.	2	7	2	28
		77	C: Chlorine residual due to chlorinated water used for sanitizing vegetables	5	6	2	60*	Less harmful disinfectants than chlorine should be used for sanitation like hydrogen peroxide. It must be considered whether chlorinated wateris categorised as "food grade". When preparing the hypochloride solutions the proportion of chlorine and water concentrations and contact times should not be exceed the recommended levels. Vegetables must be rinsed with potable water following the chlorine treatment.	1	6	1	6
		78	P: Foreign objects (pieces of materials) due to material degradation and defects of water pipeline	1	3	2	6	None				
CP12	Removing inedible parts of vegetables (stems/ stalks/ seeds/ skin)	79	B: Contamination with microorganisms (*E. coli O157:H7*) due to unclean instrument	4	10	2	80*	The knives must be washed efficiently, preferably by automatic washing equipment. UV knife disinfection cabinet should be provided and personnel should be encouraged to use it.	1	10	1	10
		80	B: Parasite zoones (Protozoa- *Cryptosporidium parvum, Giardia duodenalis, Blastocystis hominis*) transmitted by contaminated hands	2	8	4	64*	Personnel should be trained on hygine and hand washing and they should be provided with appropriate facilities to operate good hygienic practice e.g. hand basin and bactericidal soaps. Table ledges, door handlers, overhead pipes and many other areas should be routinely disinfected. Hands-on operations should be minimised. Medical examination should be applied to employees on a continuous basis.	2	9	3	54
		81	B: Contamination with microorganisms (*L. monocytogenesis, S. aureus*) due to unclean instrument	4	7	2	56*	The knives must be washed efficiently, preferably by automatic washing equipment. UV knife disinfection cabinet should be provided and personnel should be encouraged to use it.	1	7	1	7
		82	P: Foreign objects (soil, sand, inedible parts of vegetables) due to inefficient visual inspection	8	1	1	8	None				
CP13	Chopping vegetables (by knife)	83	B: Virus (NLV) contamination by personnel handling.	2	7	8	112*	Personnel should be trained to understand the risk associated with cross-contamination and they should be provided with appropriate facilities to operate good hygienic practice e.g. hand basin and bactericidal soaps. Table ledges, door handlers, overhead pipes and many other areas should be routinely disinfected. Hands-on operations should be minimised.	2	7	6	84

CP	Processing stage	Risk number	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections
		84	B: Contamination with microorganisms (*E. coli O157:H7*) due to unclean instrument	4	10	2	80*	The knives and chopping boards must be washed efficiently, preferably by automatic washing equipment. UV knife disinfection cabinet should be provided and personnel should be encouraged to use it.	1	10	1	10
		85	B: Virus (Rotavirus, Hepatitis A) contamination by personnel handling.	1	10	8	80*	Personnel should be trained to understand the risk associated with cross-contamination and they should be provided with appropriate facilities to operate good hygienic practice e.g. hand basin and bactericidal soaps. Table ledges, door handlers, overhead pipes and many other areas should be routinely disinfected. Hands-on operations should be minimised. Personnel must get vaccinated for Hepatitis A.	1	10	6	60
		86	B: Parasite zoones (Protozoa- *Cryptosporidium parvum*) transmitted by chopping board and knife.	3	7	3	63*	The chopping boards and knifes should be thoroughly washed and disinfected.	1	9	2	18
		87	B: Contamination with microorganisms (*L. monocytogenesis, S. aureus*) due to unclean instrument	4	7	2	56*	The knives and chopping boards must be washed efficiently, preferably by automatic washing equipment. UV knife disinfection cabinet should be provided and personnel should be encouraged to use it.	1	7	1	7
		88	B: Pathogen contamination (*S. aureus, L. monocytogenes, Shigella spp.*) by personnel handling	2	7	4	56*	Personnel should be trained to understand the risk associated with cross-contamination and they should be provided with appropriate facilities to operate good hygienic practice e.g. hand basin and bactericidal soaps. Table ledges, door handlers, overhead pipes and many other areas should be routinely disinfected. Hands-on operations should be minimised.	2	7	3	42
		89	B: Pathogen (*Shigella dysenteriae*) contamination by personnel handling	1	10	4	40	None				
		90	C: Detergent residue from chopping board	2	3	5	30	None				
		91	P: Foreign objects (hair, button, nails) due to personal effects	6	4	1	24	None				
CP14	Soaking chickpeas	92	B: Virus (Rotavirus, Hepatitis A) transmission from water	6	10	3	180*	Water only from a public water system that is regularly monitored and chlorinated should be used. Water should be filtrated by a specially constructed filter system.	2	10	2	40
		93	B: Virus (NLV, Hepatitis E) transmission from water	6	7	3	126*	Water only from a public water system that is regularly monitored and chlorinated should be used. Water should be filtrated by a specially constructed filter system.	2	7	2	28
		94	B: Contamination with *Salmonella Thyphimurium, E. coli* and *V. cholerae* by infected water	3	10	3	90*	Soaking should take place at low temperatures. Safe water should be used.	1	10	2	20
		95	B: Contamination with *Shigella* and *Aeromonas* by infected water	4	7	3	84*	Soaking should take place at low temperatures. Safe water should be used.	4	7	2	56
		96	B: Parasite zoones (Microspora- *Enterocytozooan bieneusi, Encephalitozoon cuniculi,* Protozoa- *Cryptosporidium parvum, Giardia duodenalis, Toxoplasma gondii, Blastocystis hominis, ,* Pentastomids- *Armillifer armillatus*) transmitted by water.	4	8	2	64*	Chickpeas should be rinsed with clean water. The water should be tested periodically by a laboratory. Used water should be supplied from a public water system which is regularly monitored and usage of contaminated water should be avoided. Water should be filtrated by a specially constructed filter system.	2	9	1	18

CP	Processing stage	Risk number	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections
		97	C: Chlorine residual due to water chlorinated over the limits	2	6	1	12	None				
		98	P: Foreign objects (pieces of materials) due to material degradation and defects of water pipeline	1	4	2	8	None				
		99	P: Foreign objects (insect fragments, dirt) fallen in the food due to uncovered pot	8	1	1	8	None				
CP15	Boiling milk	100	B: Survival of heat resistant spores of the pathogens (*B. cereus and C. perfringens)* and presence of enterotoxin produced by *S. Aureus* due to inefficient time and duration of boiling	3	7	3	63*	Efficient pasteurisation conditions of milk should be applied (63°C for 30 min., 72°C for 15 s). After pasteurisation the milk should be tested by sterilization test kits to see if it has been adequately heat-treated.	1	7	2	14
		101	B: Survival of microorganisms (*Mycobacterium avium*) due to inefficient time and duration of boiling	1	10	5	50*	Efficient pasteurisation conditions of milk should be applied (63°C for 30 min., 72°C for 15 s). After pasteurisation the milk should be tested by sterilization test kits to see if it has been adequately heat-treated.	1	10	4	40
		102	C: Detergent/ sanitizer residues (Nitrates, Phosphates, Chlorinated organics, Iodophors)	4	3	5	60*	Equipment should be rinsed efficiently after cleaning. Rinsable and biodegredable detergents should be used for cleaning.	1	3	4	12
CP16	Cooling milk	103	B: Rapid growth of microorganisms (*Bacillus licheniformis* and *S. Thermophilus*) due to long cooling time and high temperature	4	7	2	56*	Rapid cooling should be achieved by using chilled water. The cooled milk should be used in maximum 24 hours.	1	7	1	7
		104	P: Foreign objects due to uncovered material	4	3	1	12	None				
CP17	Fermentation of milk (In the stainless steel pot, 3-4 days)	105	B: Survival and growth of microorganisms (*Y. enterocolitica, S. aureus, L. monocytogenes*) due to improper fermentation conditions.	3	7	3	63*	Efficient conditions (time, temperature, ph, sanitation) for fermentation should be enhanced. Efficient cleaning and disinfection procedures and preventive measures should be applied to instruments.	1	7	2	14
		106	B: Survival and growth of microorganisms (*E. coli O157:H7*) due to improper fermentation conditions.	3	10	2	60*	Efficient conditions (time, temperature, ph, sanitation) for fermentation should be enhanced. Efficient cleaning and disinfection procedures and preventive measures should be applied to instruments.	1	10	1	10
		107	C: Disinfectant or detergent residue on mixer due to application of inefficient washing procedures	4	3	5	60*	Detergents must be rinsable and biodegredable. Disinfectants should be non toxic and non-corrosive. The equipment should be rinsed appropriately following the cleaning.	1	3	4	12
		108	C: Survival of aflatoxin (Ochratoxin A) due to poor fermentation conditions	2	8	2	32	None				
		109	P: Foreign objects (animal leucocyte, cells) due to inefficiently filtrated milk	2	1	10	20	None				
		110	P: Foreign objects (animal hair, chaff) due to inefficiently filtrated milk	2	1	1	2	None				

CP	Processing stage	Risk number	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections
CP18	Mixing ingredients (by electric mixer)	111	B: Contamination with microorganisms (*L. monocytogenesis, S. aureus*) due to unclean instrument	7	7	4	196*	Efficient cleaning, disinfection and prevention procedures of the equipment should be applied. Disinfection should follow immediately after cleaning and before a process run. All equipment should be routinely dismantled or parts loosened for disinfection. Cleaning efficacy should be monitored using indicators of hygiene by tests for coliform bacteria. The cleaning utensils (brushers, sponges and spray guns) themselves must be disinfected properly. Movements of personnel and goods should be limited. The correct hygienic design and proper maintenance of equipment should be provided.	1	7	3	21
		112	B: Machinery mold (*Geotrichum candidum*) due to inefficient cleaning of equipment	5	9	3	135*	Good equipment cleaning procedure must be applied.	2	9	2	36
		113	B: Contamination with microorganisms (*E. coli O157:H7*) due to unclean instrument	2	10	3	60*	Efficient cleaning, disinfection and prevention procedures of the equipment should be applied. Disinfection should follow immediately after cleaning and before a process run. All equipment should be routinely dismantled or parts loosened for disinfection. Cleaning efficacy should be monitored using indicators of hygiene by tests for coliform bacteria. The cleaning utensils (brushers, sponges and spray guns) themselves must be disinfected properly. Movements of personnel and goods should be limited. The correct hygienic design and proper maintenance of equipment should be provided.	1	10	2	20
		114	C: Disinfectant or detergent residue on mixer due to application of inefficient washing procedures	4	3	5	60*	Detergents must be rinsable and biodegredable. Disinfectants should be non toxic and non-corrosive. The equipment should be rinsed appropriately following the cleaning.	1	3	4	12
		115	C: Heavy metal contamination due to metal surfaces of instruments which come into contact with food	1	8	3	24	None				
		116	P: Foreign objects (metal pieces) due to old-expired equipment	3	6	1	18	None				
CP19	Fermentation of tarhana (in stainless steel tanks, 3 days)	117	B: Survival of parasites (*Cryptosporidium, Giardia lamblia*) due to improper fermentation conditions	3	7	5	105*	Appropriate acidification should be provided.	1	7	4	28
		118	B: Survival of virus (Rotavirus, Hepatitis A) due to improper fermentation conditions	1	10	8	80*	The fermentation tanks and tools should be disinfected just before use. Appropriate acidification should be provided.	1	10	6	60
		119	B: Survival of acid tolerant pathogens microorganisms during fermentation (*E. coli O157:H7*) due to improper fermentation conditions	3	10	2	60*	Process challenge tests must be carried out to determine whether the process achieves a special reduction of pathogens. Appropriate conditions (time, temperature, ph) for fermentation should be enhanced. The starter culture should be of adequate quantity to ensure rapid fermentation. The temperature of the environment should be kept at an optimum level to ensure adequate starter culture activity and this activity may be measured by pH changes. The fermentation environment should be efficient (clean, closed, without insects, dust). Prolonged fermentation should be avoided. Rapid acidification should be provided.	1	10	1	10

CP	Processing stage	Risk number	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections
		120	B: Growth and/or survival of microorganisms during fermentation (*Cl. botulinum*) due to improper fermentation conditions	1	10	6	60*	Process challenge tests must be carried out to determine whether the process achieves a special reduction of pathogens. Appropriate conditions (time, temperature, ph) for fermentation should be enhanced. The starter culture should be of adequate quantity to ensure rapid fermentation. The temperature of the environment should be kept at an optimum level to ensure adequate starter culture activity and this activity may be measured by pH changes. The fermentation environment should be efficient (clean, closed, without insects, dust). Prolonged fermentation should be avoided. Rapid acidification should be provided.	1	10	5	50
		121	B: Growth and/or survival of microorganisms during fermentation (*S. aureus, Salmonella, L. monocytogenes*) due to improper fermentation conditions	2	7	4	56*	Process challenge tests must be carried out to determine whether the process achieves a special reduction of pathogens. Appropriate conditions (time, temperature, ph) for fermentation should be enhanced. The starter culture should be of adequate quantity to ensure rapid fermentation. The temperature of the environment should be kept at an optimum level to ensure adequate starter culture activity and this activity may be measured by pH changes. The salt level and its distribution should be adjusted. The fermentation environment should be efficient (clean, closed, without insects, dust). Prolonged fermentation should be avoided. Rapid acidification should be provided.	1	7	3	21
		122	B: Formation of toxin by *S. aureus* due to improper fermentation conditions	2	7	4	56*	Rapid acidification should be provided. The salt level and distribution of salt should be adjusted.	1	7	3	21
		123	C: Disinfectant or detergent residue on the fermentation tanks due to application of inefficient washing procedures due to dirty fermentation equipment	4	3	5	60*	Equipment should be rinsed efficiently after cleaning. Rinsable and biodegredable detergents should be used for cleaning.	1	3	4	12
		124	C: Survival of aflatoxin (Ochratoxin A) due to poor fermentation conditions	2	8	2	32	None				
		125	P: Foreign objects (dust, insect fragments) transferred by air	8	1	2	16	None				
CP20	Sieving wheat flour	126	B: Contamination with microorganisms (*L. monocytogenesis, S. aureus*) due to unclean instrument	4	7	5	140*	Efficient cleaning, disinfection and prevention procedures of the equipment should be applied. Disinfection should follow immediately after cleaning and before a process run. All equipment should be routinely dismantled or parts loosened for disinfection. Cleaning efficacy should be monitored using indicators of hygiene by tests for coliform bacteria. The cleaning utensils (brushers, sponges and spray guns) themselves must be disinfected properly. Movements of personnel and goods should be limited. The correct hygienic design and proper maintenance of equipment should be provided.	1	7	4	28

CP	Processing stage	Risk number	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections
		127	B: Machinery mold (*Geotrichum candidum*) due to inefficient cleaning of equipment	5	9	3	135*	Good equipment cleaning procedure must be applied.	2	9	2	36
		128	B: Contamination with microorganisms (*E. coli O157:H7*) due to unclean instrument	2	10	4	80*	Efficient cleaning, disinfection and prevention procedures of the equipment should be applied. Disinfection should follow immediately after cleaning and before a process run. All equipment should be routinely dismantled or parts loosened for disinfection. Cleaning efficacy should be monitored using indicators of hygiene by tests for coliform bacteria. The cleaning utensils (brushers, sponges and spray guns) themselves must be disinfected properly. Movements of personnel and goods should be limited. The correct hygienic design and proper maintenance of equipment should be provided.	1	10	3	30
		129	C: Heavy metal contamination due to metal surfaces of instruments which come into contact with food	3	8	3	72*	The free iron on the surfaces of instruments should be detected and removed by chemical or mechanical methods. Moving parts and presence of rust on the instruments should be checked regularly. Food-grade metals must be used for all metal surfaces that come into contact with food. Non-lead solder and food-grade items must be used at any repairing.	1	8	2	16
		130	P: Foreign objects (wire pieces) due to old-expired equipment	4	7	3	84*	The efficiency of the equipment should be monitored periodically. The expired, broken pieces should be changed periodically.	2	7	2	28
CP21	Mixing wheat flour into the mixture (by electric mixer)	131	B: Contamination with microorganisms (*L. monocytogenesis*, *S. aureus*) due to unclean instrument	7	7	4	196*	Efficient cleaning, disinfection and prevention procedures of the equipment should be applied. Disinfection should follow immediately after cleaning and before a process run. All equipment should be routinely dismantled or parts loosened for disinfection. Cleaning efficacy should be monitored using indicators of hygiene by tests for coliform bacteria. The cleaning utensils (brushers, sponges and spray guns) themselves must be disinfected properly. Movements of personnel and goods should be limited. The correct hygienic design and proper maintenance of equipment should be provided.	1	7	3	21
		132	B: Machinery mold (*Geotrichum candidum*) due to inefficient cleaning of equipment	5	9	3	135*	Good equipment cleaning procedure must be applied.	2	9	2	36
		133	B: Contamination with microorganisms (*E. coli O157:H7*) due to unclean instrument	2	10	3	60*	Efficient cleaning, disinfection and prevention procedures of the equipment should be applied. Disinfection should follow immediately after cleaning and before a process run. All equipment should be routinely dismantled or parts loosened for disinfection. Cleaning efficacy should be monitored using indicators of hygiene by tests for coliform bacteria. The cleaning utensils (brushers, sponges and spray guns) themselves must be disinfected properly. Movements of personnel and goods should be limited. The correct hygienic design and proper maintenance of equipment should be provided.	1	10	2	20

CP	Processing stage	Risk number	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections
		134	C: Disinfectant or detergent residue on mixer due to application of inefficient washing procedures	4	3	5	60*	Detergents must be rinsable and biodegredable. Disinfectants should be non toxic and non-corrosive. The equipment should be rinsed appropriately following the cleaning.	1	3	4	12
		135	C: Heavy metal contamination due to metal surfaces of instruments which come into contact with food	1	8	3	24	None				
		136	P: Foreign objects (metal pieces) due to old-expired equipment	3	6	1	18	None				
CP22	Fermentation of tarhana (in stainless steel tanks, 3 days)	137	B: Survival of parasites (*Cryptosporidium, Giardia lamblia*) due to improper fermentation conditions	3	7	5	105*	Appropriate acidification should be provided.	1	7	4	28
		138	B: Survival of virus (Rotavirus, Hepatitis A) due to improper fermentation conditions	1	10	8	80*	The fermentation tanks and tools should be disinfected just before use. Appropriate acidification should be provided.	1	10	6	60
		139	B: Survival of acid tolerant pathogens microorganisms during fermentation (*E. coli O157:H7*) due to improper fermentation conditions	3	10	2	60*	Process challenge tests must be carried out to determine whether the process achieves a special reduction of pathogens. Appropriate conditions (time, temperature, ph) for fermentation should be enhanced. The starter culture should be of adequate quantity to ensure rapid fermentation. The temperature of the environment should be kept at an optimum level to ensure adequate starter culture activity and this activity may be measured by pH changes. The fermentation environment should be efficient (clean, closed, without insects, dust). Prolonged fermentation should be avoided. Rapid acidification should be provided.	1	10	1	10
		140	B: Growth and/or survival of microorganisms during fermentation (*Cl. botulinum*) due to improper fermentation conditions	1	10	6	60*	Process challenge tests must be carried out to determine whether the process achieves a special reduction of pathogens. Appropriate conditions (time, temperature, ph) for fermentation should be enhanced. The starter culture should be of adequate quantity to ensure rapid fermentation. The temperature of the environment should be kept at an optimum level to ensure adequate starter culture activity and this activity may be measured by pH changes. The fermentation environment should be efficient (clean, closed, without insects, dust). Prolonged fermentation should be avoided. Rapid acidification should be provided.	1	10	5	50
		141	B: Growth and/or survival of microorganisms during fermentation (*S. aureus, Salmonella, L. monocytogenes*) due to improper fermentation conditions	2	7	4	56*	Process challenge tests must be carried out to determine whether the process achieves a special reduction of pathogens. Appropriate conditions (time, temperature, ph) for fermentation should be enhanced. The starter culture should be of adequate quantity to ensure rapid fermentation. The temperature of the environment should be kept at an optimum level to ensure adequate starter culture activity and this activity may be measured by pH changes. The salt level and its distribution should be adjusted. The fermentation environment should be efficient (clean, closed, without insects, dust). Prolonged fermentation should be avoided. Rapid acidification should be provided.	1	7	3	21
		142	B: Formation of toxin by *S. aureus* due to improper fermentation conditions	2	7	4	56*	Rapid acidification should be provided. The salt level and distribution of salt should be adjusted.	1	7	3	21

CP	Processing stage	Risk number	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections
		143	C: Disinfectant or detergent residue on the fermentation tanks due to application of inefficient washing procedures due to dirty fermentation equipment	4	3	5	60*	Equipment should be rinsed efficiently after cleaning. Rinsable and biodegredable detergents should be used for cleaning.	1	3	4	12
		144	C: Survival of aflatoxin (Ochratoxin A) due to poor fermentation conditions	2	8	2	32	None				
		145	P: Foreign objects (dust, insect fragments) transferred by air	8	1	2	16	None				
CP23	Dividing the dough (by hand)	146	B: Virus (NLV) contamination by personnel handling.	3	7	8	168*	Personnel should be trained to understand the risk associated with cross-contamination and they should be provided with appropriate facilities to operate good hygienic practice e.g. hand basin and bactericidal soaps. Table ledges, door handlers, overhead pipes and many other areas should be routinely disinfected. Hands-on operations should be minimised.	2	7	6	84
		147	B: Virus (Rotavirus, Hepatitis A) contamination by personnel handling	2	10	8	160*	Personnel should be trained to understand the risk associated with cross-contamination and they should be provided with appropriate facilities to operate good hygienic practice e.g. hand basin and bactericidal soaps. Table ledges, door handlers, overhead pipes and many other areas should be routinely disinfected. Hands-on operations should be minimised. Personnel must get vaccinated for Hepatitis A.	1	10	6	60
		148	B: Contamination with microorganisms (*S. aureus, L. monocytogenes*, *Shigella spp*.) due to personnel handling	3	7	4	84*	Personnel should be trained to understand the risk associated with cross-contamination and they should be provided with appropriate facilities to operate good hygienic practice e.g. hand basin and bactericidal soaps. Table ledges, door handlers, overhead pipes and many other areas should be routinely disinfected. Hands-on operations should be minimised.	2	7	3	42
		149	B: Pathogen (*Shigella dysenteriae*) contamination by personnel handling	2	10	4	80*	Personnel should be trained to understand the risk associated with cross-contamination and they should be provided with appropriate facilities to operate good hygienic practice e.g. hand basin and bactericidal soaps. Table ledges, door handlers, overhead pipes and many other areas should be routinely disinfected. Hands-on operations should be minimised.	1	10	3	30
		150	B: Parasite zoones (Protozoa- *Cryptosporidium parvum, Giardia duodenalis, Blastocystis hominis*) transmitted by contaminated hands	2	8	4	64*	Personnel should be trained on hygiene and hand washing and they should be provided with appropriate facilities to operate good hygienic practice e.g. hand basin and bactericidal soaps. Table ledges, door handlers, overhead pipes and many other areas should be routinely disinfected. Hands-on operations should be minimised. Medical examination should be applied to employees on a continuous basis.	2	9	3	54
		151	P: Foreign objects (jewelery, button, fingernail, pieces of glove) due to personal effects	1	8	1	8	None				

CP	Processing stage	Risk number	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections
CP24	Drying tarhana (1 day)	152	B: Contamination with microorganisms (*E. coli, Salmonella*) due to improper drying conditions, contamination by flies, rodents and cockroaches	2	10	4	80*	Tarhana should be dried in a clean, dry and closed area to avoid insect and rodent infestation. Drying time and final moisture content should be monitored. Personnel should change shoes when entering the area.	1	10	3	30
		153	B: Growth of microorganisms (*S. aureus*) due to prolonged drying time and improper drying conditions	3	7	3	63*	Tarhana should be dried in a clean, dry and closed area to avoid insect and rodent infestation. Drying time and final moisture content should be monitored. Personnel should change shoes when entering the area.	2	7	2	28
		154	C: Mycotoxin contamination due to poor drying conditions	7	8	2	112*	Tarhana should be dried in a clean and dry area (to avoid dust) and with minimum temperature fluctuations (to indicate mold growth) as well as to reduce moisture by regular aeration to avoid mold contamination and growth. Personnel should change shoes when entering the area.	3	8	1	24
		155	C: Toxins (benzoquinones) and allergens, maintained from the body fluids or tissues of some insects (flour beetles, mites, cockroaches)	2	5	3	30	None				
		156	P: Foreign objects (dust, sand) contamination which transferred by air and insect fragments	8	1	1	8	None				
CP25	Milling tarhana (by electric mill)	157	B: Contamination with microorganisms (*L. monocytogenesis, S. aureus*) due to unclean instrument	7	7	4	196*	Efficient cleaning, disinfection and prevention procedures of the equipment should be applied. Disinfection should follow immediately after cleaning and before a process run. All equipment should be routinely dismantled or parts loosened for disinfection. Cleaning efficacy should be monitored using indicators of hygiene by tests for coliform bacteria. The cleaning utensils (brushers, sponges and spray guns) themselves must be disinfected properly. Movements of personnel and goods should be limited. The correct hygienic design and proper maintenance of equipment should be provided.	1	7	3	21
		158	B: Machinery mold (*Geotrichum candidum*) due to inefficient cleaning of equipment	5	9	3	135*	Good equipment cleaning procedure must be applied.	2	9	2	36
		159	B: Contamination with microorganisms (*E. coli O157:H7*) due to unclean instrument	2	10	3	60*	Efficient cleaning, disinfection and prevention procedures of the equipment should be applied. Disinfection should follow immediately after cleaning and before a process run. All equipment should be routinely dismantled or parts loosened for disinfection. Cleaning efficacy should be monitored using indicators of hygiene by tests for coliform bacteria. The cleaning utensils (brushers, sponges and spray guns) themselves must be disinfected properly. Movements of personnel and goods should be limited. The correct hygienic design and proper maintenance of equipment should be provided.	1	10	2	20

CP	Processing stage	Risk number	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections
		160	C: Heavy metal contamination due to metal surfaces of instruments which come into contact with food	3	8	3	72*	The free iron on the surfaces of instruments should be detected and removed by chemical or mechanical methods. Moving parts and presence of rust on the instruments should be checked regularly. Food-grade metals must be used for all metal surfaces that come into contact with food. Non-lead solder and food-grade items must be used at any repairing.	1	8	2	16
		161	P: Foreign objects (machinery parts) due to old-expired equipment	2	6	2	24	None				
CP26	Sieving tarhana	162	B: Contamination with microorganisms (*L. monocytogenesis, S. aureus*) due to unclean instrument	7	7	4	196*	Efficient cleaning, disinfection and prevention procedures of the equipment should be applied. Disinfection should follow immediately after cleaning and before a process run. All equipment should be routinely dismantled or parts loosened for disinfection. Cleaning efficacy should be monitored using indicators of hygiene by tests for coliform bacteria. The cleaning utensils (brushers, sponges and spray guns) themselves must be disinfected properly. Movements of personnel and goods should be limited. The correct hygienic design and proper maintenance of equipment should be provided.	1	7	3	21
		163	B: Machinery mold (*Geotrichum candidum*) due to inefficient cleaning of equipment	5	9	3	135*	Good equipment cleaning procedure must be applied.	2	9	2	36
		164	B: Contamination with microorganisms (*E. coli O157:H7*) due to unclean instrument	2	10	3	60*	Efficient cleaning, disinfection and prevention procedures of the equipment should be applied. Disinfection should follow immediately after cleaning and before a process run. All equipment should be routinely dismantled or parts loosened for disinfection. Cleaning efficacy should be monitored using indicators of hygiene by tests for coliform bacteria. The cleaning utensils (brushers, sponges and spray guns) themselves must be disinfected properly. Movements of personnel and goods should be limited. The correct hygienic design and proper maintenance of equipment should be provided.	1	10	2	20
		165	C: Heavy metal contamination due to metal surfaces of instruments which come into contact with food	3	8	3	72*	The free iron on the surfaces of instruments should be detected and removed by chemical or mechanical methods. Moving parts and presence of rust on the instruments should be checked regularly. Food-grade metals must be used for all metal surfaces that come into contact with food. Non-lead solder and food-grade items must be used at any repairing.	1	8	2	16
		166	P: Hard foreign objects (wire from sieving) due to old-expired equipment	4	7	3	84*	Metal detectors should be used. Detectors should be carefully chosen and calibrated to pick up the smallest pieces of metal. The efficiency of the equipment should be monitored and its expired, broken pieces should be changed periodically.	2	7	2	28

CP	Processing stage	Risk number	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections
CP27	Drying tarhana (5 days)	167	B: Contamination with microorganisms (*E. coli, Salmonella*) due to improper drying conditions, contamination by flies, rodents and cockroaches	2	10	4	80*	Tarhana should be dried in a clean, dry and closed area to avoid insect and rodent infestation. Drying time and final moisture content should be monitored.	1	10	3	30
		168	B: Growth of microorganisms (*S. aureus*) due to extended drying time and improper drying conditions	3	7	3	63*	Tarhana should be dried in a clean, dry and closed area to avoid insect and rodent infestation. Drying time and final moisture content should be monitored.	2	7	2	28
		169	C: Mycotoxin contamination due to poor drying conditions	7	8	2	112*	Tarhana should be dried in a clean and dry area (to avoid dust) and with minimum temperature fluctuations (to indicate mold growth) as well as to reduce moisture by regular aeration to avoid mold contamination and growth.	3	8	1	24
		170	C: Toxins (benzoquinones) and allergens, maintained from the body fluids or tissues of some insects (flour beetles, mites, cockroaches)	2	5	3	30	None				
		171	P: Foreign objects (dust, sand) contamination which transferred by air and insect fragments	8	1	1	8	None				
CP28	Packaging (with nylon bags)	172	B: Virus (NLV) contamination by personnel handling	2	7	8	112*	Personnel should be trained to understand the risk associated with cross-contamination and they should be provided with appropriate facilities to operate good hygienic practice e.g. hand basin and bactericidal soaps. Table ledges, door handlers, overhead pipes and many other areas should be routinely disinfected. Hands-on operations should be minimised.	1	7	6	42
		173	B: Virus (Rotavirus, Hepatitis A) contamination by personnel handling	1	10	8	80*	Personnel should be trained to understand the risk associated with cross-contamination and they should be provided with appropriate facilities to operate good hygienic practice e.g. hand basin and bactericidal soaps. Table ledges, door handlers, overhead pipes and many other areas should be routinely disinfected. Hands-on operations should be minimised. Personnel must get vaccinated for Hepatitis A.	1	10	6	60
		174	B: Contamination with microorganisms (*S. aureus, L. monocytogenes, Shigella spp.*) due to personnel handling	4	7	2	56*	Bare hand contact with the product must be avoided. Personnel should comply with the Good Manufacturing Practice and avoid extraneous materials, such as insects and rodent hairs, in the final product. Efficient lighting and temperature must be provided in the environment to avoid personnel failures.	2	7	1	14
		175	B: Survival of pathogens (*Cl. Botulinum, E. coli*) due to inappropriate preparation of the food (post process)	3	9	2	54*	Appropriate information should be given on the product packaging to provide guidance concerning safe handling and storage conditions and cooking processes that need to be employed.	2	9	1	18
		176	C: Low molecular weight substances (Biosphenol A), migrated from the packaging material into the food	2	9	3	54*	Packaging material should be suitable for coming in contact with food.	1	9	2	18
		177	C: Heavy metal contamination (lead) due to lead based printings used for packaging	1	8	1	8	None				

CP	Processing stage	Risk number	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections
		178	P: Foreign objects due to personal effects (false fingernail, button, hair, apron and glove pieces) and inappropriate packaging (pieces of packaging material)	6	4	1	24	None				

* Corrective actions are required since RPN is above 50.

Table A.2. Failure mode and effect analysis table for the Maraş tarhana production

CP	Processing stage	Risk number	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections
CP1	Receiving wheat	1	B: Microorganisms (*E. coli, C.botulinum, Shigella*) due to improper storage conditions, transferred by rodent excreta and diseased seeds	6	7	2	84*	It must be avoided to supply diseased grains. Grain moisture level must be tested by a grain moisture tester.	3	10	1	30
		2	B: Microorganisms (*B. Cereus, Sallmonella spp., C. perfringens, Micrococcus, Alcaligenes*) due to improper storage conditions, transferred by rodent excreta and diseased seeds	6	7	2	84*	It must be avoided to supply diseased grains. Grain moisture level must be tested by a grain moisture tester.	3	7	1	21
		3	B: Fungi (*Ascohyta fagopyri, Sclerotinia sp, Peronospora documeti, Botrytis cinerea, Fusarium sp., Phyllosticta polyconorum, Cercospora fagopyri*) due to inefficient post harvest operations like poor storage	6	5	2	60*	Wheat must come from approved suppliers. It must come along with quality certificates. The certificates should report the moisture content of wheat, the number/ colonies of fungi that appear compared with the upper-approved standards. Visual control of the wheat must be carried out in order to detect the high humidity, undesirable odours and defective grains. Grain moisture content must be measured by a grain moisture tester. It must avoid to supply grains which were stored in long duration (more than 3 months). The defective grains must be removed by physical methods like density, air blowing, specific gravity tables and dry cleaning.	2	5	1	10
		4	C: Pesticide, Insecticide residues due to post harvest pesticides, applied to protect the stored food from pests	8	8	3	192*	Wheat must come from approved suppliers. It must come along with quality certificates and a pesticide analysis. The certificates should report the pesticide content of the wheat. It must avoid to supply grains which were stored with insecticide application.	2	8	2	32
		5	C: Mycotoxins (Deoxynilvaneol, Aflatoxin, Ochratoxin A) produced by mold which present due to environmental conditions in growing period of the crop and poor storage during the post-harvest period	8	8	2	128*	Wheat must come from approved suppliers. It must come along with quality certificates and a mycotoxin analysis. The certificates should report the moisture content of wheat, the average of the occurring foreign materials, and as far as the mycotoxins are concerned, the number/ colonies of insects and fungi that appear compared with the upper-approved standards. Visual control of the wheat must be carried out in order to detect the presence of extraneous materials, high humidity, undesirable odours and defective grains. Grain moisture content must measure by a grain moisture tester. It must avoid to supply grains which were stored in long duration (more than 3 months). The defective grains must be removed by physical methods like density, air blowing, specific gravity tables and dry cleaning.	2	8	1	16
		6	C: Heavy metal contamination (lead, cadmium) due to usage of contaminated soil and/or water in the agricultural land.	6	10	2	120*	Wheat must come from approved suppliers. It must be considered whether the land used to produce crops have been treated with lead containing pesticides or sewage sludge. Wheat must be washed before using.	2	10	1	20

CP	Processing stage	Risk number	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections
		7	C: Toxins and allergens, maintained from some storage pests	5	3	3	45	None				
		8	P: Pests (Angoumois grain moth-*Sitotroga cerealella*-, weevils- *Sitophilus spp*.-, confused flour beetles-*Tribolium spp*.-, saw-toothed grain beetles, mites), rodent excreta pellets, insect pieces due to inefficient post harvest applications like poor storage conditions	7	3	4	84*	The grains should be inspected visually. It must be avoided to supply grains which were stored in more than 3 months. The grains, damaged, cracked and with holes, shouldn't be supplied . Moisture level of grains should be measured by a tester and grains moisture content must be under 7%.	2	3	3	18
		9	P: Hard foreign objects (stone) found in wheat due to inefficient visual inspection and sorting	8	5	2	80*	The stones should be removed physically and washed efficiently just before usage	2	5	1	10
		10	P: Foreign objects, presence of wild plants (specks of Lolium perenne, Vicia sativa L.)) due to improper harvesting practices	5	3	1	15	None				
CP2	Receiving yoghurt	11	B: Microorganisms (*Y. enterocolitica, S. aureus, L. monocytogenes*), survived due to inefficient fermentation conditions.	3	7	3	63*	Yoghurt must be manufactured and purchased from approved suppliers. Its receipt should be accompanied with certificates of quality control. The certificates should report the microbial content of yoghurt, and its comparison with the upper approved standards. Yoghurt should be supplied in low temperatures (2-3°C).	1	7	2	14
		12	B: Microorganisms (*E. Coli O157:H7*), survived due to inefficient fermentation conditions.	3	10	2	60*	Yoghurt must be manufactured and purchased from approved suppliers. Its receipt should be accompanied with certificates of quality control. The certificates should report the microbial content of yoghurt, and its comparison with the upper approved standards. Yoghurt should be supplied in low temperatures (2-3°C).	1	10	1	10
		13	B: Molds, yeast , survived due to inefficient fermentation conditions.	5	6	2	60*	Yoghurt must be manufactured and purchased from approved suppliers. Its receipt should be accompanied with certificates of quality control. The certificates should report the mould count of yoghurt, and its comparison with the upper approved standards. Yoghurt should be supplied in low temperatures (2-3°C).	1	6	1	6
		14	C: Dioxin due to accumulation of the pollutants into the fatty tissues and products of animals.	6	8	3	144*	The dairy supplier must provide the documents certifying the dioxin content of yoghurt. Tarhana producer should pay attention to the dioxin levels on the documents and evaluate the results.	2	8	2	32
		15	C: Heavy metal contamination due to contaminated milk	10	10	1	100*	Yoghurt must be manufactured and purchased from approved suppliers. Its receipt should be accompanied with certificates of quality control. The certificates should report the heavy metal content of yoghurt, comparison with the upper approved standards.	1	10	1	10
		16	C: Pesticide residue due to bioaccumulation on milk	5	8	2	80*	Yoghurt must be manufactured and purchased from approved suppliers. Its receipt should be accompanied with certificates of quality control. The certificates should report the pesticide residue content of yoghurt, comparison with the upper approved standards.	2	8	1	16
		17	C: Veterinary drug residues due to drugs given into unhealthy animal	7	9	1	63*	Yoghurt must be manufactured and purchased from approved suppliers. Its receipt should be accompanied with certificates of quality control. The certificates should report the drug residue content of yoghurt, comparison with the upper approved standards.	1	9	1	9
		18	P: Foreign objects (animal leucocyte cells.) due to using inefficiently filtrated milk	2	1	10	20	None				

CP	Processing stage	Risk number	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections
		19	P: Foreign objects (animal hair, chaff) due to using inefficiently filtrated milk	2	1	1	2	None				
CP3	Receiving thyme, dried	20	C: Pesticide residue due to deficient pesticide applications in the agricultural land	2	8	2	32	None				
		21	P: Foreign objects (soil, sand) due to improper harvesting practices	6	3	2	36	None				
CP4	Receiving salt	22	C: Additives, magnesium carbonate, calcium phosphate, calcium carbonate, magnesium oxide, added over the legal limits	2	6	1	12	None				
		23	P: Foreign objects due to failure in processing	3	5	1	15	None				
CP5	Cleaning the stones of wheat (by dry stoner)	24	P: Hard foreign objects (stone) due to insufficient cleaning of wheat	8	5	1	40	None				
CP6	Washing wheat	25	B: Contamination with *Salmonella thyphimurium* and *E. coli* due to contaminated water used for washing	3	10	3	90*	Wash water should be clean. Water only from a public water system that is regularly monitored and chlorinated should be used.	1	10	2	20
		26	B: Contamination with *Shigella*, and *Aeromonas* due to contaminated water used for washing	6	7	2	84*	Wash water should be clean. Water only from a public water system that is regularly monitored and chlorinated should be used.	2	7	1	14
		27	B: Parasite zoones (Microspora- *Enterocytozooan bieneusi*, *Encephalitozoon cuniculi*, Protozoa- *Cryptosporidium parvum, Giardia duodenalis, Toxoplasma gondii, Blastocystis hominis,* , Pentastomids- *Armillifer armillatus*) transmitted by water	4	8	2	64*	Wheat should be washed with clean and safe water. Water only from a public water system that is regularly monitored and chlorinated should be used.	2	9	1	18
		28	C: Pesticide residue due to inappropriate washing	6	8	3	144*	Wheat should be washed appropriately.	2	8	2	32
		29	P: Foreign objects (sand) due to insufficient washing of wheat	8	1	1	8	None				
		30	P: Foreign objects (pieces of materials) due to material degradation and defects of water pipeline	1	3	2	6	None				
CP7	Shelling of wheat (by stone mill)	31	B: Contamination with microorganisms (*L. monocytogenesis, S. aureus*) due to unclean instrument	4	7	4	112*	Efficient cleaning, disinfection and prevention procedures of the equipment should be applied. All equipment should be routinely dismantled or parts loosened for disinfection.	1	7	3	21
		32	B: Contamination with microorganisms (*E. Coli O157:H7*) due to unclean instrument	2	10	3	60*	Efficient cleaning, disinfection and prevention procedures of the equipment should be applied. All equipment should be routinely dismantled or parts loosened for disinfection.	1	10	2	20
		33	P: Foreign objects (wheat shells) due to improper shelling	6	1	2	12	None				
CP8	Cooling wheat (in stainless steel tanks, 4 h)	34	B: Growth of bacterial spores due to prolonged cooling	1	7	4	28	None				
		35	P: Foreign objects (soil, dirt) fell in food due to uncovered pot	8	1	1	8	None				

CP	Processing stage	Risk number	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections
CP9	Mixing and kneading (by electric mixer)	36	B: Contamination with microorganisms (*L. monocytogenesis, S. aureus*) due to unclean instrument	7	7	4	196*	Efficient cleaning, disinfection and prevention procedures of the equipment should be applied. Disinfection should follow immediately after cleaning and before a process run. All equipment should be routinely dismantled or parts loosened for disinfection. Cleaning efficacy should be monitored using indicators of hygiene by tests for coliform bacteria. The cleaning utensils (brushers, sponges and spray guns) themselves must be disinfected properly. Movements of personnel and goods should be limited. The correct hygienic design and proper maintenance of equipment should be provided.	1	7	3	21
		37	B: Contamination with microorganisms (*E. Coli O157:H7*) due to unclean instrument	2	10	3	60*	Efficient cleaning, disinfection and prevention procedures of the equipment should be applied. Disinfection should follow immediately after cleaning and before a process run. All equipment should be routinely dismantled or parts loosened for disinfection. Cleaning efficacy should be monitored using indicators of hygiene by tests for coliform bacteria. The cleaning utensils (brushers, sponges and spray guns) themselves must be disinfected properly. Movements of personnel and goods should be limited. The correct hygienic design and proper maintenance of equipment should be provided.	1	10	2	20
		38	C: Disinfectant or detergent residue on mixer due to application of inefficient washing procedures	4	3	5	60*	Detergents must be rinsable and biodegredable. Disinfectants should be non toxic and non-corrosive. The equipment should be rinsed appropriately following the cleaning.	1	3	4	12
		39	C: Heavy metal contamination to metal surfaces of instruments which come into contact with food	1	8	3	24	None				
		40	P: Foreign objects (metal pieces) due to old-expired equipment	3	6	1	18	None				
CP10	Holding the dough at room temperature (fermentation) (approx. 15 hours)	41	B: Survival of parasites (*Cryptosporidium, Giardia lamblia*) due to inefficient fermentation conditions	4	7	5	140*	Appropriate acidification should be provided.	1	7	4	28
		42	B: Growth and/or survival of microorganisms during fermentation (*Cl. botulinum*) due to inefficient fermentation conditions	2	10	6	120*	Process challenge tests must be carried out to determine whether the process achieves a special reduction of pathogens. Appropriate conditions (time, temperature, ph) for fermentation should be enhanced. The fermentation environment should be efficient (clean, closed, without insects, dust). Rapid acidification should be provided.	1	10	5	50
		43	B: Growth and/or survival of microorganisms during fermentation (*S. aureus, Salmonella, L. monocytogenes*) due to inefficient fermentation conditions	3	7	4	84*	Process challenge tests must be carried out to determine whether the process achieves a special reduction of pathogens. Appropriate conditions (time, temperature, ph) for fermentation should be enhanced. The fermentation environment should be efficient (clean, closed, without insects, dust). Rapid acidification should be provided.	2	7	3	42
		44	B: Formation of toxin by *S. aureus* due to inefficient fermentation conditions	3	7	4	84*	Rapid acidification should be provided. The salt level and distribution of salt should be adjusted.	1	7	3	21

CP	Processing stage	Risk number	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections
		45	B: Survival of acid tolerant pathogens microorganisms during fermentation (*E. coli O157:H7*) due to inefficient fermentation conditions	4	10	2	80*	Process challenge tests must be carried out to determine whether the process achieves a special reduction of pathogens. Appropriate conditions (time, temperature, ph) for fermentation should be enhanced. The fermentation environment should be efficient (clean, closed, without insects, dust). Rapid acidification should be provided.	2	10	1	20
		46	C: Survival of aflatoxin (Ochratoxin A) due to poor fermentation conditions	2	8	2	32	None				
		47	P: Foreign objects (soil, dirt, sand, insect pieces) due to uncovered tank	8	1	1	8	None				
CP11	Spreading the tarhana on plastic mats	48	B: Virus (NLV) contamination by personnel handling.	3	7	8	168*	Personnel should be trained to understand the risk associated with cross-contamination and they should be provided with appropriate facilities to operate good hygienic practice e.g. hand basin and bactericidal soaps. Table ledges, door handlers, overhead pipes and many other areas should be routinely disinfected. Hands-on operations should be minimised.	2	7	6	84
		49	B: Virus (Rotavirus, Hepatitis A) contamination by personnel handling.	2	10	8	160*	Personnel should be trained to understand the risk associated with cross-contamination and they should be provided with appropriate facilities to operate good hygienic practice e.g. hand basin and bactericidal soaps. Table ledges, door handlers, overhead pipes and many other areas should be routinely disinfected. Hands-on operations should be minimised. Personnel must get vaccinated for Hepatitis A.	1	10	6	60
		50	B: Pathogen (*Shigella dysenteriae*) contamination by personnel handling	3	10	4	120*	Personnel should be trained to understand the risk associated with cross-contamination and they should be provided with appropriate facilities to operate good hygienic practice e.g. hand basin and bactericidal soaps. Table ledges, door handlers, overhead pipes and many other areas should be routinely disinfected. Hands-on operations should be minimised.	1	10	3	30
		51	B: Contamination with microorganisms (*S. aureus, L. monocytogenes, Shigella* spp.) due to personnel handling	4	7	4	112*	Personnel should be trained to understand the risk associated with cross-contamination and they should be provided with appropriate facilities to operate good hygienic practice e.g. hand basin and bactericidal soaps. Table ledges, door handlers, overhead pipes and many other areas should be routinely disinfected. Hands-on operations should be minimised.	2	7	3	42
		52	B: Parasite zoones (Protozoa- *Cryptosporidium parvum, Giardia duodenalis, Blastocystis hominis*) transmitted by contaminated hands	2	8	4	64*	Personnel should be trained on hygiene and hand washing and they should be provided with appropriate facilities to operate good hygienic practice e.g. hand basin and bactericidal soaps. Table ledges, door handlers, overhead pipes and many other areas should be routinely disinfected. Hands-on operations should be minimised. Medical examination should be applied to employees on a continuous basis.	2	9	3	54
		53	P: Foreign objects due to personal effects (false fingernail, hair, feather) and old, defective mat material	8	1	2	16	None				

CP	Processing stage	Risk number	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections
CP12	Drying tarhana (3-4 h)	54	B: Contamination with microorganisms (*E. coli, Salmonella*) due to improper drying conditions, contamination by flies, rodents and cockroaches	2	10	4	80*	Tarhana should not be dried in outdoor environment. If necessary to dry the tarhana outside, a shelter must be used and tarhana should be placed on a platform. Good drying practices should be applied. It must be avoided food to come in contact with any dust and other foreign materials. Drying time should be monitored. Personnel should change shoes when entering the area.	1	10	3	30
		55	B: Growth of microorganisms (*S. aureus*) due to extended drying time and improper drying conditions	3	7	3	63*	Tarhana should not be dried in outdoor environment. If necessary to dry the tarhana outside, a shelter must be used and tarhana should be placed on a platform. Good drying practices should be applied. It must be avoided food to come in contact with any dust and other foreign materials. Drying time should be monitored. Personnel should change shoes when entering the area.	2	7	2	28
		56	C: Mycotoxins due to poor drying conditions	7	8	2	112*	Tarhana should not be dried in outdoor environment. If necessary to dry the tarhana outside, a shelter must be used and tarhana should be placed on a platform. Good drying practices should be applied. It must be avoided food to come in contact with any dust and other foreign materials. Personnel should change shoes when entering the area.	3	8	1	24
		57	C: Toxins (benzoquinones) and allergens, maintained from the body fluids or tissues of some insects (flour beetles, mites, cockroaches)	2	5	3	30	None				
		58	P: Foreign objects (dust, sand) transferred by air, insect fragments	8	3	1	24	None				
CP13	Drying tarhana (after reversing) (5-6 h)	59	B: Contamination with microorganisms (*E. coli, Salmonella*) due to improper drying conditions, contamination by flies, rodents and cockroaches	2	10	4	80*	Tarhana should not be dried in outdoor environment. If necessary to dry the tarhana outside, a shelter must be used and tarhana should be placed on a platform. Good drying practices should be applied. It must be avoided food to come in contact with any dust and other foreign materials. Drying time should be monitored. Personnel should change shoes when entering the area.	1	10	3	30
		60	B: Growth of microorganisms (*S. aureus*) due to extended drying time and improper drying conditions	3	7	3	63*	Tarhana should not be dried in outdoor environment. If necessary to dry the tarhana outside, a shelter must be used and tarhana should be placed on a platform. Good drying practices should be applied. It must be avoided food to come in contact with any dust and other foreign materials. Drying time should be monitored. Personnel should change shoes when entering the area.	2	7	2	28
		61	C: Mycotoxins due to poor drying conditions	7	8	2	112*	Tarhana should not be dried in outdoor environment. If necessary to dry the tarhana outside, a shelter must be used and tarhana should be placed on a platform. Good drying practices should be applied. It must be avoided food to come in contact with any dust and other foreign materials. Mould count of the product should be tested. Personnel should change shoes when entering the area.	3	8	1	24
		62	C: Heavy metal contamination due to dust and air pollutants	2	9	3	54*	The drying process of Maraş tarhana should be carried out in an indoor environment, tarhana should cover with a shelter and place on a platform with a distance from ground.	1	9	2	18

CP	Processing stage	Risk number	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections
		63	C: Toxins (benzoquinones) and allergens, maintained from the body fluids or tissues of some insects (flour beetles, mites, cockroaches)	2	5	3	30	None				
		64	P: Foreign objects (dust, sand) transferred by air, insect fragments	8	3	1	24	None				
CP14	Removing the dried tarhana from mats (by hand)	65	B: Virus (NLV) contamination by personnel handling.	3	7	8	168*	Personnel should be trained to understand the risk associated with cross-contamination and they should be provided with appropriate facilities to operate good hygienic practice e.g. hand basin and bactericidal soaps. Table ledges, door handlers, overhead pipes and many other areas should be routinely disinfected. Hands-on operations should be minimised.	2	7	6	84
		66	B: Virus (Rotavirus, Hepatitis A) contamination by personnel handling.	2	10	8	160*	Personnel should be trained to understand the risk associated with cross-contamination and they should be provided with appropriate facilities to operate good hygienic practice e.g. hand basin and bactericidal soaps. Table ledges, door handlers, overhead pipes and many other areas should be routinely disinfected. Hands-on operations should be minimised. Personnel must get vaccinated for Hepatitis A.	1	10	6	60
		67	B: Pathogen (*Shigella dysenteriae*) contamination by personnel handling	3	10	4	120*	Personnel should be trained to understand the risk associated with cross-contamination and they should be provided with appropriate facilities to operate good hygienic practice e.g. hand basin and bactericidal soaps. Table ledges, door handlers, overhead pipes and many other areas should be routinely disinfected. Hands-on operations should be minimised. The product should be tested by coliform.	1	10	3	30
		68	B: Contamination with microorganisms (*S. aureus, L. monocytogenes*, *Shigella spp.*) due to personnel handling	4	7	4	112*	Personnel should be trained to understand the risk associated with cross-contamination and they should be provided with appropriate facilities to operate good hygienic practice e.g. hand basin and bactericidal soaps. Table ledges, door handlers, overhead pipes and many other areas should be routinely disinfected. Hands-on operations should be minimised. The product should be tested by coliform.	2	7	3	42
		69	B: Parasite zoones (Protozoa- *Cryptosporidium parvum, Giardia duodenalis, Blastocystis hominis*) transmitted by contaminated hands	2	8	4	64*	Personnel should be trained on hygiene and hand washing and they should be provided with appropriate facilities to operate good hygienic practice e.g. hand basin and bactericidal soaps. Table ledges, door handlers, overhead pipes and many other areas should be routinely disinfected. Hands-on operations should be minimised. Medical examination should be applied to employees on a continuous basis.	2	9	3	54
		70	P: Foreign objects due to personal effects (false fingernail, hair, feather) and old, defective mat material	8	1	2	16	Good and strong material should be used for spreading the tarhana on. Tarhana should be removed gently from the product.	1	6	1	6

CP	Processing stage	Risk number	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections
CP15	Packaging (with nylon bags)	71	B: Virus (NLV) contamination by personnel handling	2	7	8	112*	Personnel should be trained to understand the risk associated with cross-contamination and they should be provided with appropriate facilities to operate good hygienic practice e.g. hand basin and bactericidal soaps. Table ledges, door handlers, overhead pipes and many other areas should be routinely disinfected. Hands-on operations should be minimised.	1	7	6	42
		72	B: Virus (Rotavirus, Hepatitis A) contamination by personnel handling	1	10	8	80*	Personnel should be trained to understand the risk associated with cross-contamination and they should be provided with appropriate facilities to operate good hygienic practice e.g. hand basin and bactericidal soaps. Table ledges, door handlers, overhead pipes and many other areas should be routinely disinfected. Hands-on operations should be minimised. Personnel must get vaccinated for Hepatitis A.	1	10	6	60
		73	B: Contamination with microorganisms (*S. aureus, L. monocytogenes, Shigella spp.*) due to personnel handling	4	7	2	56*	Bare hand contact with the product must be avoided. Personnel should comply with the Good Manufacturing Practice and avoid extraneous materials, such as insects and rodent hairs, in the final product. Efficient lighting and temperature must be provided in the environment to avoid personnel failures.	2	7	1	14
		74	B: Survival of pathogens (*Cl. Botulinum, E. coli*) due to inappropriate preparation of the food (post process)	3	9	2	54*	Appropriate information should be given on the product packaging to provide guidance concerning safe handling and storage conditions and cooking processes that need to be employed.	2	9	1	18
		75	C: Low molecular weight substances (Biosphenol A), migrated from the packaging material into the food	2	9	3	54*	Packaging material should be suitable for coming in contact with food.	1	9	2	18
		76	C: Heavy metal contamination (lead) due to lead based printings used for packaging	1	8	1	8	None				
		77	P: Foreign objects due to personal effects (false fingernail, button, hair, apron and glove pieces) and inappropriate packaging (pieces of packaging material)	6	4	1	24	None				

* Corrective actions are required since RPN is above 50.

Table A.3. Failure mode and effect analysis table for the Uşak tarhana production

CP	Processing stage	Risk number	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections
CP1	Receiving Onion, dry	1	B: Virus (*Hepatitis A*) due to unsanitary agricultural applications	2	10	8	160*	Vegetables must come from approved suppliers. It must be considered whether the land used to produce crops have been treated with sewage sludge and fecally treated water and if the sanitary facilities are provided for field workers. Very soiled vegetables should not be purchased.	1	10	6	60
		2	B: Moulds, transferred by diseased onions (Bacterial soft rot, black mold rot, botrytis neck rot, blue mold rot, fusarium bulb rot caused by *Erwinia carotovora, Aspergillus alliaceus, Aspergillus niger, Botrytis allii, Fusarium spp.*)	7	5	2	70*	Onions must come from approved suppliers. Wounded, bruised and soiled bulbs should be excluded.	3	5	1	15
		3	B: Parasite zoones (Protozoa- *Cryptosporidium parvum, Giardia duodenalis, Toxoplasma gondii, Blastocystis hominis,* Nematodes- *Toxocara canis, Toxascaris leonina, Toxocara cati, Lagochilascaris minor,* Pentastomids-*Armillifer armillatus*) due to poor agricultural applications	4	8	2	64*	Vegetables should be handled carefully and supplied from reliable wholesalers/ producers. Handling of soiled and dirty vegetables should be avoided.	2	8	1	16
		4	C: Heavy metal contamination (lead, cadmium) due to usage of contaminated soil and/or water in the agricultural land.	8	10	3	240*	Vegetables must come from approved suppliers. It must be considered whether the agricultural land of crops was treated with lead containing pesticides, sewage sludge, irrigated water and/ or soil and effective agricultural approaches were applied to reduce metal accumulation on the soil. Very soiled onions should not be purchased.	2	10	2	40
		5	C: Pesticide residue due to deficient pesticide applications in the agricultural land.	6	8	3	144*	Vegetables must come from approved suppliers. The supplier must provide the documents certifying the safety of vegetables.	2	8	2	32
		6	C: Nitrate contamination due to environmental factors (soil, water) or fertilisers containing nitrate	5	7	3	105*	The supplier should report the nitrate concentration of vegetables by documents. The results should be in limits.	2	7	2	28
		7	P: Foreign objects (soil, sand) due to improper harvesting practices	8	1	1	8	None				
CP2	Receiving Tomatoes	8	B: Microorganisms (*salmonella, B. cereus, L. monocytogenes, shigella* spp., *aeromonas, Cl. perfringens*) due to inappropriate agricultural applications, irrigation of water and soil by faecal materials, and environmental factors like pests, and flies	5	7	5	175*	Vegetables must come from approved suppliers. It must be considered whether the land used to produce crops have been treated with sewage sludge. Defective vegetables shouldn't be supplied.	2	7	4	56

CP	Processing stage	Risk number	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections
		9	B: Virus (*Hepatitis A*) due to unsanitary agricultural applications	2	7	8	112*	Vegetables must come from approved suppliers. It must be considered whether the land used to produce crops have been treated with sewage sludge and fecally treated water and if the sanitary facilities are provided for field workers. Very soiled vegetables should not be purchased.	1	7	6	42
		10	B: Microorganisms (*E. coli O157:H7, Cl. botulinum*) due to inappropriate agricultural applications, irrigation of water and soil by faecal materials, and environmental factors like pests, and flies	2	10	5	100*	Vegetables must come from approved suppliers. It must be considered whether the land used to produce crops have been treated with sewage sludge. Defective vegetables shouldn't be supplied.	1	10	4	40
		11	B: Parasite zoones (Protozoa- *Cryptosporidium parvum, Giardia duodenalis, Toxoplasma gondii, Blastocystis hominis*, Nematodes- *Toxocara canis, Toxascaris leonina, Toxocara cati, Lagochilascaris minor*, Pentastomids-*Armillifer armillatus*) due to poor agricultural applications	4	8	2	64*	Vegetables should be handled carefully and supplied from reliable wholesalers/ producers. Handling of soiled and dirty vegetables should be avoided.	2	8	1	16
		12	B: Moulds, transferred by diseased and decaying tomatoes (Alternaria rot, soft rot, bacterial canker)	5	5	2	50*	Tomatoes must come from approved suppliers. Contaminated, damaged and discoloured tomatoes should be excluded by manual selection.	1	5	1	5
		13	C: Pesticide, herbicide, insecticide, and spray residues due to deficient pesticide applications in the agricultural land.	6	8	3	144*	Vegetables must come from approved suppliers. The supplier must provide the documents certifying the safety of vegetables.	2	8	2	32
		14	C: Mycotoxins produced by moulds *(Alternaria spp.)* which present due to environmental conditions in growing period of the crop	8	8	2	128*	The moldy, damaged, discoloured tomatoes must be removed physically by manual selection. The supplier must provide the documents certifying the mycotoxin content of vegetables.	2	8	1	16
		15	C: Nitrate contamination due to environmental factors (soil, water) or fertilisers containing nitrate	5	7	3	105*	The supplier should report the nitrate concentration of vegetables by documents. The results should be in limits.	2	7	2	28
		16	C: Heavy metal contamination (lead, cadmium) due to usage of contaminated soil and/or water in the agricultural land.	3	10	3	90*	Vegetables must come from approved suppliers. It must be considered whether the agricultural land of crops was treated with lead containing pesticides, sewage sludge, irrigated water and/ or soil and effective agricultural approaches were applied to reduce metal accumulation on the soil. Very soiled vegetables should not be purchased.	1	10	1	10
		17	C: Plant growth regulators (Oxins, Etilen, 2,4 D) due to poor agricultural applications	4	5	3	60*	Vegetables must come from approved suppliers.	2	5	2	20
		18	P: Foreign objects (eggs and larvae of small flies adhered to the food)	8	1	6	48	None				
		19	P: Foreign objects (soil, sand, dirt) due to improper harvesting practices	8	1	1	8	None				

CP	Processing stage	Risk number	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections
CP3	Receiving red pepper	20	B: Microorganisms (*salmonella, L. monocytogenes, shigella spp., aeromonas, Cl. perfringens*) due to inappropriate agricultural applications, irrigation of water and soil by faecal materials, and environmental factors like pests, and flies	5	7	5	175*	Vegetables must come from approved suppliers. It must be considered whether the land used to produce crops have been treated with sewage sludge. Defective vegetables shouldn't be supplied.	2	7	4	56
		21	B: Microorganisms (*E. coli O157:H7, Cl. botulinum*) due to inappropriate agricultural applications, irrigation of water and soil by faecal materials, and environmental factors like pests, and flies	2	10	5	100*	Vegetables must come from approved suppliers. It must be considered whether the land used to produce crops have been treated with sewage sludge. Defective vegetables shouldn't be supplied.	1	10	4	40
		22	B: Parasite zoones (Protozoa- *Cryptosporidium parvum, Giardia duodenalis, Toxoplasma gondii, Blastocystis hominis*, Nematodes- *Toxocara canis, Toxascaris leonina, Toxocara cati, Lagochilascaris minor*, Pentastomids-*Armillifer armillatus*) due to poor agricultural applications	4	8	2	64*	Vegetables should be handled carefully and supplied from reliable wholesalers/ producers. Handling of soiled and dirty vegetables should be avoided.	2	8	1	16
		23	B: Moulds, transferred by diseased peppers (Bacterial soft rot, gray mould rot, alternaria rot diseases of red pepper)	5	5	2	50	Peppers must come from approved suppliers. Injured peppers should be culled out.	3	5	1	15
		24	C: Pesticide residue due to deficient pesticide applications in the agricultural land.	6	8	3	144*	Vegetables must come from approved suppliers. The supplier must provide the documents certifying the safety of vegetables.	2	8	2	32
		25	C: Mycotoxins produced by moulds (Aflatoxin B1, produced by Aspergillus flavus) produced by mold which present due to environmental conditions in growing period of the crop	8	8	2	128*	The moldy, damaged, discoloured peppers should be removed by manual selection. Fresh peppers should be supplied. The supplier must provide the documents certifying the mycotoxin content of vegetables.	2	8	1	16
		26	C: Nitrate contamination due to environmental factors (soil, water) or fertilisers containing nitrate	5	7	3	105*	The supplier should report the nitrate concentration of vegetables by documents. The results should be in limits.	2	7	2	28
		27	C: Heavy metal contamination (lead, cadmium) due to usage of contaminated soil and/or water in the agricultural land.	3	10	3	90*	Vegetables must come from approved suppliers. It must be considered whether the agricultural land of crops was treated with lead containing pesticides, sewage sludge, irrigated water and/ or soil and effective agricultural approaches were applied to reduce metal accumulation on the soil. Very soiled vegetables should not be purchased.	1	10	1	10
		28	P: Foreign objects (soil, sand) due to improper harvesting practices	8	1	3	24	None				
CP4	Receiving green pepper	29	B: Microorganisms (*salmonella, L. monocytogenes, shigella spp., aeromonas, Cl. perfringens*) due to inappropriate agricultural applications, irrigation of water and soil by faecal materials, and environmental factors like pests, and flies	5	7	5	175*	Vegetables must come from approved suppliers. It must be considered whether the land used to produce crops have been treated with sewage sludge. Defective vegetables shouldn't be supplied.	2	7	4	56

CP	Processing stage	Risk number	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections
		30	B: Microorganisms (*E. coli O157:H7, Cl. botulinum*) due to inappropriate agricultural applications, irrigation of water and soil by faecal materials, and environmental factors like pests, and flies	2	10	5	100*	Vegetables must come from approved suppliers. It must be considered whether the land used to produce crops have been treated with sewage sludge. Defective vegetables shouldn't be supplied.	1	10	4	40
		31	B: Parasite zoones (Protozoa- *Cryptosporidium parvum, Giardia duodenalis, Toxoplasma gondii, Blastocystis hominis*, Nematodes- *Toxocara canis, Toxascaris leonina, Toxocara cati, Lagochilascaris minor*, Pentastomids-*Armillifer armillatus*) due to poor agricultural applications	4	8	2	64*	Vegetables should be handled carefully and supplied from reliable wholesalers/ producers. Handling of soiled and dirty vegetables should be avoided.	2	8	1	16
		32	B: Moulds (Bacterial soft rot, gray mold rot, alternaria rot diseases of green pepper) produced by mold which present due to environmental conditions in growing period or transferred by diseased green peppers	5	5	2	50	Peppers must come from approved suppliers. Injured peppers should be culled out.	3	5	1	15
		33	C: Pesticide residue due to deficient pesticide applications in the agricultural land.	6	8	3	144*	Vegetables must come from approved suppliers. The supplier must provide the documents certifying the safety of vegetables.	2	8	2	32
		34	C: Nitrate contamination due to environmental factors (soil, water) or fertilisers containing nitrate	5	7	3	105*	The supplier should report the nitrate concentration of vegetables by documents. The results should be in limits.	2	7	2	28
		35	C: Heavy metal contamination (lead, cadmium) due to usage of contaminated soil and/or water in the agricultural land.	3	10	3	90*	Vegetables must come from approved suppliers. It must be considered whether the agricultural land of crops was treated with lead containing pesticides, sewage sludge, irrigated water and/ or soil and effective agricultural approaches were applied to reduce metal accumulation on the soil. Very soiled vegetables should not be purchased.	1	10	1	10
		36	C: Plant growth regulators (2,4 D) due to poor agricultural applications	4	5	3	60*	Vegetables must come from approved suppliers.	2	5	2	20
		37	P: Foreign objects (soil, sand) due to improper harvesting practices	8	1	3	24	None				
CP5	Receiving mint	38	B: Microorganisms (*E. Coli O157:H7*) due to inappropriate agricultural applications, irrigation of water and soil by faecal materials, and environmental factors like pests, and flies	6	10	2	120*	Mints should be cleaned appropriately.	3	10	1	30
		39	B: Parasite zoones (Protozoa- *Cryptosporidium parvum, Giardia duodenalis, Toxoplasma gondii, Blastocystis hominis*, Nematodes- *Toxocara canis, Toxascaris leonina, Toxocara cati, Lagochilascaris minor*, Pentastomids-*Armillifer armillatus*) due to poor agricultural applications	4	8	2	64*	Vegetables should be handled carefully and supplied from reliable wholesalers/ producers. Handling of soiled and dirty vegetables should be avoided.	2	8	1	16
		40	C: Pesticide residue due to deficient pesticide applications in the agricultural land.	6	8	3	144*	Vegetables must come from approved suppliers. The supplier must provide the documents certifying the safety of vegetables.	3	8	2	48
		41	C: Nitrate contamination due to environmental factors (soil, water) or fertilisers containing nitrate	5	7	3	105*	The supplier should report the nitrate concentration of vegetables by documents. The results should be in limits.	2	7	2	28
		42	P: Foreign objects (soil, sand) due to improper harvesting practices	8	1	3	24	None				

CP	Processing stage	Risk number	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections
CP6	Receiving yoghurt	43	B: Microorganisms (*Y. enterocolitica, S. aureus, L. monocytogenes*), survived due to inefficient fermentation conditions.	3	7	3	63*	Yoghurt must be manufactured and purchased from approved suppliers. Its receipt should be accompanied with certificates of quality control. The certificates should report the microbial content of yoghurt, and its comparison with the upper approved standards. Yoghurt should be supplied in low temperatures (2-3°C).	1	7	2	14
		44	B: Microorganisms (*E. Coli O157:H7*), survived due to inefficient fermentation conditions.	3	10	2	60*	Yoghurt must be manufactured and purchased from approved suppliers. Its receipt should be accompanied with certificates of quality control. The certificates should report the microbial content of yoghurt, and its comparison with the upper approved standards. Yoghurt should be supplied in low temperatures (2-3°C).	1	10	1	10
		45	B: Molds, yeast , survived due to inefficient fermentation conditions.	5	6	2	60*	Yoghurt must be manufactured and purchased from approved suppliers. Its receipt should be accompanied with certificates of quality control. The certificates should report the mould count of yoghurt, and its comparison with the upper approved standards. Yoghurt should be supplied in low temperatures (2-3°C).	1	6	1	6
		46	C: Dioxin due to accumulation of the pollutants into the fatty tissues and products of animals.	6	8	3	144*	The dairy supplier must provide the documents certifying the dioxin content of yoghurt. Tarhana producer should pay attention to the dioxin levels on the documents and evaluate the results.	2	8	2	32
		47	C: Heavy metal contamination due to contaminated milk	10	10	1	100*	Yoghurt must be manufactured and purchased from approved suppliers. Its receipt should be accompanied with certificates of quality control. The certificates should report the heavy metal content of yoghurt, comparison with the upper approved standards.	1	10	1	10
		48	C: Pesticide residue due to bioaccumulation on milk	5	8	2	80*	Yoghurt must be manufactured and purchased from approved suppliers. Its receipt should be accompanied with certificates of quality control. The certificates should report the pesticide residue content of yoghurt, comparison with the upper approved standards.	2	8	1	16
		49	C: Veterinary drug residues due to drugs given into unhealthy animal	7	8	1	56*	Yoghurt must be manufactured and purchased from approved suppliers. Its receipt should be accompanied with certificates of quality control. The certificates should report the drug residue content of yoghurt, comparison with the upper approved standards.	1	8	1	8
		50	P: Foreign objects (animal leucocyte cells.) due to using inefficiently filtrated milk	2	1	10	20	None				
		51	P: Foreign objects (animal hair, chaff) due to using inefficiently filtrated milk	2	1	1	2	None				
CP7	Receiving wheat flour	52	B: Microorganisms (*E. coli, Cl.botulinum, Shigella*) due to equipment contamination or improper storage properties	6	10	2	120*	Flour must be purchased from approved suppliers. Its receipt should be accompanied with certificates of quality control and microbiological analysis. The certificates should report the humidity of flour and regarding microorganisms, their content and comparison with the upper approved standards.	3	10	1	30
		53	B: Microorganisms (*B. Cereus, Sallmonella* spp., *C. perfringens, Micrococcus, Alcaligenes*) due to equipment contamination or improper storage properties	6	7	2	84*	Flour must be purchased from approved suppliers. Its receipt should be accompanied with certificates of quality control and microbiological analysis. The certificates should report the humidity of flour and regarding microorganisms, their content and comparison with the upper approved standards.	3	7	1	21

CP	Processing stage	Risk number	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections
		54	B: Molds, fungi due to inappropriate storage conditions and careless food handling	7	4	2	56*	Flour must be purchased from approved suppliers. Its receipt should be accompanied with certificates of quality control. The certificates should report the moisture, mold, and mold spore count of flour, and their comparison with the upper approved standards. Moisture content of flour should be measured by a grain moisture tester.	4	4	1	16
		55	C: Pesticide, Insecticide residues due to post harvest pesticides, applied to protect the stored food from pests	6	8	3	144*	Flour must be purchased from approved suppliers. Its receipt should be accompanied with certificates of quality control. The certificates should report the pesticides of flour, their content and comparison with the upper approved standards.	2	8	2	32
		56	C: Mycotoxins (Trichothencene pruced by *Fusarium spp.*, Aflatoxins, deoksinivalenol, zearalenon, citrinin, achratoxin, cyclopiazonic acid, viomellein, xanthomegnin, patulin) produced by mold which present due to environmental conditions in growing period of the crop and poor storage during the post-harvest period	8	8	2	128*	Flour must be purchased from approved suppliers. Its receipt should be accompanied with certificates of quality control. The certificates should report the mycotoxins of flour, their content and comparison with the upper approved standards.	2	8	1	16
		57	C: Heavy metal contamination (lead, cadmium) due to usage of contaminated soil and/or water in the agricultural land.	6	9	2	108*	Flour must be purchased from approved suppliers. Its receipt should be accompanied with certificates of quality control which should report the pieces of metals and heavy metal, their content and comparison with the upper approved standards.	3	9	1	27
		58	C: Quinones (benzoquinones), allergens, maintained from some pests (flour beetles-*Alphitobius spp.*, *Tribolium spp.*, *Tenebrio spp.*, mites, cockroaches).	4	3	3	36	None				
		59	P: Hard foreign objects (wire from sieving) due to old-expired equipment	6	6	1	36	None				
		60	P: Foreign objects (insect fragments and larvae of small flies adhered to the food)	3	1	3	9	None				
CP8	Receiving yeast source (Fermented tarhana dough which is kept from previous production)	61	B: Survival of microorganisms during fermentation (*S. aureus*) due to contamination in previous production	2	7	2	28	None				
		62	B: Survival of microorganisms (*Vero-cytotoxigenic E. coli*) due to contamination in previous production	2	10	1	20	None				
		63	C: Mycotoxins (*ochratoxin A, type B trichothecenes*) transferred by the previous dough	1	8	2	16	None				
		64	P: Foreign objects due to improper handling and storage	1	3	2	6	None				
CP9	Receiving salt	65	C: Additives, magnesium carbonate, calcium phosphate, calcium carbonate, magnesium oxide, added over the legal limits	2	6	1	12	None				
		66	P: Foreign objects due to failure in processing	3	5	1	15	None				

CP	Processing stage	Risk number	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections
CP10	Washing vegetables	67	B: Survival of Virus (*Hepatitis A*) due o inefficient washing procedure	2	7	8	112*	Vegetables should be treated with sanitizers and rinsed efficiently.	1	7	6	42
		68	B: Survival of microorganisms (*E. coli O157:H7*) due to inefficient washing. Contamination with *Salmonella Thyphimurium, E. coli* and *V. cholerae* due to contaminated water used for washing	3	10	3	90*	Efficient washing procedure should be applied to vegetables: washing vegetables min 3 times, 1st with water, 2nd with effective sanitizer (hydrogen peroxide), 3rd with water (rinsing). Wash water should be clean and cool. Wash water must be removed by centrifugation.	2	10	2	40
		69	B: Survival of microorganisms (*L. monocytogenes*) due to inefficient washing. Contamination with *Shigella* and *Aeromonas* due to contaminated water used for washing	6	7	2	84*	Efficient washing procedure should be applied to vegetables: washing vegetables min 3 times, 1st with water, 2nd with effective sanitizer (hydrogen peroxide), 3rd with water (rinsing). Wash water should be clean and cool. Wash water must be removed by centrifugation.	3	7	1	21
		70	B: Parasite zoones (Microspora- *Enterocytozooan bieneusi, Encephalitozoon cuniculi*, Protozoa- *Cryptosporidium parvum, Giardia duodenalis, Toxoplasma gondii, Blastocystis hominis*, Pentastomids- *Armillifer armillatus*) transmitted by water	4	8	2	64*	Vegetables should be rinsed with clean water. The water should be tested periodically by a laboratory. Used water should be supplied from a public water system which is regularly monitored and usage of contaminated water should be avoided. Water should be filtrated by a specially constructed filter system.	2	9	1	18
		71	C: Pesticide and spray residues left on the vegetables due to inappropriate washing	6	8	3	144*	Vegetables must be washed appropriately using water and preferably by acetic acid solutions. Tomatoes and peppers must be washed in water tanks agitated with compressed air, followed by rinsing with high-pressure water sprays.	2	8	2	32
		72	C: Nitrate contamination due to inefficient washing	3	7	5	105*	Vegetables must be washed appropriately.	2	7	2	28
		73	C: Chlorine residual due to chlorinated waterused for sanitizing vegetables	5	6	2	60*	Less harmful disinfectants than chlorine should be used for sanitation like hydrogen peroxide. It must be considered whether chlorinated wateris categorised as "food grade". When preparing the hypochloride solutions the proportion of chlorine and water concentrations and contact times should not be exceed the recommended levels. Vegetables must be rinsed with potable water following the chlorine treatment.	1	6	1	6
		74	P: Foreign objects (pieces of materials) due to material degradation and defects of water pipeline	8	1	1	8	None				
CP11	Removing inedible parts of vegetables (stem/ stalks/ seeds/ skin)	75	B: Contamination with microorganisms (*E. coli O157:H7*) due to unclean instrument	4	10	2	80*	The knives must be washed efficiently, preferably by automatic washing equipment. UV knife disinfection cabinet should be provided and personnel should be encouraged to use it.	1	10	1	10
		76	B: Parasite zoones (Protozoa- *Cryptosporidium parvum, Giardia duodenalis, Blastocystis hominis*) transmitted by contaminated hands	2	8	4	64*	Personnel should be trained on hygiene and hand washing and they should be provided with appropriate facilities to operate good hygienic practice e.g. hand basin and bactericidal soaps. Table ledges, door handlers, overhead pipes and many other areas should be routinely disinfected. Hands-on operations should be minimised. Medical examination should be applied to employees on a continuous basis.	2	9	3	54
		77	B: Contamination with microorganisms (*L. monocytogenesis, S. aureus*) due to unclean instrument	4	7	2	56*	The knives must be washed efficiently, preferably by automatic washing equipment. UV knife disinfection cabinet should be provided and personnel should be encouraged to use it.	1	7	1	7
		78	P: Foreign objects (soil, sand, inedible parts of vegetables) due to inefficient visual inspection	8	1	1	8	None				

CP	Processing stage	Risk number	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections
CP12	Milling ingredients (by electric mill)	79	B: Contamination with microorganisms (*L. monocytogenesis, S. aureus*) due to unclean instrument	7	7	4	196*	Efficient cleaning, disinfection and prevention procedures of the equipment should be applied. Disinfection should follow immediately after cleaning and before a process run. All equipment should be routinely dismantled or parts loosened for disinfection. Cleaning efficacy should be monitored using indicators of hygiene by tests for coliform bacteria. The cleaning utensils (brushers, sponges and spray guns) themselves must be disinfected properly. Movements of personnel and goods should be limited. The correct hygienic design and proper maintenance of equipment should be provided.	1	7	3	21
		80	B: Machinery mold (*Geotrichum candidum*) due to inefficient cleaning of equipment	5	9	3	135*	Good equipment cleaning procedure must be applied.	2	9	2	36
		81	B: Contamination with microorganisms (*E. Coli O157:H7*) due to unclean instrument	2	10	3	60*	Efficient cleaning, disinfection and prevention procedures of the equipment should be applied. Disinfection should follow immediately after cleaning and before a process run. All equipment should be routinely dismantled or parts loosened for disinfection. Cleaning efficacy should be monitored using indicators of hygiene by tests for coliform bacteria. The cleaning utensils (brushers, sponges and spray guns) themselves must be disinfected properly. Movements of personnel and goods should be limited. The correct hygienic design and proper maintenance of equipment should be provided.	1	10	2	20
		82	C: Heavy metal contamination due to metal surfaces of instruments which come into contact with food	3	8	3	72*	The free iron on the surfaces of instruments should be detected and removed by chemical or mechanical methods. Moving parts and presence of rust on the instruments should be checked regularly. Food-grade metals must be used for all metal surfaces that come into contact with food. Non-lead solder and food-grade items must be used at any repairing.	1	8	2	16
		83	P: Foreign objects (machinery part) due to old-expired equipment	1	6	2	12	None				
CP13	Mixing ingredients (by electric mixer)	84	B: Contamination with microorganisms (*L. monocytogenesis, S. aureus*) due to unclean instrument	7	7	4	196*	Efficient cleaning, disinfection and prevention procedures of the equipment should be applied. Disinfection should follow immediately after cleaning and before a process run. All equipment should be routinely dismantled or parts loosened for disinfection. Cleaning efficacy should be monitored using indicators of hygiene by tests for coliform bacteria. The cleaning utensils (brushers, sponges and spray guns) themselves must be disinfected properly. Movements of personnel and goods should be limited. The correct hygienic design and proper maintenance of equipment should be provided.	1	7	3	21
		85	B: Machinery mold (*Geotrichum candidum*) due to inefficient cleaning of equipment	5	9	3	135*	Good equipment cleaning procedure must be applied.	2	9	2	36

CP	Processing stage	Risk number	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections
		86	B: Contamination with microorganisms (*E. coli O157:H7*) due to unclean instrument	2	10	3	60*	Efficient cleaning, disinfection and prevention procedures of the equipment should be applied. Disinfection should follow immediately after cleaning and before a process run. All equipment should be routinely dismantled or parts loosened for disinfection. Cleaning efficacy should be monitored using indicators of hygiene by tests for coliform bacteria. The cleaning utensils (brushers, sponges and spray guns) themselves must be disinfected properly. Movements of personnel and goods should be limited. The correct hygienic design and proper maintenance of equipment should be provided.	1	10	2	20
		87	C: Disinfectant or detergent residue on mixer due to application of inefficient washing procedures	4	3	5	60*	Detergents must be rinsable and biodegredable. Disinfectants should be non toxic and non-corrosive. The equipment should be rinsed appropriately following the cleaning.	1	3	4	12
		88	C: Heavy metal contamination due to metal surfaces of instruments which come into contact with food	1	8	3	24	None				
		89	P: Foreign objects (metal pieces) due to old-expired equipment	3	6	1	18	None				
CP14	Fermentation of tarhana (kneading by hands for 30 min every day) (in stainless steel tanks) (12-20 days)	90	B: Virus (NLV) contamination by personnel handling.	3	7	8	168*	The fermentation tanks and tools should be disinfected just before use. Appropriate acidification should be provided.	2	7	6	84
		91	B: Virus (Rotavirus, Hepatitis A) contamination by personnel handling.	2	10	8	160*	Personnel should be trained to understand the risk associated with cross-contamination and they should be provided with appropriate facilities to operate good hygienic practice e.g. hand basin and bactericidal soaps. Table ledges, door handlers, overhead pipes and many other areas should be routinely disinfected. Hands-on operations should be minimised. Personnel must get vaccinated for Hepatitis A.	1	10	6	60
		92	B: Pathogen (*Shigella dysenteriae*) contamination by personnel handling	3	10	4	120*	Personnel should be trained to understand the risk associated with cross-contamination and they should be provided with appropriate facilities to operate good hygienic practice e.g. hand basin and bactericidal soaps. Table ledges, door handlers, overhead pipes and many other areas should be routinely disinfected. Hands-on operations should be minimised.	1	10	3	30
		93	B: Pathogen contamination (*S.aureus, L. monocytogenes, Shigella spp.*) by personnel handling	4	7	4	112*	Personnel should be trained to understand the risk associated with cross-contamination and they should be provided with appropriate facilities to operate good hygienic practice e.g. hand basin and bactericidal soaps. Table ledges, door handlers, overhead pipes and many other areas should be routinely disinfected. Hands-on operations should be minimised.	2	7	3	42
		94	B: Parasite zoones (Protozoa- *Cryptosporidium parvum, Giardia duodenalis, Blastocystis hominis*) transmitted by contaminated hands	2	8	4	64*	Personnel should be trained on hygiene and hand washing and they should be provided with appropriate facilities to operate good hygienic practice e.g. hand basin and bactericidal soaps. Table ledges, door handlers, overhead pipes and many other areas should be routinely disinfected. Hands-on operations should be minimised. Medical examination should be applied to employees on a continuous basis.	2	9	3	54

CP	Processing stage	Risk number	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections
		95	B: Survival of acid tolerant pathogens microorganisms during fermentation (*E. coli O157:H7*) due to improper fermentation conditions	3	10	2	60*	Process challenge tests must be carried out to determine whether the process achieves a special reduction of pathogens. Appropriate conditions (time, temperature, ph) for fermentation should be enhanced. The starter culture should be of adequate quantity to ensure rapid fermentation. The temperature of the environment should be kept at an optimum level to ensure adequate starter culture activity and this activity may be measured by pH changes. The fermentation environment should be efficient (clean, closed, without insects, dust). Prolonged fermentation should be avoided. Rapid acidification should be provided.	1	10	1	10
		96	B: Growth and/or survival of microorganisms during fermentation (*Cl. botulinum*) due to improper fermentation conditions	1	10	6	60*	Process challenge tests must be carried out to determine whether the process achieves a special reduction of pathogens. Appropriate conditions (time, temperature, ph) for fermentation should be enhanced. The starter culture should be of adequate quantity to ensure rapid fermentation. The temperature of the environment should be kept at an optimum level to ensure adequate starter culture activity and this activity may be measured by pH changes. The fermentation environment should be efficient (clean, closed, without insects, dust). Prolonged fermentation should be avoided. Rapid acidification should be provided.	1	10	5	50
		97	B: Growth and/or survival of microorganisms during fermentation (*S. aureus, Salmonella, L. monocytogenes*) due to improper fermentation conditions	2	7	4	56*	Process challenge tests must be carried out to determine whether the process achieves a special reduction of pathogens. Appropriate conditions (time, temperature, ph) for fermentation should be enhanced. The starter culture should be of adequate quantity to ensure rapid fermentation. The temperature of the environment should be kept at an optimum level to ensure adequate starter culture activity and this activity may be measured by pH changes. The salt level and its distribution should be adjusted. The fermentation environment should be efficient (clean, closed, without insects, dust). Prolonged fermentation should be avoided. Rapid acidification should be provided.	1	7	3	21
		98	B: Formation of toxin by *S. aureus* due to improper fermentation conditions	2	7	4	56*	Rapid acidification should be provided. The salt level and distribution of salt should be adjusted.	1	7	3	21
		99	C: Disinfectant or detergent residue on the fermentation tanks due to application of inefficient washing procedures	4	3	5	60*	Equipment should be rinsed efficiently after cleaning. Rinsable and biodegredable detergents should be used for cleaning.	1	3	4	12
		100	C: Survival of aflatoxin (Ochratoxin A) due to poor fermentation conditions	2	8	2	32	None				
		101	P: Foreign objects (dust, insect fragments) contamination while container is not covered	8	1	2	16	None				
		102	P: Foreign objects due to personal effects (jewellery, button, fingernail, pieces of glove)	1	8	1	8	None				

CP	Processing stage	Risk number	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections
CP15	Dividing the dough (by hand)	103	B: Pathogen (*Shigella dysenteriae*) contamination by personnel handling	3	10	4	120*	Personnel should be trained to understand the risk associated with cross-contamination and they should be provided with appropriate facilities to operate good hygienic practice e.g. hand basin and bactericidal soaps. Table ledges, door handlers, overhead pipes and many other areas should be routinely disinfected. Hands-on operations should be minimised.	1	10	3	30
		104	B: Pathogen contamination (*S.aureus, L. monocytogenes, Shigella spp.*) by personnel handling	4	7	4	112*	Personnel should be trained to understand the risk associated with cross-contamination and they should be provided with appropriate facilities to operate good hygienic practice e.g. hand basin and bactericidal soaps. Table ledges, door handlers, overhead pipes and many other areas should be routinely disinfected. Hands-on operations should be minimised.	2	7	3	42
		105	B: Virus (NLV) contamination by personnel handling.	3	7	8	168*	The fermentation tanks and tools should be disinfected just before use. Appropriate acidification should be provided.	2	7	6	84
		106	B: Virus (Rotavirus, Hepatitis A) contamination by personnel handling.	2	10	8	160*	Personnel should be trained to understand the risk associated with cross-contamination and they should be provided with appropriate facilities to operate good hygienic practice e.g. hand basin and bactericidal soaps. Table ledges, door handlers, overhead pipes and many other areas should be routinely disinfected. Hands-on operations should be minimised. Personnel must get vaccinated for Hepatitis A.	1	10	6	60
		107	B: Parasite zoones (Protozoa- *Cryptosporidium parvum, Giardia duodenalis, Blastocystis hominis*) transmitted by contaminated hands	2	8	4	64*	Personnel should be trained on hygiene and hand washing and they should be provided with appropriate facilities to operate good hygienic practice e.g. hand basin and bactericidal soaps. Table ledges, door handlers, overhead pipes and many other areas should be routinely disinfected. Hands-on operations should be minimised. Medical examination should be applied to employees on a continuous basis.	2	9	3	54
		108	P: Foreign objects due to personal effects (jewellery, button, fingernail, pieces of glove)	1	8	1	8	None				
CP16	Drying tarhana (1-1.5 days)	109	B: Contamination with microorganisms (*E. coli, Salmonella*) due to improper drying conditions, contamination by flies, rodents and cockroaches	2	10	4	80*	Tarhana should be dried in a clean, dry and closed area to avoid insect and rodent infestation. Drying time and final moisture content should be monitored. Personnel should change shoes when entering the area.	1	10	3	30
		110	B: Growth of microorganisms (*S. aureus*) due to extended drying time and improper drying conditions	3	7	3	63*	Tarhana should be dried in a clean, dry and closed area to avoid insect and rodent infestation. Drying time and final moisture content should be monitored. Personnel should change shoes when entering the area.	2	7	2	28
		111	C: Mycotoxin contamination due to poor drying conditions	7	8	2	112*	Tarhana should be dried in a clean and dry area (to avoid dust) and with minimum temperature fluctuations (to indicate mould growth) as well as to reduce moisture by regular aeration to avoid mold contamination and growth. Personnel should change shoes when entering the area.	3	8	1	24
		112	C: Toxins (benzoquinones) and allergens, maintained from the body fluids or tissues of some insects (flour beetles, mites, cockroaches).	2	5	3	30	None				
		113	P: Foreign object (dust, sand) contamination which transferred by air and insect fragments	8	1	1	8	None				

CP	Processing stage	Risk number	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections
CP17	Milling tarhana (by electric mill)	114	B: Contamination with microorganisms (*L. monocytogenesis, S. aureus*) due to unclean instrument	7	7	4	196*	Efficient cleaning, disinfection and prevention procedures of the equipment should be applied. Disinfection should follow immediately after cleaning and before a process run. All equipment should be routinely dismantled or parts loosened for disinfection. Cleaning efficacy should be monitored using indicators of hygiene by tests for coliform bacteria. The cleaning utensils (brushers, sponges and spray guns) themselves must be disinfected properly. Movements of personnel and goods should be limited. The correct hygienic design and proper maintenance of equipment should be provided.	1	7	3	21
		115	B: Machinery mold (*Geotrichum candidum*) due to inefficient cleaning of equipment	5	9	3	135*	Good equipment cleaning procedure must be applied.	2	9	2	36
		116	B: Contamination with microorganisms (*E. Coli O157:H7*) due to unclean instrument	2	10	3	60*	Efficient cleaning, disinfection and prevention procedures of the equipment should be applied. Disinfection should follow immediately after cleaning and before a process run. All equipment should be routinely dismantled or parts loosened for disinfection. Cleaning efficacy should be monitored using indicators of hygiene by tests for coliform bacteria. The cleaning utensils (brushers, sponges and spray guns) themselves must be disinfected properly. Movements of personnel and goods should be limited. The correct hygienic design and proper maintenance of equipment should be provided.	1	10	2	20
		117	C: Heavy metal contamination due to metal surfaces of instruments which come into contact with food	3	8	3	72*	The free iron on the surfaces of instruments should be detected and removed by chemical or mechanical methods. Moving parts and presence of rust on the instruments should be checked regularly. Food-grade metals must be used for all metal surfaces that come into contact with food. Non-lead solder and food-grade items must be used at any repairing.	1	8	2	16
		118	P: Foreign objects (machinery part) due to old-expired equipment	1	6	2	12	None				
CP18	Sieving tarhana	119	B: Contamination with microorganisms (*L. monocytogenesis, S. aureus*) due to unclean instrument	7	7	4	196*	Efficient cleaning, disinfection and prevention procedures of the equipment should be applied. Disinfection should follow immediately after cleaning and before a process run. All equipment should be routinely dismantled or parts loosened for disinfection. Cleaning efficacy should be monitored using indicators of hygiene by tests for coliform bacteria. The cleaning utensils (brushers, sponges and spray guns) themselves must be disinfected properly. Movements of personnel and goods should be limited. The correct hygienic design and proper maintenance of equipment should be provided.	1	7	3	21
		120	B: Machinery mold (*Geotrichum candidum*) due to inefficient cleaning of equipment	5	9	3	135*	Good equipment cleaning procedure must be applied.	2	9	2	36

CP	Processing stage	Risk number	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections
		121	B: Contamination with microorganisms (*E. Coli O157:H7*) due to unclean instrument	2	10	3	60*	Efficient cleaning, disinfection and prevention procedures of the equipment should be applied. Disinfection should follow immediately after cleaning and before a process run. All equipment should be routinely dismantled or parts loosened for disinfection. Cleaning efficacy should be monitored using indicators of hygiene by tests for coliform bacteria. The cleaning utensils (brushers, sponges and spray guns) themselves must be disinfected properly. Movements of personnel and goods should be limited. The correct hygienic design and proper maintenance of equipment should be provided.	1	10	2	20
		122	C: Heavy metal contamination due to metal surfaces of instruments which come into contact with food	3	8	3	72*	The free iron on the surfaces of instruments should be detected and removed by chemical or mechanical methods. Moving parts and presence of rust on the instruments should be checked regularly. Food-grade metals must be used for all metal surfaces that come into contact with food. Non-lead solder and food-grade items must be used at any repairing.	1	8	2	16
		123	P: Hard foreign objects (wire from sieving) due to old-expired equipment	4	7	3	84*	Metal detectors should be used. Detectors should be carefully chosen and calibrated to pick up the smallest pieces of metal. The efficiency of the equipment should be monitored and its expired, broken pieces should be changed periodically.	2	7	2	28
CP19	Packaging (with nylon bags)	124	B: Virus (NLV) contamination by personnel handling	2	7	8	112*	Personnel should be trained to understand the risk associated with cross-contamination and they should be provided with appropriate facilities to operate good hygienic practice e.g. hand basin and bactericidal soaps. Table ledges, door handlers, overhead pipes and many other areas should be routinely disinfected. Hands-on operations should be minimised.	1	7	6	42
		125	B: Virus (Rotavirus, Hepatitis A) contamination by personnel handling	1	10	8	80*	Personnel should be trained to understand the risk associated with cross-contamination and they should be provided with appropriate facilities to operate good hygienic practice e.g. hand basin and bactericidal soaps. Table ledges, door handlers, overhead pipes and many other areas should be routinely disinfected. Hands-on operations should be minimised. Personnel must get vaccinated for Hepatitis A.	1	10	6	60
		126	B: Contamination with microorganisms (*S. aureus, L. monocytogenes, Shigella spp.*) due to personnel handling	4	7	2	56*	Bare hand contact with the product must be avoided. Personnel should comply with the Good Manufacturing Practice and avoid extraneous materials, such as insects and rodent hairs, in the final product. Efficient lighting and temperature must be provided in the environment to avoid personnel failures.	2	7	1	14
		127	B: Survival of pathogens (*Cl. Botulinum, E. coli*) due to inappropriate preparation of the food (post process)	3	9	2	54*	Appropriate information should be given on the product packaging to provide guidance concerning safe handling and storage conditions and cooking processes that need to be employed.	2	9	1	18
		128	C: Low molecular weight substances (Biosphenol A), migrated from the packaging material into the food	2	9	3	54*	Packaging material should be suitable for coming in contact with food.	1	9	2	18
		129	C: Heavy metal contamination (lead) due to lead based printings used for packaging	1	8	1	8	None				

CP	Processing stage	Risk number	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections
		130	P: Foreign objects due to personal effects (false fingernail, button, hair, apron and glove pieces) and inappropriate packaging (pieces of packaging material)	6	4	1	24	None				

*Corrective actions are required since RPN is above 50.

Table A.4. Failure mode and effect analysis table for the Gediz tarhana production

CP	Processing stage	Risk number	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections
CP1	Receiving Onion, dry	1	B: Virus (*Hepatitis A*) due to unsanitary agricultural applications	2	10	8	160*	Vegetables must come from approved suppliers. It must be considered whether the land used to produce crops have been treated with sewage sludge and fecally treated water and if the sanitary facilities are provided for field workers. Very soiled vegetables should not be purchased.	1	10	6	60
		2	B: Moulds, transferred by diseased onions (Bacterial soft rot, black mold rot, botrytis neck rot, blue mold rot, fusarium bulb rot caused by *Erwinia carotovora, Aspergillus alliaceus, Aspergillus niger, Botrytis allii, Fusarium spp.*)	7	5	2	70*	Onions must come from approved suppliers. Wounded, bruised and soiled bulbs should be excluded.	3	5	1	15
		3	B: Parasite zoones (Protozoa- *Cryptosporidium parvum, Giardia duodenalis, Toxoplasma gondii, Blastocystis hominis,* Nematodes- *Toxocara canis, Toxascaris leonina, Toxocara cati, Lagochilascaris minor,* Pentastomids- *Armillifer armillatus*) due to poor agricultural applications	4	8	2	64*	Vegetables should be handled carefully and supplied from reliable wholesalers/ producers. Handling of soiled and dirty vegetables should be avoided.	2	8	1	16
		4	C: Heavy metal contamination (lead, cadmium) due to usage of contaminated soil and/or water in the agricultural land	8	10	3	240*	Vegetables must come from approved suppliers. It must be considered whether the agricultural land of crops was treated with lead containing pesticides, sewage sludge, irrigated water and/ or soil and effective agricultural approaches were applied to reduce metal accumulation on the soil. Very soiled onions should not be purchased.	2	10	2	40
		5	C: Pesticide residue due to deficient pesticide applications in the agricultural land	6	8	3	144*	Vegetables must come from approved suppliers. The supplier must provide the documents certifying the safety of vegetables.	2	8	2	32
		6	C: Nitrate contamination due to environmental factors (soil, water) or fertilisers containing nitrate	8	1	3	24	None				
		7	P: Foreign objects (soil, sand) due to improper harvesting practices	8	1	1	8	None				
CP2	Receiving red pepper	8	B: Microorganisms (*salmonella, L. monocytogenes, shigella spp., aeromonas, Cl. perfringens*) due to inappropriate agricultural applications, irrigation of water and soil by faecal materials, and environmental factors like pests, and flies	5	7	5	175*	Vegetables must come from approved suppliers. It must be considered whether the land used to produce crops have been treated with sewage sludge. Defective vegetables shouldn't be supplied.	2	7	4	56
		9	B: Microorganisms (*E. coli O157:H7, Cl. botulinum*) due to inappropriate agricultural applications, irrigation of water and soil by faecal materials, and environmental factors like pests, and flies	2	10	5	100*	Vegetables must come from approved suppliers. It must be considered whether the land used to produce crops have been treated with sewage sludge. Defective vegetables shouldn't be supplied.	1	10	4	40

CP	Processing stage	Risk number	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections
		10	B: Parasite zoones (Protozoa- *Cryptosporidium parvum, Giardia duodenalis, Toxoplasma gondii, Blastocystis hominis*, Nematodes- *Toxocara canis, Toxascaris leonina, Toxocara cati, Lagochilascaris minor*, Pentastomids- *Armillifer armillatus*) due to poor agricultural applications	4	8	2	64*	Vegetables should be handled carefully and supplied from reliable wholesalers/ producers. Handling of soiled and dirty vegetables should be avoided.	2	8	1	16
		11	B: Moulds, transferred by diseased peppers (Bacterial soft rot, gray mould rot, alternaria rot diseases of red pepper)	5	5	2	50*	Peppers must come from approved suppliers. Injured peppers should be culled out.	3	5	1	15
		12	C: Pesticide residue due to deficient pesticide applications in the agricultural land.	6	8	3	144*	Vegetables must come from approved suppliers. The supplier must provide the documents certifying the safety of vegetables.	2	8	2	32
		13	C: Mycotoxins produced by moulds (Aflatoxin B1, produced by Aspergillus flavus) produced by mold which present due to environmental conditions in growing period of the crop	8	8	2	128*	The moldy, damaged, discoloured peppers should be removed by manual selection. Fresh peppers should be supplied. The supplier must provide the documents certifying the mycotoxin content of vegetables.	2	8	1	16
		14	C: Nitrate contamination due to environmental factors (soil, water) or fertilisers containing nitrate	5	7	3	105*	The supplier should report the nitrate concentration of vegetables by documents. The results should be in limits.	2	7	2	28
		15	C: Heavy metal contamination (lead, cadmium) due to usage of contaminated soil and/or water in the agricultural land.	3	10	3	90*	Vegetables must come from approved suppliers. It must be considered whether the agricultural land of crops was treated with lead containing pesticides, sewage sludge, irrigated water and/ or soil and effective agricultural approaches were applied to reduce metal accumulation on the soil. Very soiled vegetables should not be purchased.	1	10	1	10
		16	P: Foreign objects (soil, sand) due to improper harvesting practices	8	1	3	24	None				
CP3	Receving mint	17	B: Pathogens (*E. coli*) due to inappropriate agricultural applications, irrigation of water and soil by faecal materials, and environmental factors like pests, and flies	6	9	1	54*	Mints must come from approved suppliers. Injured mints should be culled out.	1	9	1	9
		18	C: Pesticide residue due to deficient pesticide applications in the agricultural land.	6	8	3	144*	Vegetables must come from approved suppliers. It must be considered whether the land used to produce crops have been treated with lead containing pesticides or sewage sludge.	2	8	2	32
		19	P: Foreign objects (soil, sand) due to improper harvesting practices	8	1	3	24	None				
CP4	Receiving yoghurt	20	B: Microorganisms (*Y. enterocolitica, S. aureus, L. monocytogenes*), survived due to inefficient fermentation conditions.	3	7	3	63*	Yoghurt must be manufactured and purchased from approved suppliers. Its receipt should be accompanied with certificates of quality control. The certificates should report the microbial content of yoghurt, and its comparison with the upper approved standards. Yoghurt should be supplied in low temperatures (2-3°C).	1	7	2	14
		21	B: Microorganisms (*E. Coli O157:H7*), survived due to inefficient fermentation conditions.	3	10	2	60*	Yoghurt must be manufactured and purchased from approved suppliers. Its receipt should be accompanied with certificates of quality control. The certificates should report the microbial content of yoghurt, and its comparison with the upper approved standards. Yoghurt should be supplied in low temperatures (2-3°C).	1	10	1	10

CP	Processing stage	Risk number	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections
		22	B: Molds, yeast , survived due to inefficient fermentation conditions.	5	6	2	60*	Yoghurt must be manufactured and purchased from approved suppliers. Its receipt should be accompanied with certificates of quality control. The certificates should report the mould count of yoghurt, and its comparison with the upper approved standards. Yoghurt should be supplied in low temperatures (2-3°C).	1	6	1	6
		23	C: Dioxin due to accumulation of the pollutants into the fatty tissues and products of animals.	6	8	3	144*	The dairy supplier must provide the documents certifying the dioxin content of yoghurt. Tarhana producer should pay attention to the dioxin levels on the documents and evaluate the results.	2	8	2	32
		24	C: Heavy metal contamination due to contaminated milk	10	10	1	100*	Yoghurt must be manufactured and purchased from approved suppliers. Its receipt should be accompanied with certificates of quality control. The certificates should report the heavy metal content of yoghurt, comparison with the upper approved standards.	1	10	1	10
		25	C: Pesticide residue due to bioaccumulation on milk	5	8	2	80*	Yoghurt must be manufactured and purchased from approved suppliers. Its receipt should be accompanied with certificates of quality control. The certificates should report the pesticide residue content of yoghurt, comparison with the upper approved standards.	2	8	1	16
		26	C: Veterinary drug residues due to drugs given into unhealthy animal	7	8	1	56*	Yoghurt must be manufactured and purchased from approved suppliers. Its receipt should be accompanied with certificates of quality control. The certificates should report the drug residue content of yoghurt, comparison with the upper approved standards.	1	8	1	8
		27	P: Foreign objects (animal leucocyte cells.) due to using inefficiently filtrated milk	2	1	10	20	None				
		28	P: Foreign objects (animal hair, chaff) due to using inefficiently filtrated milk	2	1	1	2	None				
CP5	Receiving Wheat flour	29	B: Microorganisms (*E. coli, Cl.botulinum, Shigella*) due to equipment contamination or improper storage properties	6	10	2	120*	Flour must be purchased from approved suppliers. Its receipt should be accompanied with certificates of quality control and microbiological analysis. The certificates should report the humidity of flour and regarding microorganisms, their content and comparison with the upper approved standards.	3	10	1	30
		30	B: Microorganisms (*B. Cereus, Sallmonella* spp., *C. perfringens, Micrococcus, Alcaligenes*) due to equipment contamination or improper storage properties	6	7	2	84*	Flour must be purchased from approved suppliers. Its receipt should be accompanied with certificates of quality control and microbiological analysis. The certificates should report the humidity of flour and regarding microorganisms, their content and comparison with the upper approved standards.	3	7	1	21
		31	B: Molds, fungi due to inappropriate storage conditions and careless handling	7	4	2	56*	Flour must be purchased from approved suppliers. Its receipt should be accompanied with certificates of quality control. The certificates should report the moisture, mold, and mold spore count of flour, and their comparison with the upper approved standards. Moisture content of flour should be measured by a grain moisture tester.	4	4	1	16
		32	C: Pesticide, Insecticide residues due to post harvest pesticides, applied to protect the stored food from pests	6	8	3	144*	Flour must be purchased from approved suppliers. Its receipt should be accompanied with certificates of quality control. The certificates should report the pesticides of flour, their content and comparison with the upper approved standards.	2	8	2	32

CP	Processing stage	Risk number	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections
		33	C: Mycotoxins (Trichothencene pruced by *Fusarium spp*., Aflatoxins, deoksinivalenol, zearalenon, citrinin, achratoxin, cyclopiazonic acid, viomellein, xanthomegnin, patulin) produced by mold which present due to environmental conditions in growing period of the crop and poor storage during the post-harvest period	8	8	2	128*	Flour must be purchased from approved suppliers. Its receipt should be accompanied with certificates of quality control. The certificates should report the mycotoxins of flour, their content and comparison with the upper approved standards.	2	8	1	16
		34	C: Heavy metal contamination (lead, cadmium) due to usage of contaminated soil and/or water in the agricultural land.	6	9	2	108*	Flour must be purchased from approved suppliers. Its receipt should be accompanied with certificates of quality control which should report the pieces of metals and heavy metal, their content and comparison with the upper approved standards.	3	9	1	27
		35	C: Quinones (benzoquinones), allergens, maintained from some pests (flour beetles-*Alphitobius spp., Tribolium spp., Tenebrio spp.*, mites, cockroaches).	4	3	3	36	None				
		36	P: Hard foreign objects (wire from sieving) due to old-expired equipment	6	6	1	36	None				
		37	P: Foreign objects (insect fragments and larvae of small flies adhered to the food)	3	1	3	9	None				
CP6	Receiving yeast source (Fermented tarhana dough which is kept from previous production)	38	B: Survival of microorganisms during fermentation (*S. aureus*) due to contamination in previous production	2	7	2	28	None				
		39	B: Survival of microorganisms (*Vero-cytotoxigenic E. coli*) due to contamination in previous production	2	10	1	20	None				
		40	C: Mycotoxins (*ochratoxin A, type B trichothecenes*) transferred by the previous dough	1	8	2	16	None				
		41	P: Foreign objects due to improper handling and storage	1	3	2	6	None				
CP7	Receiving Salt	42	C: Additives, magnesium carbonate, calcium phosphate, calcium carbonate, magnesium oxide, added over the legal limits	2	6	1	12	None				
		43	P: Foreign objects due to failure in processing	3	5	1	15	None				
CP8	Washing vegetables	44	B: Survival of Virus (Hepatitis A) due to inefficient washing procedure	2	7	8	112*	Vegetables should be treated with sanitizers and rinsed efficiently.	1	7	6	42
		45	B: Survival of microorganisms (*E. coli O157:H7*) due to inefficient washing. Contamination with *Salmonella Thyphimurium, E. coli* and *V. cholerae* due to contaminated water used for washing	3	10	3	90*	Efficient washing procedure should be applied to vegetables: washing vegetables min 3 times, 1st with water, 2nd with effective sanitizer (hydrogen peroxide), 3rd with water (rinsing). Wash water should be clean and cool. Wash water must be removed by centrifugation.	2	10	2	40
		46	B: Survival of microorganisms (*L. monocytogenes*) due to inefficient washing. Contamination with *Shigella* and *Aeromonas* due to contaminated water used for washing	6	7	2	84*	Efficient washing procedure should be applied to vegetables: washing vegetables min 3 times, 1st with water, 2nd with effective sanitizer (hydrogen peroxide), 3rd with water (rinsing). Wash water should be clean and cool. Wash water must be removed by centrifugation.	3	7	1	21

CP	Processing stage	Risk number	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections
		47	B: Parasite zoones (Microspora- *Enterocytozooan bieneusi, Encephalitozoon cuniculi,* Protozoa- *Cryptosporidium parvum, Giardia duodenalis, Toxoplasma gondii, Blastocystis hominis,* Pentastomids- *Armillifer armillatus*) transmitted by water	4	8	2	64*	Vegetables should be rinsed with clean water. The water should be tested periodically by a laboratory. Used water should be supplied from a public water system which is regularly monitored and usage of contaminated water should be avoided. Water should be filtrated by a specially constructed filter system.	2	9	1	18
		48	C: Pesticide and spray residues left on the vegetables due to inappropriate washing	6	8	3	144*	Vegetables must be washed appropriately using water and preferably by acetic acid solutions. Tomatoes and peppers must be washed in water tanks agitated with compressed air, followed by rinsing with high-pressure water sprays.	2	8	2	32
		49	C: Chlorine residual due to chlorinated waterused for sanitizing	5	6	2	60*	Less harmful disinfectants than chlorine should be used for sanitation like hydrogen peroxide. It must be considered whether chlorinated wateris categorised as "food grade". When preparing the hypochloride solutions the proportion of chlorine and water concentrations and contact times should not be exceed the recommended levels. Vegetables must be rinsed with potable water following the chlorine treatment.	1	6	1	6
		50	P: Foreign objects (pieces of materials) due to material degradation and defects of water pipeline	8	1	1	8	None				
		51	B: Survival of Virus (Hepatitis A) due to inefficient washing procedure	1	3	2	6	None				
CP9	Removing inedible parts of vegetables (stem/ stalks/ seeds/skin)	52	B: Contamination with microorganisms (*E. coli O157:H7*) due to unclean instrument	4	10	2	80*	The knives must be washed efficiently, preferably by automatic washing equipment. UV knife disinfection cabinet should be provided and personnel should be encouraged to use it.	1	10	1	10
		53	B: Parasite zoones (Protozoa- *Cryptosporidium parvum, Giardia duodenalis, Blastocystis hominis*) transmitted by contaminated hands	2	8	4	64*	Personnel should be trained on hygine and hand washing and they should be provided with appropriate facilities to operate good hygienic practice e.g. hand basin and bactericidal soaps. Table ledges, door handlers, overhead pipes and many other areas should be routinely disinfected. Hands-on operations should be minimised. Medical examination should be applied to employees on a continuous basis.	2	9	3	54
		54	B: Contamination with microorganisms (*L. monocytogenesis, S. aureus*) due to unclean instrument	4	7	2	56*	The knives must be washed efficiently, preferably by automatic washing equipment. UV knife disinfection cabinet should be provided and personnel should be encouraged to use it.	1	7	1	7
		55	P: Foreign objects (soil, sand, inedible parts of vegetables) due to inefficient visual inspection	8	1	1	8	None				
CP10	Drying mint (by hanging on a rope)	56	B: Contamination with microorganisms (*E. coli, Salmonella*) due to improper drying conditions, contamination by flies, rodents and cockroaches	2	10	4	80*	Tarhana should be dried in a clean, dry and closed area to avoid insect and rodent infestation. Drying time and final moisture content should be monitored.	1	10	3	30
		57	B: Growth of microorganisms (*S. aureus*) due to extended drying time and improper drying conditions	3	7	3	63*	Tarhana should be dried in a clean, dry and closed area to avoid insect and rodent infestation. Drying time and final moisture content should be monitored.	2	7	2	28
		58	P: Foreign objects (dust, sand, insect pieces) transferred by air	8	1	2	16	None				

CP	Processing stage	Risk number	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections
CP11	Milling ingredients (by electric mill)	59	B: Contamination with microorganisms (*L. monocytogenesis, S. aureus*) due to unclean instrument	7	7	4	196*	Efficient cleaning, disinfection and prevention procedures of the equipment should be applied. Disinfection should follow immediately after cleaning and before a process run. All equipment should be routinely dismantled or parts loosened for disinfection. Cleaning efficacy should be monitored using indicators of hygiene by tests for coliform bacteria. The cleaning utensils (brushers, sponges and spray guns) themselves must be disinfected properly. Movements of personnel and goods should be limited. The correct hygienic design and proper maintenance of equipment should be provided.	1	7	3	21
		60	B: Machinery mold (*Geotrichum candidum*) due to inefficient cleaning of equipment	5	9	3	135*	Good equipment cleaning procedure must be applied.	2	9	2	36
		61	B: Contamination with microorganisms (*E. Coli O157:H7*) due to unclean instrument	2	10	3	60*	Efficient cleaning, disinfection and prevention procedures of the equipment should be applied. Disinfection should follow immediately after cleaning and before a process run. All equipment should be routinely dismantled or parts loosened for disinfection. Cleaning efficacy should be monitored using indicators of hygiene by tests for coliform bacteria. The cleaning utensils (brushers, sponges and spray guns) themselves must be disinfected properly. Movements of personnel and goods should be limited. The correct hygienic design and proper maintenance of equipment should be provided.	1	10	2	20
		62	C: Heavy metal contamination due to metal surfaces of instruments which come into contact with food	3	8	3	72*	The free iron on the surfaces of instruments should be detected and removed by chemical or mechanical methods. Moving parts and presence of rust on the instruments should be checked regularly. Food-grade metals must be used for all metal surfaces that come into contact with food. Non-lead solder and food-grade items must be used at any repairing.	1	8	2	16
		63	P: Foreign objects (machinery part) due to old-expired equipment	1	6	2	12	None				
CP12	Mixing ingredients (by electric mixer)	64	B: Contamination with microorganisms (*L. monocytogenesis, S. aureus*) due to unclean instrument	7	7	4	196*	Efficient cleaning, disinfection and prevention procedures of the equipment should be applied. Disinfection should follow immediately after cleaning and before a process run. All equipment should be routinely dismantled or parts loosened for disinfection. Cleaning efficacy should be monitored using indicators of hygiene by tests for coliform bacteria. The cleaning utensils (brushers, sponges and spray guns) themselves must be disinfected properly. Movements of personnel and goods should be limited. The correct hygienic design and proper maintenance of equipment should be provided.	1	7	3	21
		65	B: Machinery mold (*Geotrichum candidum*) due to inefficient cleaning of equipment	5	9	3	135*	Good equipment cleaning procedure must be applied.	2	9	2	36

CP	Processing stage	Risk number	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections
		66	B: Contamination with microorganisms (*E. coli O157:H7*) due to unclean instrument	2	10	3	60*	Efficient cleaning, disinfection and prevention procedures of the equipment should be applied. Disinfection should follow immediately after cleaning and before a process run. All equipment should be routinely dismantled or parts loosened for disinfection. Cleaning efficacy should be monitored using indicators of hygiene by tests for coliform bacteria. The cleaning utensils (brushers, sponges and spray guns) themselves must be disinfected properly. Movements of personnel and goods should be limited. The correct hygienic design and proper maintenance of equipment should be provided.	1	10	2	20
		67	C: Disinfectant or detergent residue on mixer due to application of inefficient washing procedures	4	3	5	60*	Detergents must be rinsable and biodegredable. Disinfectants should be non toxic and non-corrosive. The equipment should be rinsed appropriately following the cleaning.	1	3	4	12
		68	C: Heavy metal contamination due to metal surfaces of instruments which come into contact with food	1	8	3	24	None				
		69	P: Foreign objects (metal pieces) due to old-expired equipment	3	6	1	18	None				
CP13	Fermentation of tarhana (in stainless steel tanks, 14 days)	70	B: Survival of parasites (*Cryptosporidium, Giardia lamblia*) due to improper fermentation conditions	3	7	5	105*	Appropriate acidification should be provided.	1	7	4	28
		71	B: Survival of virus (Rotavirus, Hepatitis A) due to improper fermentation conditions	1	10	8	80*	The fermentation tanks and tools should be disinfected just before use. Appropriate acidification should be provided.	1	10	6	60
		72	B: Survival of acid tolerant pathogens microorganisms during fermentation (*E. coli O157:H7*) due to improper fermentation conditions	3	10	2	60*	Process challenge tests must be carried out to determine whether the process achieves a special reduction of pathogens. Appropriate conditions (time, temperature, ph) for fermentation should be enhanced. The starter culture should be of adequate quantity to ensure rapid fermentation. The temperature of the environment should be kept at an optimum level to ensure adequate starter culture activity and this activity may be measured by pH changes. The fermentation environment should be efficient (clean, closed, without insects, dust). Prolonged fermentation should be avoided. Rapid acidification should be provided.	1	10	1	10
		73	B: Growth and/or survival of microorganisms during fermentation (*Cl. botulinum*) due to improper fermentation conditions	1	10	6	60*	Process challenge tests must be carried out to determine whether the process achieves a special reduction of pathogens. Appropriate conditions (time, temperature, ph) for fermentation should be enhanced. The starter culture should be of adequate quantity to ensure rapid fermentation. The temperature of the environment should be kept at an optimum level to ensure adequate starter culture activity and this activity may be measured by pH changes. The fermentation environment should be efficient (clean, closed, without insects, dust). Prolonged fermentation should be avoided. Rapid acidification should be provided.	1	10	5	50

CP	Processing stage	Risk number	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections
		74	B: Growth and/or survival of microorganisms during fermentation (*S. aureus, Salmonella, L. monocytogenes*) due to improper fermentation conditions	2	7	4	56*	Process challenge tests must be carried out to determine whether the process achieves a special reduction of pathogens. Appropriate conditions (time, temperature, ph) for fermentation should be enhanced. The starter culture should be of adequate quantity to ensure rapid fermentation. The temperature of the environment should be kept at an optimum level to ensure adequate starter culture activity and this activity may be measured by pH changes. The salt level and its distribution should be adjusted. The fermentation environment should be efficient (clean, closed, without insects, dust). Prolonged fermentation should be avoided. Rapid acidification should be provided.	1	7	3	21
		75	B: Formation of toxin by *S. aureus* due to improper fermentation conditions	2	7	4	56*	Rapid acidification should be provided. The salt level and distribution of salt should be adjusted.	1	7	3	21
		76	C: Disinfectant or detergent residue on the fermentation tanks due to application of inefficient washing procedures due to dirty fermentation equipment	4	3	5	60*	Equipment should be rinsed efficiently after cleaning. Rinsable and biodegredable detergents should be used for cleaning.	1	3	4	12
		77	C: Survival of aflatoxin (Ochratoxin A) due to poor fermentation conditions	2	8	2	32	None				
		78	P: Foreign objects (dust, insect fragments) transferred by air	8	1	2	16	None				
CP14	Dividing the dough (by hand)	79	B: Virus (NLV) contamination by personnel handling.	3	7	8	168*	Personnel should be trained to understand the risk associated with cross-contamination and they should be provided with appropriate facilities to operate good hygienic practice e.g. hand basin and bactericidal soaps. Table ledges, door handlers, overhead pipes and many other areas should be routinely disinfected. Hands-on operations should be minimised.	2	7	6	84
		80	B: Virus (Rotavirus, Hepatitis A) contamination by personnel handling.	2	10	8	160*	Personnel should be trained to understand the risk associated with cross-contamination and they should be provided with appropriate facilities to operate good hygienic practice e.g. hand basin and bactericidal soaps. Table ledges, door handlers, overhead pipes and many other areas should be routinely disinfected. Hands-on operations should be minimised. Personnel must get vaccinated for Hepatitis A.	1	10	6	60
		81	B: Contamination with microorganisms (*S. aureus, L. monocytogenes, Shigella spp.*) due to personnel handling	3	7	4	84*	Personnel should be trained to understand the risk associated with cross-contamination and they should be provided with appropriate facilities to operate good hygienic practice e.g. hand basin and bactericidal soaps. Table ledges, door handlers, overhead pipes and many other areas should be routinely disinfected. Hands-on operations should be minimised.	2	7	3	42
		82	B: Pathogen (*Shigella dysenteriae*) contamination by personnel handling	2	10	4	80*	Personnel should be trained to understand the risk associated with cross-contamination and they should be provided with appropriate facilities to operate good hygienic practice e.g. hand basin and bactericidal soaps. Table ledges, door handlers, overhead pipes and many other areas should be routinely disinfected. Hands-on operations should be minimised.	1	10	3	30

CP	Processing stage	Risk number	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections
		83	B: Parasite zoones (Protozoa- *Cryptosporidium parvum, Giardia duodenalis, Blastocystis hominis*) transmitted by contaminated hands	2	8	4	64*	Personnel should be trained on hygiene and hand washing and they should be provided with appropriate facilities to operate good hygienic practice e.g. hand basin and bactericidal soaps. Table ledges, door handlers, overhead pipes and many other areas should be routinely disinfected. Hands-on operations should be minimised. Medical examination should be applied to employees on a continuous basis.	2	9	3	54
		84	P: Foreign objects due to personal effects (jewelery, button, fingernail, pieces of glove)	1	8	1	8	None				
CP15	Drying tarhana (4-5 days)	85	B: Contamination with microorganisms (*E. coli, Salmonella*) due to improper drying conditions, contamination by flies, rodents and cockroaches	2	10	4	80*	Tarhana should be dried in a clean, dry and closed area to avoid insect and rodent infestation. Drying time and final moisture content should be monitored. Personnel should change shoes when entering the area.	1	10	3	30
		86	B: Growth of microorganisms (*S. aureus*) due to extended drying time and improper drying conditions	3	7	3	63*	Tarhana should be dried in a clean, dry and closed area to avoid insect and rodent infestation. Drying time and final moisture content should be monitored. Personnel should change shoes when entering the area.	2	7	2	28
		87	C: Mycotoxins due to poor drying conditions	7	8	2	112*	Tarhana should be dried in a clean and dry area (to avoid dust) and with minimum temperature fluctuations (to indicate mould growth) as well as to reduce moisture by regular aeration to avoid mold contamination and growth. Personnel should change shoes when entering the area.	3	8	1	24
		88	C: Toxins (benzoquinones) and allergens, maintained from the body fluids or tissues of some insects (flour beetles, mites, cockroaches)	2	5	3	30	None				
		89	P: Foreign objects (dust, sand) contamination which transferred by air and insect fragments	8	1	1	8	None				
CP16	Milling tarhana (by electric mill)	90	B: Contamination with microorganisms (*L. monocytogenesis, S. aureus*) due to unclean instrument	7	7	4	196*	Efficient cleaning, disinfection and prevention procedures of the equipment should be applied. Disinfection should follow immediately after cleaning and before a process run. All equipment should be routinely dismantled or parts loosened for disinfection. Cleaning efficacy should be monitored using indicators of hygiene by tests for coliform bacteria. The cleaning utensils (brushers, sponges and spray guns) themselves must be disinfected properly. Movements of personnel and goods should be limited. The correct hygienic design and proper maintenance of equipment should be provided.	1	7	3	21
		91	B: Machinery mold (*Geotrichum candidum*) due to inefficient cleaning of equipment	5	9	3	135*	Good equipment cleaning procedure must be applied.	2	9	2	36

CP	Processing stage	Risk number	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections
		92	B: Contamination with microorganisms (*E. Coli O157:H7*) due to unclean instrument	2	10	3	60*	Efficient cleaning, disinfection and prevention procedures of the equipment should be applied. Disinfection should follow immediately after cleaning and before a process run. All equipment should be routinely dismantled or parts loosened for disinfection. Cleaning efficacy should be monitored using indicators of hygiene by tests for coliform bacteria. The cleaning utensils (brushers, sponges and spray guns) themselves must be disinfected properly. Movements of personnel and goods should be limited. The correct hygienic design and proper maintenance of equipment should be provided.	1	10	2	20
		93	C: Heavy metal contamination due to metal surfaces of instruments which come into contact with food	3	8	3	72*	The free iron on the surfaces of instruments should be detected and removed by chemical or mechanical methods. Moving parts and presence of rust on the instruments should be checked regularly. Food-grade metals must be used for all metal surfaces that come into contact with food. Non-lead solder and food-grade items must be used at any repairing.	1	8	2	16
		94	P: Foreign objects (machinery part) due to old-expired equipment	1	6	2	12	None				
CP17	Sieving tarhana	95	B: Contamination with microorganisms (*L. monocytogenesis, S. aureus*) due to unclean instrument	7	7	4	196*	Efficient cleaning, disinfection and prevention procedures of the equipment should be applied. Disinfection should follow immediately after cleaning and before a process run. All equipment should be routinely dismantled or parts loosened for disinfection. Cleaning efficacy should be monitored using indicators of hygiene by tests for coliform bacteria. The cleaning utensils (brushers, sponges and spray guns) themselves must be disinfected properly. Movements of personnel and goods should be limited. The correct hygienic design and proper maintenance of equipment should be provided.	1	7	3	21
		96	B: Machinery mold (*Geotrichum candidum*) due to inefficient cleaning of equipment	5	9	3	135*	Good equipment cleaning procedure must be applied.	2	9	2	36
		97	B: Contamination with microorganisms (*E. Coli O157:H7*) due to unclean instrument	2	10	3	60*	Efficient cleaning, disinfection and prevention procedures of the equipment should be applied. Disinfection should follow immediately after cleaning and before a process run. All equipment should be routinely dismantled or parts loosened for disinfection. Cleaning efficacy should be monitored using indicators of hygiene by tests for coliform bacteria. The cleaning utensils (brushers, sponges and spray guns) themselves must be disinfected properly. Movements of personnel and goods should be limited. The correct hygienic design and proper maintenance of equipment should be provided.	1	10	2	20
		98	C: Heavy metal contamination due to metal surfaces of instruments which come into contact with food	3	8	3	72*	The free iron on the surfaces of instruments should be detected and removed by chemical or mechanical methods. Moving parts and presence of rust on the instruments should be checked regularly. Food-grade metals must be used for all metal surfaces that come into contact with food. Non-lead solder and food-grade items must be used at any repairing.	1	8	2	16

CP	Processing stage	Risk number	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections
		99	P: Foreign objects (wire pieces) due to old-expired equipment	4	7	3	84*	Metal detectors should be used. detectors should be carefully chosen and calibrated to pick up the smallest pieces of metal. The efficiency of the equipment should be monitored and its expired, broken pieces should be changed periodically.	2	7	2	28
CP18	Drying tarhana (5 days)	100	B: Contamination with microorganisms (*E. coli, Salmonella*) due to improper drying conditions, contamination by flies, rodents and cockroaches	2	10	4	80*	Tarhana should be dried in a clean, dry and closed area to avoid insect and rodent infestation. Drying time and final moisture content should be monitored. Personnel should change shoes when entering the area.	1	10	3	30
		101	B: Growth of microorganisms (*S. aureus*) due to extended drying time and improper drying conditions	3	7	3	63*	Tarhana should be dried in a clean, dry and closed area to avoid insect and rodent infestation. Drying time and final moisture content should be monitored. Personnel should change shoes when entering the area.	2	7	2	28
		102	C: Mycotoxins due to poor drying conditions	7	8	2	112*	Tarhana should be dried in a clean and dry area (to avoid dust) and with minimum temperature fluctuations (to indicate mould growth) as well as to reduce moisture by regular aeration to avoid mold contamination and growth. Personnel should change shoes when entering the area.	3	8	1	24
		103	C: Toxins (benzoquinones) and allergens, maintained from the body fluids or tissues of some insects (flour beetles, mites, cockroaches)	2	5	3	30	None				
		104	P: Foreign objects (dust, sand) transferred by air, insect fragments	8	1	1	8	None				
CP19	Sieving tarhana	105	B: Contamination with microorganisms (*L. monocytogenesis, S. aureus*) due to unclean instrument	7	7	4	196*	Efficient cleaning, disinfection and prevention procedures of the equipment should be applied. Disinfection should follow immediately after cleaning and before a process run. All equipment should be routinely dismantled or parts loosened for disinfection. Cleaning efficacy should be monitored using indicators of hygiene by tests for coliform bacteria. The cleaning utensils (brushers, sponges and spray guns) themselves must be disinfected properly. Movements of personnel and goods should be limited. The correct hygienic design and proper maintenance of equipment should be provided.	1	7	3	21
		106	B: Machinery mold (*Geotrichum candidum*) due to inefficient cleaning of equipment	5	9	3	135*	Good equipment cleaning procedure must be applied.	2	9	2	36
		107	B: Contamination with microorganisms (*E. coli O157:H7*) due to unclean instrument	2	10	3	60*	Efficient cleaning, disinfection and prevention procedures of the equipment should be applied. Disinfection should follow immediately after cleaning and before a process run. All equipment should be routinely dismantled or parts loosened for disinfection. Cleaning efficacy should be monitored using indicators of hygiene by tests for coliform bacteria. The cleaning utensils (brushers, sponges and spray guns) themselves must be disinfected properly. Movements of personnel and goods should be limited. The correct hygienic design and proper maintenance of equipment should be provided.	1	10	2	20

CP	Processing stage	Risk number	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections
		108	C: Heavy metal contamination due to metal surfaces of instruments which come into contact with food	3	8	3	72*	The free iron on the surfaces of instruments should be detected and removed by chemical or mechanical methods. Moving parts and presence of rust on the instruments should be checked regularly. Food-grade metals must be used for all metal surfaces that come into contact with food. Non-lead solder and food-grade items must be used at any repairing.	1	8	2	16
		109	P: Hard foreign objects (wire from sieving) due to old-expired equipment	4	7	3	84*	Metal detectors should be used. detectors should be carefully chosen and calibrated to pick up the smallest pieces of metal. The efficiency of the equipment should be monitored and its expired, broken pieces should be changed periodically.	2	7	2	28
CP20	Packaging (with nylon bags)	110	B: Virus (NLV) contamination by personnel handling	2	7	8	112*	Personnel should be trained to understand the risk associated with cross-contamination and they should be provided with appropriate facilities to operate good hygienic practice e.g. hand basin and bactericidal soaps. Table ledges, door handlers, overhead pipes and many other areas should be routinely disinfected. Hands-on operations should be minimised.	1	7	6	42
		111	B: Virus (Rotavirus, Hepatitis A) contamination by personnel handling	1	10	8	80*	Personnel should be trained to understand the risk associated with cross-contamination and they should be provided with appropriate facilities to operate good hygienic practice e.g. hand basin and bactericidal soaps. Table ledges, door handlers, overhead pipes and many other areas should be routinely disinfected. Hands-on operations should be minimised. Personnel must get vaccinated for Hepatitis A.	1	10	6	60
		112	B: Contamination with microorganisms (*S. aureus, L. monocytogenes, Shigella spp.*) due to personnel handling	4	7	2	56*	Bare hand contact with the product must be avoided. Personnel should comply with the Good Manufacturing Practice and avoid extraneous materials, such as insects and rodent hairs, in the final product. Efficient lighting and temperature must be provided in the environment to avoid personnel failures.	2	7	1	14
		113	B: Survival of pathogens (*Cl. Botulinum, E. coli*) due to inappropriate preparation of the food (post process)	3	9	2	54*	Appropriate information should be given on the product packaging to provide guidance concerning safe handling and storage conditions and cooking processes that need to be employed.	2	9	1	18
		114	C: Low molecular weight substances (Biosphenol A), migrated from the packaging material into the food	2	9	3	54*	Packaging material should be suitable for coming in contact with food.	1	9	2	18
		115	C: Heavy metal contamination (lead) due to lead based printings used for packaging	1	8	1	8	None				

CP	Processing stage	Risk number	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections
		116	P: Foreign objects due to personal effects (false fingernail, button, hair, apron and glove pieces) and inappropriate packaging (pieces of packaging material)	6	4	1	24	None				

* Corrective actions are required since RPN is above 50.

Table A.5. Failure mode and effect analysis table for the industrial tarhana production

CP	Processing stage	Risk number	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections
CP1	Receiving onion, dry	1	B: Virus (*Hepatitis A*) due to unsanitary agricultural applications	2	10	8	160*	Vegetables must come from approved suppliers. It must be considered whether the land used to produce crops have been treated with sewage sludge. Very soiled onions should not be purchased.	1	10	6	60
		2	B: Moulds, transferred by diseased onions (Bacterial soft rot, black mold rot, botrytis neck rot, blue mold rot, fusarium bulb rot caused by *Erwinia carotovora*, *Aspergillus alliaceus*, *Aspergillus niger*, *Botrytis allii*, *Fusarium spp.*)	7	5	2	70*	Onions must come from approved suppliers. Wounded, bruised and soiled bulbs should be excluded.	3	5	1	15
		3	B: Parasite zoones (Protozoa- *Cryptosporidium parvum*, *Giardia duodenalis*, *Toxoplasma gondii*, *Blastocystis hominis*, Nematodes- *Toxocara canis*, *Toxascaris leonina*, *Toxocara cati*, *Lagochilascaris minor*, Pentastomids-*Armillifer armillatus*) due to poor agricultural applications	4	8	2	64*	Vegetables should be handled carefully and supplied from reliable wholesalers/ producers. Handling of soiled and dirty vegetables should be avoided.	2	8	1	16
		4	C: Heavy metal contamination (lead, cadmium) due to usage of contaminated soil and/or water in the agricultural land.	8	10	3	240*	Vegetables must come from approved suppliers. It must be considered whether the agricultural land of crops was treated with lead containing pesticides, sewage sludge, irrigated water and/ or soil and effective agricultural approaches were applied to reduce metal accumulation on the soil. Very soiled onions should not be purchased.	2	10	2	40
		5	C: Pesticide residue due to deficient pesticide applications in the agricultural land.	6	8	3	144*	Vegetables must come from approved suppliers. The supplier must provide the documents certifying the safety of vegetables.	2	8	2	32
		6	C: Nitrate contamination due to environmental factors (soil, water) or fertilisers containing nitrate	5	7	3	105*	The supplier should report the nitrate concentration of vegetables by documents. The results should be in limits.	2	7	2	28
		7	P: Foreign objects (soil, sand) due to improper harvesting practices	8	1	1	8	None				
CP2	Receiving chickpeas	8	B: Molds due to poor post-harvest operations like inefficient storage conditions	7	5	2	70*	Chickpeas must come from approved suppliers. It must come along with quality certificates. The certificates should report the moisture content of chickpea, the number/ colonies of insects, fungi and mold that appear compared with the upper-approved standards. Visual control of the chickpea must be carried out in order to detect the high humidity, undesirable odours, defective and moldy grains. Moisture content of chickpeas must be measured by a grain moisture tester. It must avoid to supply chickpeas which were stored in long duration (more than 3 months).	3	5	1	15
		9	B: Diseased chickpeas (Chickpea rust, *U.ciceris-arietini*, infection with pea seed-borne mosaic virus) due to inefficient agricultural applications	5	1	1	5	None				

CP	Processing stage	Risk number	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections
		10	C: Pesticide, Insecticide residues due to post harvest pesticides, applied to protect the stored food from pests	6	8	3	144*	Chickpeas must come from approved suppliers. It must come along with quality certificates and pesticide analysis. It must be considered whether chickpeas stored with insecticide application.	2	8	2	32
		11	C: Mycotoxins (Aflatoxin) produced by mold which present due to environmental conditions in growing period of the crop and poor storage during the post-harvest period	6	8	2	96*	Chickpeas must come from approved suppliers. It must come along with quality certificates and a mycotoxin analysis. The certificates should report the moisture content of chickpea, the average of the occurring mycotoxins, the number/ colonies of insects and fungi that appear compared with the upper-approved standards. Visual control of the chickpea must be carried out in order to detect the high humidity, undesirable odours and defective grains. Moisture content of chickpeas must be measured by a grain moisture tester. It must avoid to supply chickpeas which were stored in long duration (more than 3 months). Chickpeas should wash efficiently with distilled water or sodium carbonate solution just before using.	3	8	2	48
		12	P: Pests (bruchidis-Callosobruchus chinesis L.) due to poor post-harvest operations like inefficient storage conditions	7	3	4	84*	The chickpeas should be inspected visually. It must be avoided to supply chickpeas which were stored in more than 3 months. The chickpeas, damaged, cracked and with holes, shouldn't be supplied . Moisture level of chickpeas should be measured by a tester and grains moisture content must be under 7%.	2	3	3	18
		13	P: Hard foreign objects (stone pieces) due to poor post-harvest operations	8	5	2	80*	Dirty chickpeas shouldn't be supplied, the chickpeas should wash efficiently and the stones should remove physically	2	5	1	10
CP3	Receiving rye	14	B: Microorganisms (*E. coli, C.botulinum, Shigella*) due to improper storage conditions, transferred by rodent excreta and diseased seeds	6	10	2	120*	It must be avoided to supply diseased grains. Grain moisture level must be tested by a grain moisture tester.	3	10	1	30
		15	B: Fungi (Ergot-*Claviceps purpurea*) due to inefficient agricultural and post harvest applications	3	10	3	90*	Rye must come from approved suppliers. It must come along with quality certificates. The certificates should report the moisture content of rye, the number/ colonies of fungi that appear compared with the upper-approved standards. Visual control of the rye must be carried out in order to detect the high humidity, undesirable odours and defective grains. Grain moisture content must be measured by a grain moisture tester. It must avoid to supply grains which were stored in long duration (more than 3 months). The defective grains must be removed by physical methods like density, air blowing, specific gravity tables and dry cleaning.	2	5	2	20
		16	B: Microorganisms (*B. Cereus, Sallmonella spp., C. perfringens, Micrococcus, Alcaligenes*) due to improper storage conditions, transferred by rodent excreta and diseased seeds	6	7	2	84*	It must be avoided to supply diseased grains. Grain moisture level must be tested by a grain moisture tester.	3	7	1	21
		17	C: Pesticide, Insecticide residues due to post harvest pesticides, applied to protect the stored food from pests	8	8	3	192*	Rye must come from approved suppliers. It must come along with quality certificates and a pesticide analysis. The certificates should report the pesticide content of the rye. It must avoid to supply grains which were stored with insecticide application.	2	8	2	32

CP	Processing stage	Risk number	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections
		18	C: Mycotoxins (Deoxynilvaneol, Aflatoxin, Ochratoxin A) produced by mold which present due to environmental conditions in growing period of the crop and poor storage during the post-harvest period	8	8	2	128*	Rye must come from approved suppliers. It must come along with quality certificates and a mycotoxin analysis. The certificates should report the moisture content of rye, the average of the occurring foreign materials, and as far as the mycotoxins are concerned, the number/ colonies of insects and fungi that appear compared with the upper-approved standards. Visual control of the rye must be carried out in order to detect the presence of extraneous materials, high humidity, undesirable odours and defective grains. Grain moisture content must measure by a grain moisture tester. It must avoid to supply grains which were stored in long duration (more than 3 months). The defective grains must be removed by physical methods like density, air blowing, specific gravity tables and dry cleaning.	2	8	1	16
		19	C: Heavy metal contamination (lead, cadmium) due to usage of contaminated soil and/or water in the agricultural land.	6	10	2	120*	Rye must come from approved suppliers. It must be considered whether the land used to produce crops have been treated with lead containing pesticides or sewage sludge. rye must be washed before using.	2	10	1	20
		20	C: Toxins and allergens, maintained from some storage pests.	5	3	3	45	None				
		21	P: Pests (Angoumois grain moth-*Sitotroga cerealella*-, weevils- *Sitophilus spp*.-, confused flour beetles-*Tribolium spp*.-, saw-toothed grain beetles, mites), rodent excreta pellets, insect pieces due to inefficient post-harvest applications like poor storage	7	3	4	84*	The grains should inspect visually for pest existence. It must be avoided to supply grains which were stored in more than 3 months. Moisture level of grains should be measured by a tester and lentils moisture content must be under 7%.	2	3	3	18
		22	P: Hard foreign objects (stone) found in rye due to inefficient visual inspection and sorting	8	5	2	80*	The grains should be washed just before usage and stones would remove physically	2	5	1	10
		23	P: Foreign objects, presence of wild plants (specks of *Lolium perenne, Vicia sativa L.*) due to improper harvesting practices	5	3	1	15	None				
CP4	Receiving buckwheat	24	B: Microorganisms (*E. coli, C.botulinum, Shigella*) due to improper storage conditions, transferred by rodent excreta and diseased seeds	6	10	2	120*	It must be avoided to supply diseased grains. Grain moisture level must be tested by a grain moisture tester.	3	10	1	30
		25	B: Microorganisms (*B. Cereus, Sallmonella spp., C. perfringens, Micrococcus, Alcaligenes*) due to improper storage conditions, transferred by rodent excreta and diseased seeds	6	7	2	84*	It must be avoided to supply diseased grains. Grain moisture level must be tested by a grain moisture tester.	3	7	1	21

CP	Processing stage	Risk number	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections
		26	B: Fungi (*Ascohyta fagopyri, Sclerotinia sp, Peronospora documeti, Botrytis cinerea, Fusarium sp., Phyllosticta polyconorum, Cercospora fagopyri*) due to inefficient agricultural and post harvest applications	6	6	2	72*	Buckwheat must come from approved suppliers. It must come along with quality certificates. The certificates should report the moisture content of buckwheat, the number/ colonies of fungi that appear compared with the upper-approved standards. Visual control of the buckwheat must be carried out in order to detect the high humidity, undesirable odours and defective grains. Grain moisture content must be measured by a grain moisture tester. It must avoid to supply grains which were stored in long duration (more than 3 months). The defective grains must be removed by physical methods like density, air blowing, specific gravity tables and dry cleaning.	2	6	1	12
		27	C: Pesticide, Insecticide residues due to post harvest pesticides, applied to protect the stored food from pests	8	8	3	192*	Buckwheat must come from approved suppliers. It must come along with quality certificates and a pesticide analysis. The certificates should report the pesticide content of the buckwheat. It must avoid to supply grains which were stored with insecticide application.	2	8	2	32
		28	C: Mycotoxins (Deoxynilvaneol, Aflatoxin, Ochratoxin A) produced by mold which present due to environmental conditions in growing period of the crop and poor storage during the post-harvest period	8	8	2	128*	Buckwheat must come from approved suppliers. It must come along with quality certificates and a mycotoxin analysis. The certificates should report the moisture content of buckwheat, the average of the occurring foreign materials, and as far as the mycotoxins are concerned, the number/ colonies of insects and fungi that appear compared with the upper-approved standards. Visual control of the buckwheat must be carried out in order to detect the presence of extraneous materials, high humidity, undesirable odours and defective grains. Grain moisture content must measure by a grain moisture tester. It must avoid to supply grains which were stored in long duration (more than 3 months). The defective grains must be removed by physical methods like density, air blowing, specific gravity tables and dry cleaning.	2	8	1	16
		29	C: Heavy metal contamination (lead, cadmium) due to usage of contaminated soil and/or water in the agricultural land.	6	10	2	120*	Buckwheat must come from approved suppliers. It must be considered whether the land used to produce crops have been treated with lead containing pesticides or sewage sludge. buckwheat must be washed before using.	2	10	1	20
		30	C: Toxins and allergens, maintained from some storage pests.	5	3	3	45	None				
		31	P: Pests (Angoumois grain moth-*Sitotroga cerealella*-, weevils- *Sitophilus spp*.-, confused flour beetles-*Tribolium spp*.-, saw-toothed grain beetles, mites), rodent excreta pellets, insect pieces due to inefficient storage conditions	7	3	4	84*	The grains should inspect visually for pest existence. It must be avoided to supply grains which were stored in more than 3 months. Moisture level of grains should be measured by a tester and lentils moisture content must be under 7%.	2	3	3	18
		32	P: Hard foreign objects (stone) found in buckwheat due to inefficient visual inspection and sorting	8	5	2	80*	The stones should remove physically and the grains should wash efficiently just before usage.	2	5	1	10
		33	P: Foreign objects (specks of *Lolium perenne*) due to improper harvesting practices	5	3	1	15	None				

CP	Processing stage	Risk number	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections
CP5	Receiving buckwheat semolina	34	B: Microorganisms (*E. coli, C.botulinum, Shigella*) due to equipment contamination or improper storage properties	6	10	2	120*	Buckwheat semolina must be purchased from approved suppliers. Its receipt should be accompanied with certificates of quality control and microbiological analysis. The certificates should report the humidity of buckwheat semolina and regarding microorganisms, their content and comparison with the upper approved standards.	3	10	1	30
		35	B: Microorganisms (*B. Cereus, Sallmonella spp., C.perfringens, Micrococcus, Alcaligenes*) due to equipment contamination or improper storage properties	6	7	2	84*	Buckwheat semolina must be purchased from approved suppliers. Its receipt should be accompanied with certificates of quality control and microbiological analysis. The certificates should report the humidity of buckwheat semolina and regarding microorganisms, their content and comparison with the upper approved standards.	3	7	1	21
		36	B: Molds, fungi due to inappropriate storage conditions and careless handling	7	4	2	56*	Buckwheat semolina must be purchased from approved suppliers. Its receipt should be accompanied with certificates of quality control. The certificates should report the moisture, mold, and mold spore count of buckwheat semolina, and their comparison with the upper approved standards. Moisture content of buckwheat semolina should be measured by a grain moisture tester.	4	4	1	16
		37	C: Pesticide, Insecticide residues due to post harvest pesticides, applied to protect the stored food from pests	6	8	3	144*	Buckwheat semolina must be purchased from approved suppliers. Its receipt should be accompanied with certificates of quality control. The certificates should report the pesticides of buckwheat semolina, their content and comparison with the upper approved standards.	2	8	2	32
		38	C: Mycotoxins (Trichothencene pruced by *Fusarium spp.*, Aflatoxins, deoksinivalenol, zearalenon, citrinin, achratoxin, cyclopiazonic acid, viomellein, xanthomegnin, patulin) produced by mold which present due to environmental conditions in growing period of the crop and poor storage during the post-harvest period	8	8	2	128*	Buckwheat semolina must be purchased from approved suppliers. Its receipt should be accompanied with certificates of quality control. The certificates should report the mycotoxins of buckwheat semolina, their content and comparison with the upper approved standards.	2	8	1	16
		39	C: Heavy metal contamination (lead, cadmium) due to usage of contaminated soil and/or water in the agricultural land	6	9	2	108*	Buckwheat semolina must be purchased from approved suppliers. Its receipt should be accompanied with certificates of quality control which should report the pieces of metals and heavy metal, their content and comparison with the upper approved standards.	3	9	1	27
		40	C: Quinones (benzoquinones), allergens, maintained from some pests (buckwheat semolina beetles-*Alphitobius spp., Tribolium spp., Tenebrio spp.*, mites, cockroaches).	4	3	3	36	None				
		41	P: Hard foreign objects (wire from sieving) due to old-expired equipment	6	6	1	36	None				
		42	P: Foreign objects (insect fragments and larvae of small flies adhered to the food)	3	1	3	9	None				

CP	Processing stage	Risk number	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections
CP6	Receiving durum clear flour	43	B: Microorganisms (E. coli, C.botulinum, Shigella) due to equipment contamination or improper storage properties	6	10	2	120*	Flour must be purchased from approved suppliers. Its receipt should be accompanied with certificates of quality control and microbiological analysis. The certificates should report the humidity of flour and regarding microorganisms, their content and comparison with the upper approved standards.	3	10	1	30
		44	B: Microorganisms (*B. Cereus, Sallmonella spp., C.perfringens, Micrococcus, Alcaligenes*) due to equipment contamination or improper storage properties	6	7	2	84*	Flour must be purchased from approved suppliers. Its receipt should be accompanied with certificates of quality control and microbiological analysis. The certificates should report the humidity of flour and regarding microorganisms, their content and comparison with the upper approved standards.	3	7	1	21
		45	B: Molds, fungi due to inappropriate storage conditions and careless handling	7	4	2	56*	Flour must be purchased from approved suppliers. Its receipt should be accompanied with certificates of quality control. The certificates should report the moisture, mold, and mold spore count of flour, and their comparison with the upper approved standards. Moisture content of flour should be measured by a grain moisture tester.	4	4	1	16
		46	C: Pesticide, Insecticide residues due to post harvest pesticides, applied to protect the stored food from pests	6	8	3	144*	Flour must be purchased from approved suppliers. Its receipt should be accompanied with certificates of quality control. The certificates should report the pesticides of flour, their content and comparison with the upper approved standards.	2	8	2	32
		47	C: Mycotoxins (Trichothencene pruced by *Fusarium spp.*, Aflatoxins, deoksinivalenol, zearalenon, citrinin, achratoxin, cyclopiazonic acid, viomellein, xanthomegnin, patulin) produced by mold which present due to environmental conditions in growing period of the crop and poor storage during the post-harvest period	8	8	2	128*	Flour must be purchased from approved suppliers. Its receipt should be accompanied with certificates of quality control. The certificates should report the mycotoxins of flour, their content and comparison with the upper approved standards.	2	8	1	16
		48	C: Heavy metal contamination (lead, cadmium) due to usage of contaminated soil and/or water in the agricultural land	6	9	2	108*	Flour must be purchased from approved suppliers. Its receipt should be accompanied with certificates of quality control which should report the pieces of metals and heavy metal, their content and comparison with the upper approved standards.	3	9	1	27
		49	C: Quinones (benzoquinones), allergens, maintained from some pests (flour beetles-*Alphitobius spp.*, *Tribolium spp.*, *Tenebrio spp.*, mites, cockroaches)	4	3	3	36	None				
		50	P: Hard foreign objects (wire from sieving) due to old-expired equipment	6	6	1	36	None				
		51	P: Foreign objects (insect fragments and larvae of small flies adhered to the food)	3	1	3	9	None				
CP7	Receiving tomato paste	52	B: Microorganisms (*Bacillus coagulants*) (due to contamination with some fly eggs and larvae during tomato harvest, and due to inadequate heat treatment in the production and seam leakage)	3	9	3	81*	Modified products which have changes in the packaging of cans should not be purchased. At each production first opened product should be used and the remain should not be used.	1	9	2	18

CP	Processing stage	Risk number	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections
		53	B: Microorganisms (*C. pasteurianum, C. Butyricum and C. Botulinum*) due to contamination with some fly eggs and larvae during tomato harvest, inadequate heat treatment and seam leakage during production	2	9	3	54*	Modified products which have changes in the packaging of cans should not be purchased. At each production first opened product should be used and the remain should not be used.	1	9	2	18
		54	B: Molds, yeasts due to poor process conditions	1	5	1	5	None				
		55	C: Pesticide residue due to contaminated tomato	8	9	1	72*	Tomato paste must be come from approved suppliers. Its receipt should be accompanied with certificates of quality control.	2	9	1	18
		56	C: Mycotoxins produced by moulds (*Alternaria spp.*) in spoiled tomatoes	4	8	2	64*	Tomato paste must be come from approved suppliers. Its receipt should be accompanied with certificates of quality control.	2	8	1	16
		57	C: Heavy metal contamination due to lead soldered cans	2	8	1	16	None				
		58	P: Foreign objects (eggs and larvae of small flies) transferred by tomato	5	2	2	20	None				
		59	P: Foreign objects (metal pieces) drop in paste while the can was opening for usage	2	7	1	14	None				
		60	P: Foreign objects (Insect fragments) due to poor process practices	5	2	1	10	None				
CP8	Receiving red pepper paste	61	B: Microorganisms (*Bacillus coagulants*) due to inadequate heat treatment during production and seam leakage	3	9	3	81*	Not supplying products with dirty, damaged, deformed package. At each production using first opened product and not keeping the remained.	1	9	2	18
		62	B: Microorganisms (*C. pasteurianum, C. Butyricum and C. Botulinum*) due to inadequate heat treatment during production and seam leakage	2	9	3	54*	Modified products which have changes in the packaging of cans should not be purchased. At each production first opened product should be used and the remain should not be used.	1	9	2	18
		63	B: Molds, yeasts due to poor process conditions	1	5	1	5	None				
		64	C: Pesticide residue due to contaminated red pepper	8	9	1	72*	Monitoring the analyse reports of supplier, not supplying products that have pesticide levels over legal limits. Supplying the product from reliable wholesalers/producers.	2	9	1	18
		65	C: Mycotoxins produced by moulds (*Alternaria spp.*) of spoiled tomatoes	4	8	2	64*	Tomato paste must be come from approved suppliers. Its receipt should be accompanied with certificates of quality control.	2	8	1	16
		66	C: Heavy metal contamination due to lead soldered cans	2	8	1	16	None				
		67	P: Foreign objects (eggs and larvae of small flies) transferred by tomato	5	2	2	20	None				
		68	P: Foreign objects (metal pieces) drop in paste while the can was opening for usage	2	7	1	14	None				
		69	P: Foreign objects (Insect fragments) due to poor process practices	5	2	1	10	None				

CP	Processing stage	Risk number	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections
CP9	Receiving yeast source (fermented tarhana dough which is kept from previous production)	70	B: Survival of microorganisms during fermentation (*S. aureus*) due to contamination in previous production	2	7	2	28	None				
		71	B: Survival of microorganisms (*Vero-cytotoxigenic E. coli*) due to contamination in previous production	2	10	1	20	None				
		72	C: Mycotoxins (*ochratoxin A, type B trichothecenes*) transferred by the previous dough	1	8	2	16	None				
		73	P: Foreign objects due to improper handling and storage	1	3	2	6	None				
CP10	Receiving wheat flour	74	B: Microorganisms (*E. coli*, *Cl.botulinum, Shigella*) due to equipment contamination or improper storage properties	6	10	2	120*	Flour must be purchased from approved suppliers. Its receipt should be accompanied with certificates of quality control and microbiological analysis. The certificates should report the humidity of flour and regarding microorganisms, their content and comparison with the upper approved standards.	3	10	1	30
		75	B: Microorganisms (*B. Cereus, Sallmonella* spp., *C. perfringens, Micrococcus, Alcaligenes*) due to equipment contamination or improper storage properties	6	7	2	84*	Flour must be purchased from approved suppliers. Its receipt should be accompanied with certificates of quality control and microbiological analysis. The certificates should report the humidity of flour and regarding microorganisms, their content and comparison with the upper approved standards.	3	7	1	21
		76	B: Molds, fungi due to inappropriate storage conditions and careless handling	7	4	2	56*	Flour must be purchased from approved suppliers. Its receipt should be accompanied with certificates of quality control. The certificates should report the moisture, mold, and mold spore count of flour, and their comparison with the upper approved standards. Moisture content of flour should be measured by a grain moisture tester.	4	4	1	16
		77	C: Pesticide, Insecticide residues due to post harvest pesticides, applied to protect the stored food from pests	6	8	3	144*	Flour must be purchased from approved suppliers. Its receipt should be accompanied with certificates of quality control. The certificates should report the pesticides of flour, their content and comparison with the upper approved standards.	2	8	2	32
		78	C: Mycotoxins (Trichothencene pruced by *Fusarium spp*., Aflatoxins, deoksinivalenol, zearalenon, citrinin, achratoxin, cyclopiazonic acid, viomellein, xanthomegnin, patulin) produced by mold which present due to environmental conditions in growing period of the crop and poor storage during the post-harvest period	8	8	2	128*	Flour must be purchased from approved suppliers. Its receipt should be accompanied with certificates of quality control. The certificates should report the mycotoxins of flour, their content and comparison with the upper approved standards.	2	8	1	16
		79	C: Heavy metal contamination (lead, cadmium) due to usage of contaminated soil and/or water in the agricultural land.	6	9	2	108*	Flour must be purchased from approved suppliers. Its receipt should be accompanied with certificates of quality control which should report the pieces of metals and heavy metal, their content and comparison with the upper approved standards.	3	9	1	27

CP	Processing stage	Risk number	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections
		80	C: Quinones (benzoquinones), allergens, maintained from some pests (flour beetles-*Alphitobius spp., Tribolium spp., Tenebrio spp.*, mites, cockroaches).	4	3	3	36	None				
		81	P: Hard foreign objects (wire from sieving) due to old-expired equipment	6	6	1	36	None				
		82	P: Foreign objects (insect fragments and larvae of small flies adhered to the food)	3	1	3	9	None				
CP11	Receiving water	83	B: Virus (Rotavirus, Hepatitis A) due to contamination of public or well waters with faecal material	6	10	3	180*	Water only from a public water system that is regularly monitored and chlorinated should be used. Water should be filtrated by a specially constructed filter system.	2	10	2	40
		84	B: Virus (NLV, Hepatitis E) due to contamination of public or well waters with faecal material	6	7	3	126*	Water only from a public water system that is regularly monitored and chlorinated should be used. Water should be filtrated by a specially constructed filter system.	2	7	2	28
		85	B: *Campylobacters, Arcobacter spp., Shigella spp., aeromonas , Salmonella spp.contamination* due to contaminated or poorly sanitised water sources	6	7	2	84*	Water should be tested by total coliform test. Water only from a public water system that is regularly monitored and chlorinated should be used. Preferably any water treatment devices like distillers, reverse osmosis should be used.	4	7	1	28
		86	B: *Salmonella Thyphi, Shigella dysenteriae, Vibrio cholerae* due to contaminated or poorly sanitised water sources	2	10	4	80*	Water should be tested by total coliform test. Water only from a public water system that is regularly monitored and chlorinated should be used. Preferably any water treatment devices like distillers, reverse osmosis should be used.	1	10	3	30
		87	B: Parasite zoones (Microspora- *Enterocytozooan bieneusi, Encephalitozoon cuniculi*, Protozoa- *Cryptosporidium parvum, Giardia duodenalis, Toxoplasma gondii, Blastocystis hominis*, Pentastomids- *Armillifer armillatus*) due to faecally contaminated water sources	4	8	2	64*	The water must be tested periodically. Water must be supplied from a public water system that is regularly monitored. It must be avoid to use contaminated water. Water should be filtrated with a specially constructed filter system.	2	9	1	18
		88	B: *E. coli O157:H7* due to contaminated or poorly sanitised water sources	3	10	2	60*	Water should be tested by total coliform test. Water only from a public water system that is regularly monitored and chlorinated should be used. Preferably any water treatment devices like distillers, reverse osmosis should be used.	1	10	1	10
		89	C: Heavy metal (lead) contamination due to corrosion on water system or environmental factors if private well is used	7	9	1	63*	The water corrosivity and Pb and Cu content must be tested periodically. The corrosive materials should be changed. Corrosion control devices like calcide filters should be used . Water must be supplied from a public water system. Before using water must be left to run for 15 to 30 seconds. It must be considered whether lead free materials are used in drinking water plumbing. Preferably any water treatment devices like distillers, reverse osmosis should be used for distilling water.	1	8	1	8
		90	C: Chlorine residual due to water chlorinated over the limits	5	6	2	60*	It must be tested periodically the chlorine residual level of potable water by quick and simple tests (the diethyl paraphenylene diamine test).	1	6	1	6
		91	C: Pesticide residue due to contamination of public water sources by agricultural waters, reservoirs and lakes	7	8	1	56*	The water must be tested periodically. Water must be supplied from a public water system that is regularly monitored.	1	8	1	8

CP	Processing stage	Risk number	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections
		92	P: Foreign objects (pieces of materials) due to material degradation and defects of water pipeline	2	7	2	28	None				
CP12	Receiving salt	93	C: Additives, magnesium carbonate, calcium phosphate, calcium carbonate, magnesium oxide, added over the legal limits	2	6	1	12	None				
		94	P: Foreign objects due to failure in processing	3	5	1	15	None				
CP13	Receiving raw milk (cow)	95	B: Microorganisms (Severe) (*E. coli O157:H7*) due to poor milking, milk processing and transferring conditions	5	10	2	100*	Milk must come from reliable suppliers. It must be considered if milk was collected at the day of receiving, immediately cooled to ≤8° after collection and transferred with chill chain. The temperature of milk should be measured by a probe and supply only the product below 6°C. The milk should be tested for its bacterial load with methylene blue or by some other tests.	1	10	1	10
		96	B: Microorganisms (Severe) (*Brucella ssp., Cl. botulinum, Salmonella typhi, paratyphi and dublin, Shigella dysenteriae, Mycobacterium avium*) due to poor milking, milk processing and transferring conditions	2	10	5	100*	Milk must come from reliable suppliers. It must be considered if milk was collected at the day of receiving, immediately cooled to ≤8° after collection and transferred with chill chain. The temperature of milk should be measured by a probe and supply only the product below 6°C. The milk should be tested for its bacterial load with methylene blue or by some other tests.	1	10	4	40
		97	B: Spoilage micro-organisms (Moderate) (*Listeria monocytogenes, Salmonella spp., Enterotoxigenic Escherichia coli, Enteroinvasive Escherichia coli, Bacillus cereus, Clostridium perfringens, Staphylococcus aerous, Campylobacter jejuni and other species, Aeromonas spp., Yersinia enterocolitica*) due to poor milking, milk processing and transferring conditions	5	7	2	70*	Milk must come from reliable suppliers. It must be considered if milk was collected at the day of receiving, immediately cooled to ≤8° after collection and transferred with chill chain. The temperature of milk should be measured by a probe and supply only the product below 6°C. The milk should be tested for its bacterial load with methylene blue or by some other tests.	2	7	1	14
		98	B: Parasites (Protozoa- *Crytosporidium spp., Giardia spp.*) due to poor milking, milk processing and transferring conditions	4	7	2	56*	Milk should come from reliable suppliers. It must be sure that milk was collected at the day of receiving and it was immediately cooled to ≤8° after collection and transferred with chill chain. The temperature of the milk should be below 6°C and must be measured by a probe.	2	7	1	14
		99	C: Heavy metal contamination (lead, copper, cadmium, mercury) due to contaminated animal feed	8	10	2	160*	Milk should come with the certificates reporting its metal content compared with the specifications. It must be considered whether the lactating animals were grown far away from potential emitting industries.	3	10	1	30
		100	C: Pesticide residues (Organo-phosphates, Fumigants, Carbamates) due to contaminated animal feed of lactating animal	6	8	3	144*	Milk must come from approved suppliers. The milk should be tested periodically by a laboratory. The supplier must provide the documents certifying the safety of animal feeds and milk.	2	8	2	32
		101	C: Dioxin due to accumulation of the pollutants into the fatty tissues and products of animals.	6	8	3	144*	Milk should be supplied from producers who maintain the routine tests of animal feed and milk. Tarhana producer should give importance to the dioxin and review the analyze results and certificates carefully.	2	8	2	32

CP	Processing stage	Risk number	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections
		102	C: Veterinary drug residues due to drugs given into unhealthy animal	8	8	2	128*	Milk must come from approved suppliers. The milk should be tested periodically by a laboratory.	2	8	1	16
		103	C: Mycotoxins (Ochratoxin, Aflatoxin, Thyro-toxicosis) due to contaminated animal feed	6	6	2	72*	Milk must come from approved suppliers. The milk should be tested periodically by a laboratory. The supplier must provide the documents certifying the mycotoxin content of milk.	3	6	1	18
		104	P: Foreign objects (soil, sand, animal leucocyte cells, hair, chaff, insects, glass fragments, wood slivers, metal fragments) due to inefficient filtration of milk	6	1	1	6	None				
CP14	Storing onion	105	B: Moulds, transferred by diseased onions and grow due to improper storage conditions (Bacterial soft rot, black mold rot, botrytis neck rot, blue mold rot, fusarium bulb rot caused by *Erwinia carotovora, Aspergillus alliaceus, Aspergillus niger, Botrytis allii, Fusarium spp.*)	7	5	2	70	Onions should be stored at 0°C. Wounded and bruised bulbs should not be stored.	3	5	1	15
CP15	Storing chickpea	106	B: Molds, fungi due to inefficient storage conditions and management	7	5	2	70	The chickpeas must be stored in a clean, dry and cool area and with minimum temperature fluctuations. Moisture content must be reduced by regular aeration to avoid mold contamination and growth. The chickpeas must store preferably in less than 3 months. Moisture content of chickpeas should be measured periodically by a grain moisture tester. The store should be cleaned thoroughly and if necessary, fumigated before new grains are added. The temperature and the humidity should be recorded and corrective actions should take place when deviations are observed.	3	5	1	15
		107	C: Mycotoxins (Aflatoxin) due to poor storage conditions	7	8	2	112*	The chickpeas must be stored in a clean, dry (low-humidity) and cool area (to avoid insect and rodent infestation and dust) and with minimum temperature fluctuations. Moisture content must be reduced by regular aeration to avoid mold contamination and growth. The chickpeas must store preferably in less than 3 months. Periodic visits of the store should be scheduled for any pest situation. Moisture content of chickpeas should be measured periodically by a grain moisture tester. The store should be cleaned thoroughly and if necessary, fumigated before new grains are added. If seeds will store for long time, Seeds must be mixed with non-toxic chemicals such as vegetable oil which avoid pests to attach on the surface of grain. The temperature and the humidity should be recorded and corrective actions should take place when deviations are observed.	3	8	1	24

CP	Processing stage	Risk number	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections
		108	P: Pests (bruchidis-*Callosobruchus chinesis L.*) due to inefficient storage conditions and management	7	3	4	84*	Before storage the dirt of chickpeas should be cleaned as much as possible. The chickpeas should be stored in short duration (less than 3 months). Periodic visits of the store should be scheduled for any pest situation. Grain moisture level should be measured periodically by a grain moisture tester. The store should be cleaned thoroughly and fumigated before new grains are added. The storage site should be in cooler, well-aerated and low-humidity place. Before storage, seeds should be mixed with non-toxic chemicals such as vegetable oil which avoid pests to attach on the surface of grain.	4	3	3	36
CP16	Storing rye and buckwheat	109	B: Microorganisms (*E. coli, C.botulinum, Shigella*) due to improper storage conditions	6	10	2	120*	Grain moisture level must be measured periodically by a grain moisture tester. The store should be cleaned thoroughly and if possible fumigated before new grains are added. The storage site must be in cooler, well-aerated and low-humidity place. The temperature and the humidity should be recorded and corrective actions should take place when deviations are observed. When grains are stored for a long period, microbiological analysis should take place.	3	10	1	30
		110	B: Microorganisms (*B. Cereus, Sallmonella spp., C. perfringens, Micrococcus, Alcaligenes*) due to improper storage conditions, transferred by rodent excreta and diseased seeds	6	7	2	84*	Grain moisture level must be measured periodically by a grain moisture tester. The store should be cleaned thoroughly and if possible fumigated before new grains are added. The storage site must be in cooler, well-aerated and low-humidity place. The temperature and the humidity should be recorded and corrective actions should take place when deviations are observed. When grains are stored for a long period, microbiological analysis should take place.	3	7	1	21
		111	B: Molds, fungi due to inefficient storage conditions and management	7	4	2	56*	Before storage the dirt of grains should be cleaned as much as possible. The grains should be stored in a clean, dry (low-humidity) and cool area (to avoid insect and rodent infestation and dust) and with minimum temperature fluctuations. The temperature of the stored grain should be controlled at several fixed time intervals. Moisture should be reduced by regular aeration to avoid mold contamination and growth. Preferably the grains should be stored in less than 3 months. Periodic visits of the store should be scheduled for any pest situation. Grain moisture level should be measured periodically by a grain moisture tester. The store should be cleaned thoroughly and if necessary, fumigated before new grains are added. Before storage, seeds should be mixed with non-toxic chemicals such as vegetable oil which avoid pests to attach on the surface of grain. The temperature and the humidity should be recorded and corrective actions should take place when deviations are observed.	4	4	1	16

CP	Processing stage	Risk number	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections
		112	C: Mycotoxins produced by mould which grow due to poor storage conditions	7	8	2	112*	The grains must be stored in a clean, dry (low-humidity) and cool area (to avoid insect and rodent infestation and dust) and with minimum temperature fluctuations. Moisture content must be reduced by regular aeration to avoid mold contamination and growth. The grains must store preferably in less than 3 months. Periodic visits of the store should be scheduled for any pest situation. Moisture content of grains should be measured periodically by a grain moisture tester. The store should be cleaned thoroughly and if necessary, fumigated before new grains are added. If seeds will store for long time, grains must be mixed with non-toxic chemicals such as vegetable oil which avoid pests to attach on the surface of grain. The temperature and the humidity should be recorded and corrective actions should take place when deviations are observed.	3	8	1	24
		113	C: Toxins and allergens maintained from some storage pests	5	3	3	45	None				
		114	P: Pests (Angoumois grain moth-*Sitotroga cerealella-*, weevils- *Sitophilus spp.-*, confused flour beetles-*Tribolium spp.-*, saw-toothed grain beetles, mites-*Acarus silo L.*) due to poor storage conditions	7	3	4	84*	The grains should be stored in short duration (less than 3 months). Periodic visits of the store should be scheduled for any pest situation. The grain moisture level should be measured periodically by a grain moisture tester. The store should be cleaned toughly and fumigated before new grains are added. The storage site should be in cooler, well-aerated and low-humidity place. Before storage, seeds should mix with non-toxic chemicals such as vegetable oil which avoid pests to attach on the surface of grain.	4	3	3	36
CP17	Storing durum clear flour, buckwheat semolina and wheat flour	115	B: Microorganisms (*E. coli, C.botulinum, Shigella*) due to inefficient storage conditions and management	3	10	2	60*	The storage site must be in cooler, well-aerated and low-humidity place. The temperature and the humidity should be recorded and corrective actions should take place when deviations are observed. When flour is stored for a long period, microbiological analysis should take place.	3	10	1	30
		116	B: Microorganisms (*B. Cereus, Salmonella spp., C. perfringens, Micrococcus, Alcaligenes*) due to inefficient storage conditions and management	4	7	2	56*	The storage site must be in cooler, well-aerated and low-humidity place. The temperature and the humidity should be recorded and corrective actions should take place when deviations are observed. When flour is stored for a long period, microbiological analysis should take place.	3	7	1	21
		117	B: Molds, fungi due to inefficient storage conditions and management	7	4	2	56*	The storage site must be in cooler, well-aerated and low-humidity place. The temperature and the humidity should be recorded and corrective actions should take place when deviations are observed. When flour is stored for a long period, mould count should take place.	4	4	1	16
		118	C: Quinones (benzoquinones), allergens, maintained from some pests (flour beetles-*Alphitobius spp., Tribolium spp., Tenebrio spp.*, mites, cockroaches) due to inefficient storage conditions and management	4	3	3	36	None				

CP	Processing stage	Risk number	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections
		119	P: Foreign objects (insect and insect fragments) due to insect infestation	7	3	4	84*	The grains should be stored in short duration. Periodic visits of the store should be scheduled for any pest situation. The flour moisture level should be measured periodically by a grain moisture tester. The storage site should be in cooler, well-aerated and low-humidity place.	4	3	3	36
CP18	Cutting off the base and root of onion (by knife)	120	B: Contamination with microorganisms (*E. coli*) due to unclean instrument	4	10	2	80*	The knives must be washed efficiently, preferably by automatic washing equipment. UV knife disinfection cabinet should be provided and personnel should be encouraged to use it.	1	10	1	10
		121	B: Parasite zoones (Protozoa- *Cryptosporidium parvum, Giardia duodenalis, Blastocystis hominis*) transmitted by contaminated hands	2	8	4	64*	Personnel should be trained on hygiene and hand washing and they should be provided with appropriate facilities to operate good hygienic practice e.g. hand basin and bactericidal soaps. Table ledges, door handlers, overhead pipes and many other areas should be routinely disinfected. Hands-on operations should be minimised. Medical examination should be applied to employees on a continuous basis.	2	9	3	54
		122	B: Contamination with microorganisms (*L. monocytogenesis, S. aureus*) due to unclean instrument	4	7	2	56*	The knives must be washed efficiently, preferably by automatic washing equipment. UV knife disinfection cabinet should be provided and personnel should be encouraged to use it.	1	7	1	7
		123	P: Foreign objects (soil, sand, inedible parts of vegetables) due to inefficient cleaning of onion	8	1	1	8	None				
CP19	Peeling the top layer of onions (by onion peeling machine)	124	B: Contamination with microorganisms (*L. monocytogenesis, S. aureus*) due to unclean instrument	7	7	4	196*	Efficient cleaning, disinfection and prevention procedures of the equipment should be applied. Disinfection should follow immediately after cleaning and before a process run. All equipment should be routinely dismantled or parts loosened for disinfection. Cleaning efficacy should be monitored using indicators of hygiene by tests for coliform bacteria. The cleaning utensils (brushers, sponges and spray guns) themselves must be disinfected properly. Movements of personnel and goods should be limited. The correct hygienic design and proper maintenance of equipment should be provided.	1	7	3	21
		125	B: Machinery mold (*Geotrichum candidum*) due to inefficient cleaning of equipment	5	9	3	135*	Good equipment cleaning procedure must be applied.	2	9	2	36
		126	B: Contamination with microorganisms (*E. Coli O157:H7*) due to unclean instrument	2	10	3	60*	Efficient cleaning, disinfection and prevention procedures of the equipment should be applied. Disinfection should follow immediately after cleaning and before a process run. All equipment should be routinely dismantled or parts loosened for disinfection. Cleaning efficacy should be monitored using indicators of hygiene by tests for coliform bacteria. The cleaning utensils (brushers, sponges and spray guns) themselves must be disinfected properly. Movements of personnel and goods should be limited. The correct hygienic design and proper maintenance of equipment should be provided.	1	10	2	20
		127	P: Foreign objects (machinery parts) due to old-expired equipment	1	6	2	12	None				

CP	Processing stage	Risk number	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections
CP20	Milling onions (by milling machine)	128	B: Contamination with microorganisms (*L. monocytogenesis, S. aureus*) due to unclean instrument	7	7	4	196*	Efficient cleaning, disinfection and prevention procedures of the equipment should be applied. Disinfection should follow immediately after cleaning and before a process run. All equipment should be routinely dismantled or parts loosened for disinfection. Cleaning efficacy should be monitored using indicators of hygiene by tests for coliform bacteria. The cleaning utensils (brushers, sponges and spray guns) themselves must be disinfected properly. Movements of personnel and goods should be limited. The correct hygienic design and proper maintenance of equipment should be provided.	1	7	3	21
		129	B: Machinery mold (*Geotrichum candidum*) due to inefficient cleaning of equipment	5	9	3	135*	Good equipment cleaning procedure must be applied.	2	9	2	36
		130	B: Contamination with microorganisms (*E. Coli O157:H7*) due to unclean instrument	2	10	3	60*	Efficient cleaning, disinfection and prevention procedures of the equipment should be applied. Disinfection should follow immediately after cleaning and before a process run. All equipment should be routinely dismantled or parts loosened for disinfection. Cleaning efficacy should be monitored using indicators of hygiene by tests for coliform bacteria. The cleaning utensils (brushers, sponges and spray guns) themselves must be disinfected properly. Movements of personnel and goods should be limited. The correct hygienic design and proper maintenance of equipment should be provided.	1	10	2	20
		131	C: Heavy metal contamination due to metal surfaces of instruments which come into contact with food	3	8	3	72*	The free iron on the surfaces of instruments should be detected and removed by chemical or mechanical methods. Moving parts and presence of rust on the instruments should be checked regularly. Food-grade metals must be used for all metal surfaces that come into contact with food. Non-lead solder and food-grade items must be used at any repairing.	1	8	2	16
		132	P: Foreign objects (machinery parts) due to old-expired equipment	1	6	2	12	None				
CP21	Milling chickpeas and rye	133	B: Contamination with microorganisms (*L. monocytogenesis, S. aureus*) due to unclean instrument	7	7	4	196*	Efficient cleaning, disinfection and prevention procedures of the equipment should be applied. Disinfection should follow immediately after cleaning and before a process run. All equipment should be routinely dismantled or parts loosened for disinfection. Cleaning efficacy should be monitored using indicators of hygiene by tests for coliform bacteria. The cleaning utensils (brushers, sponges and spray guns) themselves must be disinfected properly. Movements of personnel and goods should be limited. The correct hygienic design and proper maintenance of equipment should be provided.	1	7	3	21
		134	B: Machinery mold (*Geotrichum candidum*) due to inefficient cleaning of equipment	5	9	3	135*	Good equipment cleaning procedure must be applied.	2	9	2	36

CP	Processing stage	Risk number	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections
		135	B: Contamination with microorganisms (*E. Coli O157:H7*) due to unclean instrument	2	10	3	60*	Efficient cleaning, disinfection and prevention procedures of the equipment should be applied. Disinfection should follow immediately after cleaning and before a process run. All equipment should be routinely dismantled or parts loosened for disinfection. Cleaning efficacy should be monitored using indicators of hygiene by tests for coliform bacteria. The cleaning utensils (brushers, sponges and spray guns) themselves must be disinfected properly. Movements of personnel and goods should be limited. The correct hygienic design and proper maintenance of equipment should be provided.	1	10	2	20
		136	C: Heavy metal contamination due to metal surfaces of instruments which come into contact with food	3	8	3	72*	The free iron on the surfaces of instruments should be detected and removed by chemical or mechanical methods. Moving parts and presence of rust on the instruments should be checked regularly. Food-grade metals must be used for all metal surfaces that come into contact with food. Non-lead solder and food-grade items must be used at any repairing.	1	8	2	16
		137	P: Foreign objects (machinery parts) due to old-expired equipment	2	6	2	24	None				
CP22	Sieving milled chickpeas and rye	138	B: Contamination with microorganisms (*L. monocytogenesis, S. aureus*) due to unclean instrument	7	7	4	196*	Efficient cleaning, disinfection and prevention procedures of the equipment should be applied. Disinfection should follow immediately after cleaning and before a process run. All equipment should be routinely dismantled or parts loosened for disinfection. Cleaning efficacy should be monitored using indicators of hygiene by tests for coliform bacteria. The cleaning utensils (brushers, sponges and spray guns) themselves must be disinfected properly. Movements of personnel and goods should be limited. The correct hygienic design and proper maintenance of equipment should be provided.	1	7	3	21
		139	B: Machinery mold (*Geotrichum candidum*) due to inefficient cleaning of equipment	5	9	3	135*	Good equipment cleaning procedure must be applied.	2	9	2	36
		140	B: Contamination with microorganisms (*E. Coli O157:H7*) due to unclean instrument	2	10	3	60*	Efficient cleaning, disinfection and prevention procedures of the equipment should be applied. Disinfection should follow immediately after cleaning and before a process run. All equipment should be routinely dismantled or parts loosened for disinfection. Cleaning efficacy should be monitored using indicators of hygiene by tests for coliform bacteria. The cleaning utensils (brushers, sponges and spray guns) themselves must be disinfected properly. Movements of personnel and goods should be limited. The correct hygienic design and proper maintenance of equipment should be provided.	1	10	2	20

CP	Processing stage	Risk number	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections
		141	C: Heavy metal contamination due to metal surfaces of instruments which come into contact with food	3	8	3	72*	The free iron on the surfaces of instruments should be detected and removed by chemical or mechanical methods. Moving parts and presence of rust on the instruments should be checked regularly. Food-grade metals must be used for all metal surfaces that come into contact with food. Non-lead solder and food-grade items must be used at any repairing.	1	8	2	16
		142	P: Hard foreign objects (wire from sieving) due to old-expired equipment	4	7	3	84*	The efficiency of the equipment should be monitored. The expired, broken pieces should be changed periodically.	2	7	2	28
CP23	Milling and cracking wheat	143	B: Contamination with microorganisms (*L. monocytogenesis, S. aureus*) due to unclean instrument	7	7	4	196*	Efficient cleaning, disinfection and prevention procedures of the equipment should be applied. Disinfection should follow immediately after cleaning and before a process run. All equipment should be routinely dismantled or parts loosened for disinfection. Cleaning efficacy should be monitored using indicators of hygiene by tests for coliform bacteria. The cleaning utensils (brushers, sponges and spray guns) themselves must be disinfected properly. Movements of personnel and goods should be limited. The correct hygienic design and proper maintenance of equipment should be provided.	1	7	3	21
		144	B: Machinery mold (*Geotrichum candidum*) due to inefficient cleaning of equipment	5	9	3	135*	Good equipment cleaning procedure must be applied.	2	9	2	36
		145	B: Contamination with microorganisms (*E. Coli O157:H7*) due to unclean instrument	2	10	3	60*	Efficient cleaning, disinfection and prevention procedures of the equipment should be applied. Disinfection should follow immediately after cleaning and before a process run. All equipment should be routinely dismantled or parts loosened for disinfection. Cleaning efficacy should be monitored using indicators of hygiene by tests for coliform bacteria. The cleaning utensils (brushers, sponges and spray guns) themselves must be disinfected properly. Movements of personnel and goods should be limited. The correct hygienic design and proper maintenance of equipment should be provided.	1	10	2	20
		146	C: Heavy metal contamination due to metal surfaces of instruments which come into contact with food	3	8	3	72*	The free iron on the surfaces of instruments should be detected and removed by chemical or mechanical methods. Moving parts and presence of rust on the instruments should be checked regularly. Food-grade metals must be used for all metal surfaces that come into contact with food. Non-lead solder and food-grade items must be used at any repairing.	1	8	2	16
		147	P: Foreign objects (machinery parts) due to old-expired equipment	2	6	2	24	None				
CP24	Multiplying the yeast (mixing water, wheat flour and yeast)	148	B: *Campylobacters, Arcobacter spp., Shigella spp., aeromonas , and Salmonella spp.* contamination by infected water	4	7	4	112*	Water only from a public water system that is regularly monitored and chlorinated should be used.	4	7	3	84
		149	B: *Salmonella Thyphi, Shigella dysenteriae* contamination by infected water	2	10	4	80*	Water only from a public water system that is regularly monitored and chlorinated should be used.	1	10	3	30
		150	B: *E. coli O157:H7* contamination by infected water	3	10	1	30	None				

CP	Processing stage	Risk number	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections
		151	B: Contamination with microorganisms (*E. coli*) due to unclean instrument	1	10	2	20	None				
		152	B: Contamination with microorganisms (*L. monocytogenesis, S. aureus*) due to unclean instrument	1	7	2	14	None				
		153	C: Disinfectant or detergent residue on the mixer bowl due to application of inefficient washing procedures	4	3	5	60*	Detergents must be rinsable and biodegredable. Disinfectants should be non toxic and non-corrosive. The equipment should be rinsed appropriately following the cleaning.	1	3	4	12
		154	P: Foreign objects (Metal pieces) due to old-expired pieces of mixer.	3	6	1	18	None				
CP25	Milk filtration	155	B: Microbial contamination from the filter (*Pseudomonas spp., spores of Bacillus spp.*)	3	7	3	63*	The filter should be cleaned efficiently. Disinfection should follow immediately after cleaning also second time immediately before filtering. Disinfect should be non-corrosive.	1	7	2	14
		156	P: Foreign objects (animal leucocyte, cells, animal hair, chaff) due to improper filtration	3	2	6	36	None				
CP26	Boiling milk	157	B: Survival of heat resistant spores of the pathogens (*B. cereus and C. perfringens)* and presence of enterotoxin produced by *S. Aureus* due to inefficient time and duration of boiling	3	7	3	63*	Efficient pasteurisation conditions of milk should be applied (63°C for 30 min., 72°C for 15 s). After pasteurisation the milk should be tested by sterilization test kits to see if it has been adequately heat-treated.	1	7	2	14
		158	B: Survival of microorganisms (*Mycobacterium avium*) due to inefficient time and duration of boiling	1	10	5	50*	Efficient pasteurisation conditions of milk should be applied (63°C for 30 min., 72°C for 15 s). After pasteurisation the milk should be tested by sterilization test kits to see if it has been adequately heat-treated.	1	10	4	40
		159	C: Detergent/ sanitizer residues (Nitrates, Phosphates, Chlorinated organics, Iodophors)	4	3	5	60*	Equipment should be rinsed efficiently after cleaning. Rinsable and biodegredable detergents should be used for cleaning.	1	3	4	12
CP27	Cooling milk	160	B: Rapid growth of microorganisms (*Bacillus licheniformis* and *S. Thermophilus*) due to long cooling time and high temperature	4	7	2	56*	Rapid cooling should be achieved by using chilled water. The cooled milk should be used in maximum 24 hours.	1	7	1	7
		161	P: Foreign objects due to uncovered material	4	3	1	12	None				
CP28	Fermentation of milk (in stainless steel pot)	162	B: Survival and growth of microorganisms (*Y. enterocolitica, S. aureus, L. monocytogenes*) due to improper fermentation conditions.	3	7	3	63*	Efficient conditions (time, temperature, ph, sanitation) for fermentation should be enhanced. Efficient cleaning and disinfection procedures and preventive measures should be applied to instruments.	1	7	2	14
		163	B: Survival and growth of microorganisms (*E. coli O157:H7*) due to improper fermentation conditions.	3	10	2	60*	Efficient conditions (time, temperature, ph, sanitation) for fermentation should be enhanced. Efficient cleaning and disinfection procedures and preventive measures should be applied to instruments.	1	10	1	10
		164	C: Disinfectant or detergent residue on mixer due to application of inefficient washing procedures	4	3	5	60*	Detergents must be rinsable and biodegredable. Disinfectants should be non toxic and non-corrosive. The equipment should be rinsed appropriately following the cleaning.	1	3	4	12
		165	C: Survival of aflatoxin (Ochratoxin A) due to poor fermentation conditions	2	8	2	32	None				

CP	Processing stage	Risk number	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections
		166	P: Foreign objects (animal leucocyte, cells) due to inefficiently filtrated milk	2	1	10	20	None				
		167	P: Foreign objects (animal hair, chaff) due to inefficiently filtrated milk	2	1	1	2	None				
CP29	Mixing ingredients	168	B: Contamination with microorganisms (*L. monocytogenesis, S. aureus*) due to unclean instrument	7	7	4	196*	Efficient cleaning, disinfection and prevention procedures of the equipment should be applied. Disinfection should follow immediately after cleaning and before a process run. All equipment should be routinely dismantled or parts loosened for disinfection. Cleaning efficacy should be monitored using indicators of hygiene by tests for coliform bacteria. The cleaning utensils (brushers, sponges and spray guns) themselves must be disinfected properly. Movements of personnel and goods should be limited. The correct hygienic design and proper maintenance of equipment should be provided.	1	7	3	21
		169	B: Machinery mold (*Geotrichum candidum*) due to inefficient cleaning of equipment	5	9	3	135*	Good equipment cleaning procedure must be applied.	2	9	2	36
		170	B: Contamination with microorganisms (*E. coli O157:H7*) due to unclean instrument	2	10	3	60*	Efficient cleaning, disinfection and prevention procedures of the equipment should be applied. Disinfection should follow immediately after cleaning and before a process run. All equipment should be routinely dismantled or parts loosened for disinfection. Cleaning efficacy should be monitored using indicators of hygiene by tests for coliform bacteria. The cleaning utensils (brushers, sponges and spray guns) themselves must be disinfected properly. Movements of personnel and goods should be limited. The correct hygienic design and proper maintenance of equipment should be provided.	1	10	2	20
		171	C: Disinfectant or detergent residue on mixer due to application of inefficient washing procedures	4	3	5	60*	Detergents must be rinsable and biodegredable. Disinfectants should be non toxic and non-corrosive. The equipment should be rinsed appropriately following the cleaning.	1	3	4	12
		172	C: Heavy metal contamination due to metal surfaces of instruments which come into contact with food	1	8	3	24	None				
		173	P: Foreign objects (metal pieces) due to old-expired equipment	3	6	1	18	None				
CP30	Transferring the mixture (by stainless steel carriages)	174	B: Contamination with microorganisms (*L. monocytogenesis, S. aureus*) due to unclean instrument	7	7	4	196*	Efficient cleaning, disinfection and prevention procedures of the equipment should be applied. Disinfection should follow immediately after cleaning and before a process run. All equipment should be routinely dismantled or parts loosened for disinfection. Cleaning efficacy should be monitored using indicators of hygiene by tests for coliform bacteria. The cleaning utensils (brushers, sponges and spray guns) themselves must be disinfected properly. Movements of personnel and goods should be limited. The correct hygienic design and proper maintenance of equipment should be provided.	1	7	3	21

CP	Processing stage	Risk number	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections
		175	B: Machinery mold (*Geotrichum candidum*) due to inefficient cleaning of equipment	5	9	3	135*	Good equipment cleaning procedure must be applied.	2	9	2	36
		176	B: Contamination with microorganisms (*E. Coli O157:H7*) due to unclean instrument	2	10	3	60*	Efficient cleaning, disinfection and prevention procedures of the equipment should be applied. Disinfection should follow immediately after cleaning and before a process run. All equipment should be routinely dismantled or parts loosened for disinfection. Cleaning efficacy should be monitored using indicators of hygiene by tests for coliform bacteria. The cleaning utensils (brushers, sponges and spray guns) themselves must be disinfected properly. Movements of personnel and goods should be limited. The correct hygienic design and proper maintenance of equipment should be provided.	1	10	2	20
		177	C: Disinfectant or detergent residue on the equipment due to application of inefficient washing procedures	4	3	5	60*	Detergents must be rinsable and biodegredable. Disinfectants should be non toxic and non-corrosive. The equipment should be rinsed appropriately following the cleaning.	1	3	4	12
		178	P: Foreign objects (dirt, dust, hair, feather) due to personal affect and uncovered carriages	6	2	1	12	None				
CP31	Fermentation of tarhana (by mixing automatically in silos of 1,5 tonne capacity, 3-5 days)	179	B: Survival of parasites (*Cryptosporidium, Giardia lamblia*) due to improper fermentation conditions	3	7	5	105*	Appropriate acidification should be provided.	1	7	4	28
		180	B: Survival of virus (Rotavirus, Hepatitis A) due to improper fermentation conditions	1	10	8	80*	The fermentation tanks and tools should be disinfected just before use. Appropriate acidification should be provided.	1	10	6	60
		181	B: Survival of acid tolerant pathogens microorganisms during fermentation (*E. coli O157:H7*) due to improper fermentation conditions	3	10	2	60*	Process challenge tests must be carried out to determine whether the process achieves a special reduction of pathogens. Appropriate conditions (time, temperature, ph) for fermentation should be enhanced. The starter culture should be of adequate quantity to ensure rapid fermentation. The temperature of the environment should be kept at an optimum level to ensure adequate starter culture activity and this activity may be measured by pH changes. The fermentation environment should be efficient (clean, closed, without insects, dust). Prolonged fermentation should be avoided. Rapid acidification should be provided.	1	10	1	10
		182	B: Growth and/or survival of microorganisms during fermentation (*Cl. botulinum*) due to improper fermentation conditions	1	10	6	60*	Process challenge tests must be carried out to determine whether the process achieves a special reduction of pathogens. Appropriate conditions (time, temperature, ph) for fermentation should be enhanced. The starter culture should be of adequate quantity to ensure rapid fermentation. The temperature of the environment should be kept at an optimum level to ensure adequate starter culture activity and this activity may be measured by pH changes. The fermentation environment should be efficient (clean, closed, without insects, dust). Prolonged fermentation should be avoided. Rapid acidification should be provided.	1	10	5	50

CP	Processing stage	Risk number	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections
		183	B: Growth and/or survival of microorganisms during fermentation (*S. aureus, Salmonella, L. monocytogenes*) due to improper fermentation conditions	2	7	4	56*	Process challenge tests must be carried out to determine whether the process achieves a special reduction of pathogens. Appropriate conditions (time, temperature, ph) for fermentation should be enhanced. The starter culture should be of adequate quantity to ensure rapid fermentation. The temperature of the environment should be kept at an optimum level to ensure adequate starter culture activity and this activity may be measured by pH changes. The salt level and its distribution should be adjusted. The fermentation environment should be efficient (clean, closed, without insects, dust). Prolonged fermentation should be avoided. Rapid acidification should be provided.	1	7	3	21
		184	B: Formation of toxin by *S. aureus* due to improper fermentation conditions	2	7	4	56*	Rapid acidification should be provided. The salt level and distribution of salt should be adjusted.	1	7	3	21
		185	C: Disinfectant or detergent residue on the fermentation tanks due to application of inefficient washing procedures due to dirty fermentation equipment	4	3	5	60*	Equipment should be rinsed efficiently after the cleaning. Rinsable and biodegredable detergents should be used for cleaning.	1	3	4	12
		186	C: Survival of aflatoxin (Ochratoxin A) due to poor fermentation conditions	2	8	2	32	None				
		187	P: Foreign objects (dust, insect fragments) transferred by air	8	1	2	16	None				
CP32	Transferring the dough (by stainless steal carriages)	188	B: Contamination with microorganisms (*L. monocytogenesis, S. aureus*) due to unclean instrument	7	7	4	196*	Efficient cleaning, disinfection and prevention procedures of the equipment should be applied. Disinfection should follow immediately after cleaning and before a process run. All equipment should be routinely dismantled or parts loosened for disinfection. Cleaning efficacy should be monitored using indicators of hygiene by tests for coliform bacteria. The cleaning utensils (brushers, sponges and spray guns) themselves must be disinfected properly. Movements of personnel and goods should be limited. The correct hygienic design and proper maintenance of equipment should be provided.	1	7	3	21
		189	B: Machinery mold (*Geotrichum candidum*) due to inefficient cleaning of equipment	5	9	3	135*	Good equipment cleaning procedure must be applied.	2	9	2	36
		190	B: Contamination with microorganisms (*E. Coli O157:H7*) due to unclean instrument	2	10	3	60*	Efficient cleaning, disinfection and prevention procedures of the equipment should be applied. Disinfection should follow immediately after cleaning and before a process run. All equipment should be routinely dismantled or parts loosened for disinfection. Cleaning efficacy should be monitored using indicators of hygiene by tests for coliform bacteria. The cleaning utensils (brushers, sponges and spray guns) themselves must be disinfected properly. Movements of personnel and goods should be limited. The correct hygienic design and proper maintenance of equipment should be provided.	1	10	2	20
		191	C: Disinfectant or detergent residue on the equipment due to application of inefficient washing procedures	4	3	5	60*	Equipment should be rinsed efficiently after cleaning. Rinsable and biodegradable detergents should be used for cleaning.	1	3	4	12

CP	Processing stage	Risk number	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections
		192	P: Foreign objecs (dirt, dust, hair, feather) due to personal effect and uncovered carriages	6	2	1	12	None				
CP33	Mixing the dough (by dough mixer)	193	B: Contamination with microorganisms (*L. monocytogenesis, S. aureus*) due to unclean instrument	7	7	4	196*	Efficient cleaning, disinfection and prevention procedures of the equipment should be applied. Disinfection should follow immediately after cleaning and before a process run. All equipment should be routinely dismantled or parts loosened for disinfection. Cleaning efficacy should be monitored using indicators of hygiene by tests for coliform bacteria. The cleaning utensils (brushers, sponges and spray guns) themselves must be disinfected properly. Movements of personnel and goods should be limited. The correct hygienic design and proper maintenance of equipment should be provided.	1	7	3	21
		194	B: Machinery mold (*Geotrichum candidum*) due to inefficient cleaning of equipment	5	9	3	135*	Good equipment cleaning procedure must be applied.	2	9	2	36
		195	B: Contamination with microorganisms (*E. Coli O157:H7*) due to unclean instrument	2	10	3	60*	Efficient cleaning, disinfection and prevention procedures of the equipment should be applied. Disinfection should follow immediately after cleaning and before a process run. All equipment should be routinely dismantled or parts loosened for disinfection. Cleaning efficacy should be monitored using indicators of hygiene by tests for coliform bacteria. The cleaning utensils (brushers, sponges and spray guns) themselves must be disinfected properly. Movements of personnel and goods should be limited. The correct hygienic design and proper maintenance of equipment should be provided.	1	10	2	20
		196	C: Disinfectant or detergent residue on mixer due to application of inefficient washing procedures	4	3	5	60*	Detergents must be rinsable and biodegredable. Disinfectants should be non toxic and non-corrosive. The equipment should be rinsed appropriately following the cleaning.	1	3	4	12
		197	C: Heavy metal contamination to metal surfaces of instruments which come into contact with food	1	8	3	24	None				
		198	P: Foreign objects (metal pieces) due to old-expired equipment	3	6	1	18	None				
CP34	Transferring the dough (by stainless steel carriages)	199	B: Contamination with microorganisms (*L. monocytogenesis, S. aureus*) due to unclean instrument	7	7	4	196*	Efficient cleaning, disinfection and prevention procedures of the equipment should be applied. Disinfection should follow immediately after cleaning and before a process run. All equipment should be routinely dismantled or parts loosened for disinfection. Cleaning efficacy should be monitored using indicators of hygiene by tests for coliform bacteria. The cleaning utensils (brushers, sponges and spray guns) themselves must be disinfected properly. Movements of personnel and goods should be limited. The correct hygienic design and proper maintenance of equipment should be provided.	1	7	3	21
		200	B: Machinery mold (*Geotrichum candidum*) due to inefficient cleaning of equipment	5	9	3	135*	Good equipment cleaning procedure must be applied.	2	9	2	36

CP	Processing stage	Risk number	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections
		201	B: Contamination with microorganisms (*E. Coli O157:H7*) due to unclean instrument	2	10	3	60*	Efficient cleaning, disinfection and prevention procedures of the equipment should be applied. Disinfection should follow immediately after cleaning and before a process run. All equipment should be routinely dismantled or parts loosened for disinfection. Cleaning efficacy should be monitored using indicators of hygiene by tests for coliform bacteria. The cleaning utensils (brushers, sponges and spray guns) themselves must be disinfected properly. Movements of personnel and goods should be limited. The correct hygienic design and proper maintenance of equipment should be provided.	1	10	2	20
		202	C: Disinfectant or detergent residue on the equipment due to application of inefficient washing procedures	4	3	5	60*	Detergents must be rinsable and biodegredable. Disinfectants should be non toxic and non-corrosive. The equipment should be rinsed appropriately following the cleaning.	1	3	4	12
		203	P: Foreign objects (dirt, dust, hair, feather) due to personal effect and uncovered carriages	6	2	1	12	None				
CP35	Spreading the dough on sieve trays (by hand)	204	B: Virus (NLV) contamination by personnel handling.	3	7	8	168*	Personnel should be trained to understand the risk associated with cross-contamination and they should be provided with appropriate facilities to operate good hygienic practice e.g. hand basin and bactericidal soaps. Table ledges, door handlers, overhead pipes and many other areas should be routinely disinfected. Hands-on operations should be minimised.	2	7	6	84
		205	B: Virus (Rotavirus, Hepatitis A) contamination by personnel handling.	2	10	8	160*	Personnel should be trained to understand the risk associated with cross-contamination and they should be provided with appropriate facilities to operate good hygienic practice e.g. hand basin and bactericidal soaps. Table ledges, door handlers, overhead pipes and many other areas should be routinely disinfected. Hands-on operations should be minimised. Personnel must get vaccinated for Hepatitis A.	1	10	6	60
		206	B: Contamination with microorganisms (*S. aureus, L. monocytogenes, Shigella spp.*) due to personnel handling	3	7	4	84*	Personnel should be trained to understand the risk associated with cross-contamination and they should be provided with appropriate facilities to operate good hygienic practice e.g. hand basin and bactericidal soaps. Table ledges, door handlers, overhead pipes and many other areas should be routinely disinfected. Hands-on operations should be minimised.	2	7	3	42
		207	B: Pathogen (*Shigella dysenteriae*) contamination by personnel handling	2	10	4	80*	Personnel should be trained to understand the risk associated with cross-contamination and they should be provided with appropriate facilities to operate good hygienic practice e.g. hand basin and bactericidal soaps. Table ledges, door handlers, overhead pipes and many other areas should be routinely disinfected. Hands-on operations should be minimised.	1	10	3	30

CP	Processing stage	Risk number	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections
		208	B: Parasite zoones (Protozoa- *Cryptosporidium parvum, Giardia duodenalis, Blastocystis hominis*) transmitted by contaminated hands	2	8	4	64*	Personnel should be trained on hygiene and hand washing and they should be provided with appropriate facilities to operate good hygienic practice e.g. hand basin and bactericidal soaps. Table ledges, door handlers, overhead pipes and many other areas should be routinely disinfected. Hands-on operations should be minimised. Medical examination should be applied to employees on a continuous basis.	2	9	3	54
		209	C: Detergent/ sanitizer residues (Nitrates, Phosphates, Chlorinated organics, Iodophors)	4	3	5	60*	Detergents must be rinsable and biodegredable. Disinfectants should be non toxic and non-corrosive. The equipment should be rinsed appropriately following the cleaning.	1	3	4	12
		210	P: Foreign objects (false fingernail, hair, feather, soil, dust) due to personal effect and environment	6	2	4	48					
CP36	Vertically spacing the sieve trays into industrial dryer by carriages	211	P: Foreign objects (dirt, dust, hair, feather) due to personal effect and uncovered carriages	6	2	1	12	None				
CP37	Drying tarhana (by industrial driers) (driers are working by steam and providing ventilation by airflow (6-9 hours, final moisture %7, by progressive heating and cooling max 80°C)	212	B: Contamination with pathogens (*E. coli*, *Salmonella*) due to improper drying conditions/ improper time, temperature combination	2	10	3	60*	Drying validation should be carried out prior to introduction of a new product. Drying validation should be able to identify the conditions that will consistently produce a safe product. Drying time and final moisture content should be monitored. The product should be dried in appropriate time and temperature.	1	10	2	20
		213	B: Growth of microorganisms (*S. aureus*) due to improper drying conditions/ improper time, temperature combination	2	7	3	42	None				

CP	Processing stage	Risk number	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections
CP38	Transferring the dried tarhana (by stainless steal carriages)	214	B: Contamination with microorganisms (*L. monocytogenesis, S. aureus*) due to unclean instrument	7	7	4	196*	Efficient cleaning, disinfection and prevention procedures of the equipment should be applied. Disinfection should follow immediately after cleaning and before a process run. All equipment should be routinely dismantled or parts loosened for disinfection. Cleaning efficacy should be monitored using indicators of hygiene by tests for coliform bacteria. The cleaning utensils (brushers, sponges and spray guns) themselves must be disinfected properly. Movements of personnel and goods should be limited. The correct hygienic design and proper maintenance of equipment should be provided.	1	7	3	21
		215	B: Machinery mold (*Geotrichum candidum*) due to inefficient cleaning of equipment	5	9	3	135*	Good equipment cleaning procedure must be applied.	2	9	2	36
		216	B: Contamination with microorganisms (*E. Coli O157:H7*) due to unclean instrument	2	10	3	60*	Efficient cleaning, disinfection and prevention procedures of the equipment should be applied. Disinfection should follow immediately after cleaning and before a process run. All equipment should be routinely dismantled or parts loosened for disinfection. Cleaning efficacy should be monitored using indicators of hygiene by tests for coliform bacteria. The cleaning utensils (brushers, sponges and spray guns) themselves must be disinfected properly. Movements of personnel and goods should be limited. The correct hygienic design and proper maintenance of equipment should be provided.	1	10	2	20
		217	C: Disinfectant or detergent residue on the equipment due to application of inefficient washing procedures	4	3	5	60*	Detergents must be rinsable and biodegredable. Disinfectants should be non toxic and non-corrosive. The equipment should be rinsed appropriately following the cleaning.	1	3	4	12
		218	P: Foreign objects (dirt, dust, hair, feather) due to personal effect and uncovered carriages	6	2	1	12	None				
CP39	Milling tarhana (by electric mill)	219	B: Contamination with microorganisms (*L. monocytogenesis, S. aureus*) due to unclean instrument	7	7	4	196*	Efficient cleaning, disinfection and prevention procedures of the equipment should be applied. Disinfection should follow immediately after cleaning and before a process run. All equipment should be routinely dismantled or parts loosened for disinfection. Cleaning efficacy should be monitored using indicators of hygiene by tests for coliform bacteria. The cleaning utensils (brushers, sponges and spray guns) themselves must be disinfected properly. Movements of personnel and goods should be limited. The correct hygienic design and proper maintenance of equipment should be provided.	1	7	3	21
		220	B: Machinery mold (*Geotrichum candidum*) due to inefficient cleaning of equipment	5	9	3	135*	Good equipment cleaning procedure must be applied.	2	9	2	36

CP	Processing stage	Risk number	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections
		221	B: Contamination with microorganisms (*E. Coli O157:H7*) due to unclean instrument	2	10	3	60*	Efficient cleaning, disinfection and prevention procedures of the equipment should be applied. Disinfection should follow immediately after cleaning and before a process run. All equipment should be routinely dismantled or parts loosened for disinfection. Cleaning efficacy should be monitored using indicators of hygiene by tests for coliform bacteria. The cleaning utensils (brushers, sponges and spray guns) themselves must be disinfected properly. Movements of personnel and goods should be limited. The correct hygienic design and proper maintenance of equipment should be provided.	1	10	2	20
		222	C: Heavy metal contamination due to metal surfaces of instruments which come into contact with food	3	8	3	72*	The free iron on the surfaces of instruments should be detected and removed by chemical or mechanical methods. Moving parts and presence of rust on the instruments should be checked regularly. Food-grade metals must be used for all metal surfaces that come into contact with food. Non-lead solder and food-grade items must be used at any repairing.	1	8	2	16
		223	P: Foreign objects (machinery parts) due to old-expired equipment	1	6	2	12	None				
CP40	Sieving tarhana (by sieving part of electric mill)	224	B: Contamination with microorganisms (*L. monocytogenesis, S. aureus*) due to unclean instrument	7	7	4	196*	Efficient cleaning, disinfection and prevention procedures of the equipment should be applied. Disinfection should follow immediately after cleaning and before a process run. All equipment should be routinely dismantled or parts loosened for disinfection. Cleaning efficacy should be monitored using indicators of hygiene by tests for coliform bacteria. The cleaning utensils (brushers, sponges and spray guns) themselves must be disinfected properly. Movements of personnel and goods should be limited. The correct hygienic design and proper maintenance of equipment should be provided.	1	7	3	21
		225	B: Machinery mold (*Geotrichum candidum*) due to inefficient cleaning of equipment	5	9	3	135*	Good equipment cleaning procedure must be applied.	2	9	2	36
		226	B: Contamination with microorganisms (*E. Coli O157:H7*) due to unclean instrument	2	10	3	60*	Efficient cleaning, disinfection and prevention procedures of the equipment should be applied. Disinfection should follow immediately after cleaning and before a process run. All equipment should be routinely dismantled or parts loosened for disinfection. Cleaning efficacy should be monitored using indicators of hygiene by tests for coliform bacteria. The cleaning utensils (brushers, sponges and spray guns) themselves must be disinfected properly. Movements of personnel and goods should be limited. The correct hygienic design and proper maintenance of equipment should be provided.	1	10	2	20

CP	Processing stage	Risk number	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections
		227	C: Heavy metal contamination due to metal surfaces of instruments which come into contact with food	3	8	3	72*	The free iron on the surfaces of instruments should be detected and removed by chemical or mechanical methods. Moving parts and presence of rust on the instruments should be checked regularly. Food-grade metals must be used for all metal surfaces that come into contact with food. Non-lead solder and food-grade items must be used at any repairing.	1	8	2	16
		228	P: Foreign objects (wire pieces) due to old-expired equipment	4	7	3	84*	Metal detectors should be used. detectors should be carefully chosen and calibrated to pick up the smallest pieces of metal. The efficiency of the equipment should be monitored and its expired, broken pieces should be changed periodically.	2	7	2	28
CP41	Mixing tomato and red pepper paste into the mixture	229	B: Contamination with microorganisms (*L. monocytogenesis, S. aureus*) due to unclean instrument	7	7	4	196*	Efficient cleaning, disinfection and prevention procedures of the equipment should be applied. Disinfection should follow immediately after cleaning and before a process run. All equipment should be routinely dismantled or parts loosened for disinfection. Cleaning efficacy should be monitored using indicators of hygiene by tests for coliform bacteria. The cleaning utensils (brushers, sponges and spray guns) themselves must be disinfected properly. Movements of personnel and goods should be limited. The correct hygienic design and proper maintenance of equipment should be provided.	1	7	3	21
		230	B: Machinery mold (*Geotrichum candidum*) due to inefficient cleaning of equipment	5	9	3	135*	Good equipment cleaning procedure must be applied.	2	9	2	36
		231	B: Contamination with microorganisms (*E. Coli O157:H7*) due to unclean instrument	2	10	3	60*	Efficient cleaning, disinfection and prevention procedures of the equipment should be applied. Disinfection should follow immediately after cleaning and before a process run. All equipment should be routinely dismantled or parts loosened for disinfection. Cleaning efficacy should be monitored using indicators of hygiene by tests for coliform bacteria. The cleaning utensils (brushers, sponges and spray guns) themselves must be disinfected properly. Movements of personnel and goods should be limited. The correct hygienic design and proper maintenance of equipment should be provided.	1	10	2	20
		231	C: Disinfectant or detergent residue on the equipment due to application of inefficient washing procedures	4	3	5	60*	Detergents must be rinsable and biodegredable. Disinfectants should be non toxic and non-corrosive. The equipment should be rinsed appropriately following the cleaning.	1	3	4	12
		233	C: Heavy metal contamination to metal surfaces of instruments which come into contact with food	1	8	3	24	None				
		234	P: Foreign objects (metal pieces) due to old-expired equipment	3	6	1	18	None				

CP	Processing stage	Risk number	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections
CP42	Transferring tarhana (by stainless steel carriages)	235	B: Contamination with microorganisms (*L. monocytogenesis, S. aureus*) due to unclean instrument	7	7	4	196*	Efficient cleaning, disinfection and prevention procedures of the equipment should be applied. Disinfection should follow immediately after cleaning and before a process run. All equipment should be routinely dismantled or parts loosened for disinfection. Cleaning efficacy should be monitored using indicators of hygiene by tests for coliform bacteria. The cleaning utensils (brushers, sponges and spray guns) themselves must be disinfected properly. Movements of personnel and goods should be limited. The correct hygienic design and proper maintenance of equipment should be provided.	1	7	3	21
		236	B: Machinery mold (*Geotrichum candidum*) due to inefficient cleaning of equipment	5	9	3	135*	Good equipment cleaning procedure must be applied.	2	9	2	36
		237	B: Contamination with microorganisms (*E. Coli O157:H7*) due to unclean instrument	2	10	3	60*	Efficient cleaning, disinfection and prevention procedures of the equipment should be applied. Disinfection should follow immediately after cleaning and before a process run. All equipment should be routinely dismantled or parts loosened for disinfection. Cleaning efficacy should be monitored using indicators of hygiene by tests for coliform bacteria. The cleaning utensils (brushers, sponges and spray guns) themselves must be disinfected properly. Movements of personnel and goods should be limited. The correct hygienic design and proper maintenance of equipment should be provided.	1	10	2	20
		238	C: Disinfectant or detergent residue on the equipment due to application of inefficient washing procedures	4	3	5	60*	Detergents must be rinsable and biodegredable. Disinfectants should be non toxic and non-corrosive. The equipment should be rinsed appropriately following the cleaning.	1	3	4	12
		239	P: Foreign objects (dirt, dust, hair, feather) due to personal effect and uncovered carriages	6	2	1	12	None				
CP43	Spreading the dough on sieve trays (by hand)	240	B: Virus (NLV) contamination by personnel handling.	3	7	8	168*	Personnel should be trained to understand the risk associated with cross-contamination and they should be provided with appropriate facilities to operate good hygienic practice e.g. hand basin and bactericidal soaps. Table ledges, door handlers, overhead pipes and many other areas should be routinely disinfected. Hands-on operations should be minimised.	2	7	6	84
		241	B: Virus (Rotavirus, Hepatitis A) contamination by personnel handling.	2	10	8	160*	Personnel should be trained to understand the risk associated with cross-contamination and they should be provided with appropriate facilities to operate good hygienic practice e.g. hand basin and bactericidal soaps. Table ledges, door handlers, overhead pipes and many other areas should be routinely disinfected. Hands-on operations should be minimised. Personnel must get vaccinated for Hepatitis A.	1	10	6	60

CP	Processing stage	Risk number	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections
		242	B: Contamination with microorganisms (*S. aureus, L. monocytogenes, Shigella spp.*) due to personnel handling	3	7	4	84*	Personnel should be trained to understand the risk associated with cross-contamination and they should be provided with appropriate facilities to operate good hygienic practice e.g. hand basin and bactericidal soaps. Table ledges, door handlers, overhead pipes and many other areas should be routinely disinfected. Hands-on operations should be minimised.	2	7	3	42
		243	B: Pathogen (*Shigella dysenteriae*) contamination by personnel handling	2	10	4	80*	Personnel should be trained to understand the risk associated with cross-contamination and they should be provided with appropriate facilities to operate good hygienic practice e.g. hand basin and bactericidal soaps. Medical examination should be applied to employees on a continuous basis. Table ledges, door handlers, overhead pipes and many other areas should be routinely disinfected. Hands-on operations should be minimised.	1	10	3	30
		244	P: Foreign objects (false fingernail, hair, feather, soil, dust) due to personal effect and environment	6	2	4	48					
CP44	Vertically spacing the sieve trays on carriages of drier and into industrial dryer	245	P: Foreign objecs (dirt, dust, hair, feather) due to personal effect and uncovered carriages	6	2	1	12	None				
CP45	Drying tarhana (by industrial driers) (driers are working by steam and providing ventilation by airflow (6-9 hours, final moisture %7, by progressive heating and cooling max 80°C)	246	B: Contamination with pathogens (*E. coli, Salmonella*) due to improper drying conditions/ improper time, temperature combination	2	10	3	60*	Drying validation should be carried out prior to introduction of a new product. Drying validation should be able to identify the conditions that will consistently produce a safe product. Drying time and final moisture content should be monitored. The product should be dried in appropriate time and temperature.	1	10	2	20
		247	B: Growth of microorganisms (*S. aureus*) due to improper drying conditions/ improper time, temperature combination	2	7	3	42	None				

CP	Processing stage	Risk number	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections
CP46	Milling tarhana (by electric mill)	248	B: Contamination with microorganisms (*L. monocytogenesis, S. aureus*) due to unclean instrument	7	7	4	196*	Efficient cleaning, disinfection and prevention procedures of the equipment should be applied. Disinfection should follow immediately after cleaning and before a process run. All equipment should be routinely dismantled or parts loosened for disinfection. Cleaning efficacy should be monitored using indicators of hygiene by tests for coliform bacteria. The cleaning utensils (brushers, sponges and spray guns) themselves must be disinfected properly. Movements of personnel and goods should be limited. The correct hygienic design and proper maintenance of equipment should be provided.	1	7	3	21
		249	B: Machinery mold (*Geotrichum candidum*) due to inefficient cleaning of equipment	5	9	3	135*	Good equipment cleaning procedure must be applied.	2	9	2	36
		250	B: Contamination with microorganisms (*E. coli O157:H7*) due to unclean instrument	2	10	3	60*	Efficient cleaning, disinfection and prevention procedures of the equipment should be applied. Disinfection should follow immediately after cleaning and before a process run. All equipment should be routinely dismantled or parts loosened for disinfection. Cleaning efficacy should be monitored using indicators of hygiene by tests for coliform bacteria. The cleaning utensils (brushers, sponges and spray guns) themselves must be disinfected properly. Movements of personnel and goods should be limited. The correct hygienic design and proper maintenance of equipment should be provided.	1	10	2	20
		251	C: Heavy metal contamination due to metal surfaces of instruments which come into contact with food	3	8	3	72*	The free iron on the surfaces of instruments should be detected and removed by chemical or mechanical methods. Moving parts and presence of rust on the instruments should be checked regularly. Food-grade metals must be used for all metal surfaces that come into contact with food. Non-lead solder and food-grade items must be used at any repairing.	1	8	2	16
		252	P: Foreign objects (machinery parts) due to old-expired equipment	1	6	2	12	None				
CP47	Sieving tarhana (by sieving part of electric mill)	253	B: Contamination with microorganisms (*L. monocytogenesis, S. aureus*) due to unclean instrument	7	7	4	196*	Efficient cleaning, disinfection and prevention procedures of the equipment should be applied. Disinfection should follow immediately after cleaning and before a process run. All equipment should be routinely dismantled or parts loosened for disinfection. Cleaning efficacy should be monitored using indicators of hygiene by tests for coliform bacteria. The cleaning utensils (brushers, sponges and spray guns) themselves must be disinfected properly. Movements of personnel and goods should be limited. The correct hygienic design and proper maintenance of equipment should be provided.	1	7	3	21
		254	B: Machinery mold (*Geotrichum candidum*) due to inefficient cleaning of equipment	5	9	3	135*	Good equipment cleaning procedure must be applied.	2	9	2	36

CP	Processing stage	Risk number	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections
		255	B: Contamination with microorganisms (*E. Coli O157:H7*) due to unclean instrument	2	10	3	60*	Efficient cleaning, disinfection and prevention procedures of the equipment should be applied. Disinfection should follow immediately after cleaning and before a process run. All equipment should be routinely dismantled or parts loosened for disinfection. Cleaning efficacy should be monitored using indicators of hygiene by tests for coliform bacteria. The cleaning utensils (brushers, sponges and spray guns) themselves must be disinfected properly. Movements of personnel and goods should be limited. The correct hygienic design and proper maintenance of equipment should be provided.	1	10	2	20
		256	C: Heavy metal contamination due to metal surfaces of instruments which come into contact with food	3	8	3	72*	The free iron on the surfaces of instruments should be detected and removed by chemical or mechanical methods. Moving parts and presence of rust on the instruments should be checked regularly. Food-grade metals must be used for all metal surfaces that come into contact with food. Non-lead solder and food-grade items must be used at any repairing.	1	8	2	16
		257	P: Hard foreign objects (wire from sieving) due to old-expired equipment	4	7	3	84*	Metal detectors should be used. detectors should be carefully chosen and calibrated to pick up the smallest pieces of metal. The efficiency of the equipment should be monitored and its expired, broken pieces should be changed periodically.	2	7	2	28
CP48	Storing tarhana	258	B: Microorganism (*S. aureus*) growth due to improper storage conditions	2	7	1	14	None				
		259	C: Mycotoxins produced my molds which have grown due to improper storage conditions	2	8	2	32	None				
		260	P: Foreign objects (insect and insect fragments) due to insect infestation	4	5	3	60*	The storage temperature and relative humidity must be below 20°C and 65%, respectively. The place should be air-conditioned and both temperature humidity must be recorded, and corrective actions must be undertaken whenever deviations occur. The product should be distributed rapidly.	1	3	2	6
CP49	Packaging (with nylon bags)	261	B: Virus (NLV) contamination by personnel handling	2	7	8	112*	Personnel should be trained to understand the risk associated with cross-contamination and they should be provided with appropriate facilities to operate good hygienic practice e.g. hand basin and bactericidal soaps. Table ledges, door handlers, overhead pipes and many other areas should be routinely disinfected. Hands-on operations should be minimised.	1	7	6	42
		262	B: Virus (Rotavirus, Hepatitis A) contamination by personnel handling	1	10	8	80*	Personnel should be trained to understand the risk associated with cross-contamination and they should be provided with appropriate facilities to operate good hygienic practice e.g. hand basin and bactericidal soaps. Table ledges, door handlers, overhead pipes and many other areas should be routinely disinfected. Hands-on operations should be minimised. Personnel must get vaccinated for Hepatitis A.	1	10	6	60

CP	Processing stage	Risk number	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections
		263	B: Contamination with microorganisms (*S. aureus, L. monocytogenes, Shigella spp.*) due to personnel handling	4	7	2	56*	Bare hand contact with the product must be avoided. Personnel should comply with the Good Manufacturing Practice and avoid extraneous materials, such as insects and rodent hairs, in the final product. Efficient lighting and temperature must be provided in the environment to avoid personnel failures.	2	7	1	14
		264	B: Survival of pathogens (*Cl. Botulinum, E. coli*) due to inappropriate preparation of the food (post process)	3	9	2	54*	Appropriate information should be given on the product packaging to provide guidance concerning safe handling and storage conditions and cooking processes that need to be employed.	2	9	1	18
		265	C: Low molecular weight substances (Biosphenol A), migrated from the packaging material into the food	2	9	3	54*	Packaging material should be suitable for coming in contact with food.	1	9	2	18
		266	C: Heavy metal contamination (lead) due to lead based printings used for packaging	1	8	1	8	None				
		267	P: Foreign objects due to personal effects (false fingernail, button, hair, apron and glove pieces) and inappropriate packaging (pieces of packaging material)	6	4	1	24	None				

* Corrective actions are required since RPN is above 50.

APPENDIX B: IMAGES OF TARHANA PRODUCTION

Figure B.1. Ingredients of tarhana

Figure B.2. Mixing Ingredients

Figure B.3. Fermentation of Tarhana (Traditional method)

Figure B.4. Industrial tarhana fermentation (Fermentation silos and carriages)

Figure B.5. Drying of traditional tarhana

Figure B.6. Storage in an industrial facility

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