T.C.
YEDITEPE UNIVERSITY
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FAILURE MODE AND EFFECT ANALYSIS (FMEA) FOR PRODUCTION METHODS OF TRADITIONAL FERMENTED BEVERAGES OF TURKEY

MASTER THESIS

HASAN KAAN KAVSARA

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SUPERVISOR
Assoc. Prof. Dr. Zehra Sibel Özilgen
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TEZ ONAYI FORMU

Kurum : Yeditepe Üniversitesi Sağlık Bilimleri Enstitüsü

Program : Beslenme ve Diyetetik

Tez Başlığı : Geleneksel Fermente İçeceklerin Üretim Yöntemlerine Hata Türü ve Etkileri Analizinin Uygulanması

Tez Sahibi : Hasan Kaan KAVSARA

Sınav Tarihi : 20.12.2019

Bu çalışma jürimiz tarafından kapsam ve kalite yönünden Yüksek Lisans Tezi olarak kabul edilmiştir.

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ONAY

Bu tez Yeditepe Üniversitesi Lisansüstü Eğitim-Öğretim ve Sınav Yönetmeliğinin ilgili maddeleri uyarınca yukarıdaki jüri tarafından uygun görülmüş ve Enstitü Yönetim Kurulu'nun 31.../12/2019.. tarih ve 2019/20-02... sayılı kararı ile onaylanmıştır.

Prof. Dr. Bayram YILMAZ
Sağlık Bilimleri Enstitüsü Müdürü

DECLERATION

I hereby declare that this thesis is my own work and that, to the best of my knowledge and belief, it contains no material previously published or written by another person nor material which has been accepted for the award of any other degree except where due acknowledgment has been made in the text.

Date

Signature

Hasan Kaan Kavsara

20.12.2019

DEDICATION

I would like to express my gratitude to everyone who has been the driving force for me in this process which is a long and stressful adventure. I would like to thank my mother Mevhibe Kavsara, my father Ali İhsan Kavsara and my sister Hande Kavsara. It is amazing to know that my family is always there for me. My dear girlfriend Seda Çakmak made me feel that she was with me in every way. I dedicate my thesis to them.

ACKNOWLEDGEMENTS

I would like to express my respect to all of my department professors who trained me during the graduate course. I would like to thank for his support during data collection Mr. Musa Dağdeviren who is a famous chef with worldwide achievements. Finally, I would like to express my endless gratitude to my thesis advisor, Assoc. Prof. Dr. Sibel Özilgen, who inspired me in this challenging process.

This work is to be carried out under the chair of UNESCO/UNITWIN "Food, Culture and Development"

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LIST OF SYMBOLS AND ABBREVIATIONS

AGEs	Advanced Glycation End-products
B	Biological hazard
C	Chemical hazard
CCPs	Critical Control Points
D	Detection probability
EEA	European Economic Area
EFSA	European Food Safety Authority
EuroFIR	European Food Information Resource Network
FAO	Food and Agriculture Organization
GAP	Good Agricultural Practices
HACCP	Hazard Analysis and Critical Control Point
LAB	Lactic Acid Bacteria
O	Occurrence frequency
P	Physical hazard
PAH	Polycyclic Aromatic Hydrocarbons
PCBs	Polychlorinated Biphenyls
RASFF	Rapid Alert System for Food and Feed
RPN	Risk Priority Number
S	Severity of the failure
TürKomp	Turkish National Food Composition Database
USDA	United States Department of Agriculture

ABSTRACT

Kavsara, H. K. (2019). Failure Mode and Effect Analysis (FMEA) for Production Methods of Traditional Fermented Beverages of Turkey. Yeditepe University, Institute of Health Sciences, Department of Nutrition and Dietetics, MSc Thesis. İstanbul.

Today, some traditional foods are in danger of extinction due to changes in people's lifestyles. Therefore, it is significant to examine and record these traditional foods, which are important elements of Turkish culture, in order to preserve and transfer them to future generations. Traditional foods are often prepared under unfavorable health conditions and marketed informally. Furthermore, they are not subject to any formal control over their accordance with national regulatory standards. Thus, these foods are expected to cause public health risks.

In this study, Failure Mode and Effect Analysis (FMEA) methodology was applied to the production stages of traditional fermented beverages ekşi ayran, çüküdür suyu, gilaburu, hardaliye, hayva şerbeti, kefir, mişmiş şerbeti, şalgam suyu, töngel şerbeti, tükenmez and necessary risk assessments were made. Potential failure modes in the production stages are identified and potential hazards are identified for each failure mode. For each potential failure, the probability of occurrence (O), severity (S), and detectability (D) is determined as a three variables. Risk levels were defined by calculating the risk priority number (RPN) with the help of these variables. Corrective actions have been proposed for potential hazards with RPN values greater than 100. In addition, nutritional values of these beverages were determined with the help of national and international databases.

Töngel şerbeti had the highest caloric value with 195.46 kcal in one serving (200 mL), while şalgam suyu has been found to have the lowest caloric value with 34.32 kcal in one serving. The most carb-containing beverage was found to be Hardaliye with 33.5 g. It has been demonstrated that most of the risks during production of traditional fermented beverages stem from the supply of raw materials. Especially water supply was found to be the most significant hazard. This was followed by hazards from personnel involved in all stages of food production. In the next row, the hazards arising from the tools and equipment used during production are placed. Approximately eighty percent improvement in RPN was achieved after FMEA administration. All in all, it can be claimed that the FMEA methodology is an effective approach to food safety and quality management and can be applied to traditional food production.

Keywords: FMEA, Traditional food, Food safety, Case study

ÖZET

Kavsara, H. K. (2019). Geleneksel Fermente İçeceklerin Üretim Yöntemlerine Hata Türü ve Etkileri Analizinin Uygulanması. Yeditepe Üniversitesi, Sağlık Bilimleri Enstitüsü, Beslenme ve Diyetetik ABD., Master Tezi. İstanbul.

Türkiye'de üretilen bazı geleneksel gıdalar değişmiş yaşam tarzları nedeniyle ortadan kalkma riski altında bulunmaktadır. Bu nedenle, Türk kültürünün önemli unsurlarını sürdürmek için bu geleneksel gıdaları incelemek ve belgelemek önemlidir. Geleneksel gıdalar çoğunlukla olumsuz sağlık koşullarında hazırlanmakta ve gayrı resmi yollarla pazarlanmaktadır. Ayrıca, ulusal yasal düzenleme standartlarına uygunlukları üzerinde herhangi bir resmi kontrole tabi tutulmamaktadırlar. Dolayısıyla bu gıdaların halk sağlığını riske sokması beklenmektedir.

Bu çalışmada, ekşi ayran, çüküdür suyu, gilaburu, hardaliye, hayva şerbeti, kefir, mişmiş şerbeti, şalgam suyu, töngel şerbeti, tükenmez geleneksel fermente içeceklerinin üretim aşamalarına Hata Türü ve Etkileri Analizi (FMEA) uygulanmış ve gerekli risk değerlendirmeleri yapılmıştır. Üretim aşamalarındaki muhtemel hata modları belirlenmiş ve her bir hata modu için potansiyel tehlikeler tanımlanmıştır. Her bir potansiyel hata için, hatanın oluşma olasılığı (O), ciddiyeti (S) ve tespit edilebilirliği (D) olmak üzere üç değişken belirlenmişir. Bu değişkenler yardımıyla risk öncelik sayısı (RPN) hesaplanarak risk seviyeleri tanımlanmıştır. RPN değeri 100'den büyük olan potansiyel tehlikeler için düzeltici faaliyetler önerilmiştir. Düzeltici faaliyetlerden sonra RPN değerlerinin tekrar hesaplanması ile düzeltici faaliyetlerin etkililik düzeyleri gözlemlenmiştir. Ayrıca ulusal ve uluslararası veritabanları yardımıyla bu içeceklerin besinsel değerleri saptanmıştır.

Töngel şerbeti, bir porsiyonunda (200 mL) 195.46 kkal ihtiva ederek en yüksek kalorik değere sahipken, şalgam suyunun, bir porsiyonda 34.32 kkal ile en düşük kalorik değere sahip olduğu bulunmuştur. En çok karbonhidrat içeren içeceğin 33.5 g ile Hardaliye olduğu bulunmuştur. Geleneksel fermente içecek üretiminde risklerin çoğunun hammadde tedarikinden kaynaklandığı gösterilmiştir. Özellikle su temini en önemli tehlike olarak bulunmuştur. Bunu, gıda üretiminin tüm aşamalarında yer alan personelden kaynaklı tehlikeler takip etmiştir. Bir sonraki sıraya, üretim sırasında kullanılan ekipmanlardan kaynaklanan tehlikeler yerleşmiştir. FMEA uygulamasından sonra RPN'de yaklaşık %80 iyileşme sağlanmıştır. Bu nedenle, FMEA'nın gıda güvenliği ve kalite yönetimi için etkili bir yaklaşım olduğu ve geleneksel gıda üretimine uygulanabileceği öne sürülebilir.

Anahtar Kelimeler: FMEA, Geleneksel gıda, Gıda güvenliği, Vaka çalışması

1. INTRODUCTION

Traditional foods have been of great importance for thousands of years in several regions and different cultures. Foods that are consumed locally and regionally for many years are among these foods. Folklore of a country includes preparing methods of traditional foods (1, 2). Unfortunately, the alterations in people's lifestyle in our country cause the risk of endangered some traditional foods. Thus, it is essential to examine and document traditional foods which are significant components of Turkish culture in order to bequeath them to future generations.

Traditional food is still mainly prepared at home level in adverse health conditions and marketed through informal routes (3). They are also subject to any formal control over their compliance with national regulatory standards. Since such patterns of risk have never been scientifically predicted, because of the lack of consumption models, epidemiological data and appropriate surveillance programs, it is expected to cause public health risks (4). The lack of scientific studies on the frequency of hazards in this certain food category reinforces the challenges of conducting studies for scientifically valid risk assessment (4). This study provides a brief explanation of the production procedure of some traditionally fermented beverages produced in Turkey. Discuss the probable microbiological risks related with their production and consumption and the food safety problems they arise. In addition, attention of the decision-makers in Turkey should be attracted to the necessity of assessing the health risks related with consumption of these beverages and also it is significant to determine the essential measures to reduce these risks. To achieve this goal, the FMEA method, which has recently been introduced in the field of food safety, has been utilized. This method is suggested to be a stronger alternative to food safety management systems like HACCP and ISO-22000.

The aim of this thesis implementation of safety methodology to the traditional fermented beverages production processes, Failure Mode and Effect Analysis, relatively novel in food field. It has suggested that this method can be more effective alternative of Hazard Analysis and Critical Control Points (5).

2. LITERATURE REVIEW

2.1. Traditional Food

Traditions, which are an important part of the cultures, are the beliefs and values that are transmitted orally from generation to generation. Each country, region or ethnic group has its own culture. There may also be common traditional features between different groups. Eating habits of individuals also play an important role in shaping traditional habits. Some foods and production methods have been transferred from generation to generation for years. These foods are called "traditional food" (6).

Traditional foods have been of great importance for thousands of years in several regions and different cultures. Foods that are consumed locally and regionally for many years are among these foods. Folklore of a country includes preparing methods of traditional foods (1, 2). Unfortunately, the alterations in people's lifestyle in our country cause the risk of endangered some traditional foods. Thus, it is essential to examine and document traditional foods which are significant components of Turkish culture in order to bequeath them to future generations. The Turkish Food Codex defines traditional foods as "products created using conventional raw ingredients or defined by conventional conformation or conventional mode of production or, although not directly based on a conventional mode of production, because they have been processed to reflect such a mode of production, they can be noticeably separated from similar products of the same category (7)."

European Food Information Resource Network (EuroFIR)

EUROFIR is a non-profit, member-centered, global association. It was established in 2009 in order to ensure the continuous defense of food knowledge in Europe.

Objectives:

Develop, publish and use food composition information

Promote the harmonization of international standards in order to improve data quality, data storage and data access (8).

To accomplish these objectives, EuroFIR has established some systems and implemented them (9):

Langua Alimentaria index, Documentation of values with the help of EuroFIR thesauri, Recipe calculation procedure and nutrient retention factors, Quality assessment systems.

EUROFIR members are individuals and organizations working in the fields of food production and sales, dietetics, software development, regulation and policy makers and academia. Members are organizations, organization members, full members, individuals and students. United Kingdom, Estonia, Slovenia, Finland, France, Greece, Norway, Portugal, Sweden, Republic of Serbia, Belgium, Netherlands, Spain, Czech Republic, New Zealand, Austria, Latvia, Italy are the full members of EuroFIR while TUBITAK Marmara Research Centre from Turkey is an ordinary member of institution (10).

EuroFIR defines **"Traditional Food"** (1, 2, 11):

Traditional means that compatible with practices or specifications established before World War II. Foods of a particular feature or features that clearly distinguishes it from other similar products of the same category for use; 'Traditional ingredients, composition, production types and processing method'

The Food and Agriculture Organization (FAO) adopted the EuroFIR definition of traditional foods at the 26th Europe FAO Regional Conference in Innsbruck, Austria on 26 - 27 June 2008 (11).

2.2.Fermentation

Fermentation is a food production and preservation method that has been practiced for many years. Since ancient times, traditional fermentation as well as smoking, drying and salting processes have been used to conserve nutrients, and these processes are an important step in the history of food culture for humanity (12).

Fermentation is a natural method that increases the nutritional value of foods by the synthesis of essential amino acids and vitamins. While the digestibility of nutrients is increased by fermentation, detoxification and degradation of undesirable substances such as phytate, tannins and polyphenols in raw foods are also carried out (13, 14).

2.3. Definition and Types of Fermentation

2.3.1. Definition

Fermented products are defined as products produced from plant and animal products by adding natural or initiating cultures (12). Enzymes and microorganisms such

as bacteria, yeast and fungi help produce fermented foods and beverages. Biochemically fermentation is a metabolic process in which energy is released by partially oxidizing carbohydrate and related compounds in the absence of any electron acceptor (12, 13).

2.3.2. Types

There are three types of fermentation: solid-state, liquid-state, solid-liquid state (semi-solid state) fermentation. In solid fermentation, the product is solid, the product is liquid in liquid fermentation and it is humid in solid-liquid fermentation. There are two types of fermentation depending on the usage of the microorganism which are natural fermentation and controlled fermentation with starter culture. Controlled fermentations using starter culture are also divided into monocultural fermentation and multicultural fermentation using two or more cultures (12).

Traditional fermented products are mainly produced by solid-state fermentation either spontaneously or using initiator culture. In fermentation process, rope and micelle-shaped molds were widely used in Eastern and Southeast Asian countries. But on the other hand, bacteria and bacteria-yeast mixtures are used in Africa, Europe, Australia and America. Among the traditional foods of Himalayan, there are fermented products containing three groups that are mold, yeast and bacteria (12).

Lactic acid bacterias

Lactic acid bacterias (LAB) constitute set of gram positive bacteria according to their morphological, physiological and metabolic characteristics. The general definition of bacteria in this group; non-spore forming except *Sporolactobacillus inulinus*, gram positive, , without cytochrome, catalase negative, non-aerobic but aero-tolerant, divided into only one plane except *Pediococcus genus*, acid-tolerant, strong fermentative, lactic acid producer during glucose fermentation, coccus or rod shaped bacteria with some exceptions. Lactic acid bacteria are usually rich in nutrient-rich environments; for example milk, meat and vegetables (15, 16).

LAB was collected in two separate families in their classification. Streptococcaceae family belonged to *Pediococcus, Streptococcus, Leuconostoc* genera; Lactobacillus species belonging to the family Lactobacillaceae. The main kinds of LABs utilized in food industry and biotechnological studies are; *Oenococcus, Aerococcus, Carnobacterium, Lactococcus, Leuconostoc, Melisococcus, Enterococcus,*

Lactobacillus, Tetragenococcus, Bifidobacterium, Pediococcus, Vagococcus, Weissella and *Streptococcus.* The largest genus among them is *Lactobacillus. Bifidobacterium* genus is also located between the LABs (17).

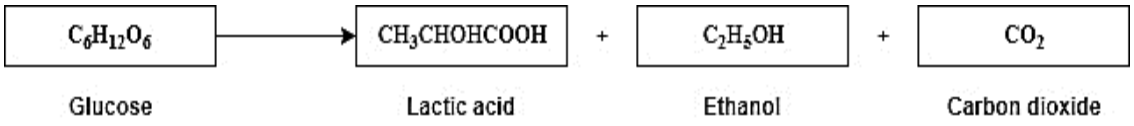
Traditionally, in the production of fermented products, *Lactobacillus* bacteria from the raw material naturally produce lactic acid fermentation. Therefore, the type and number of microorganisms on the raw material is important for a successful fermentation and final product quality (15).

Lactic acid fermentation

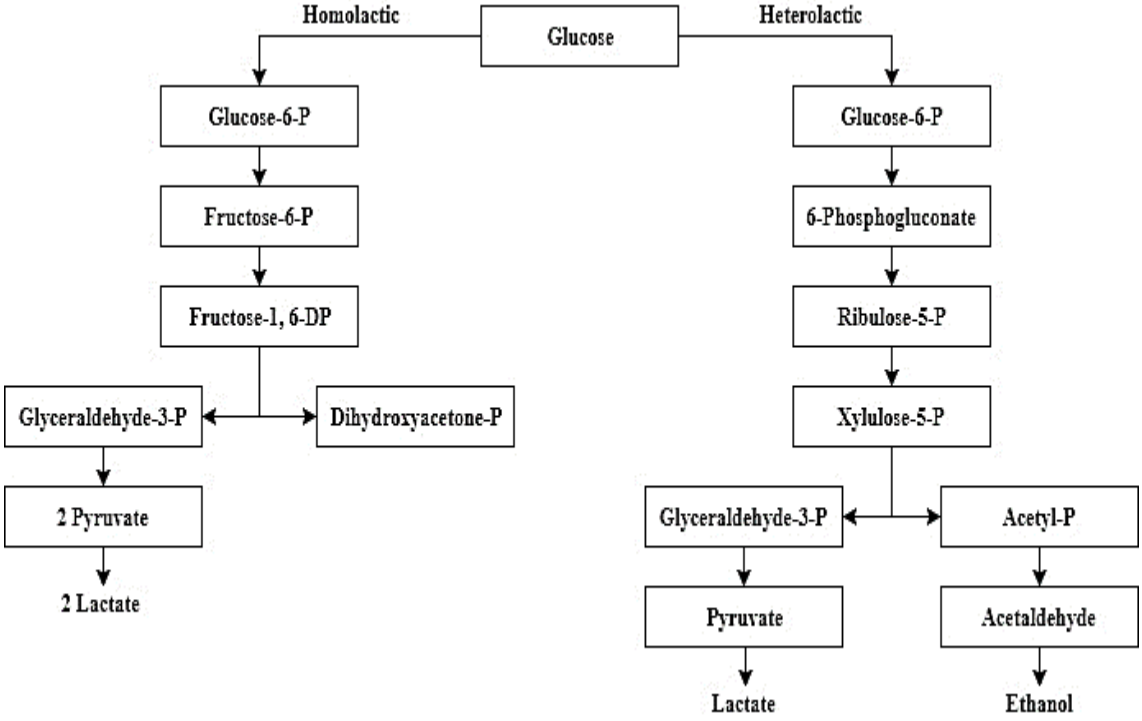
LABs are belong to two central groups which are the homofermentative and the heterofermentative. Homofermentative and heterofermentative LABs have different pathways of lactic acid production. While homofermentatives produce mainly lactic acid, via the glycolytic (Embden–Meyerhof pathway), heterofermentatives produce lactic acid besides substantial amounts of acetate, ethanol and carbondioxide, via the 6-phosphoglucanate / phosphoketolase pathway. All lactic acid bacterias utilize the glycolytic pathway with the exceptions of *lactobacilli, leuconostocs, oenococci* and *weissella*s. Excess sugar with limited oxygen is essential for this pathway as a normal conditions (18, 19).

Homolactic fermentation: Fermentation of 1 mole glucose yields two moles lactic acid;

Heterolactic fermentation: Fermentation of 1 mole glucose yields 1 mole lactic acid, 1 mole ethanol and 1 mole carbon dioxide;



Fermentation of glucose in LAB is given below as a general scheme (14)



2.4. Historical Background of Fermentation

Throughout the history of civilization, a wide variety of fermentation methods have been described, which are used in both vegetable and animal products. The earliest records were found in the fertile crescent region, including Mesopotamia and the Eastern Mediterranean, which date back to 6000 BC (20).

Although the role of microorganisms in the preparation of fermented foods and beverages in ancient times is unknown, these products have been produced skillfully. However, there have been changes in nutrient fermentation and process in 19th century. In the middle of the 19th century microbiology had emerged as a science. Thus, biological based information provided a great understanding of the fermentation process (20).

Food fermentation in history is indicated as a natural process occurring with the activity of natural flora in raw material. Later on, different methods were applied to increase the quality and to create different taste, odor and image in each of the foods. These natural fermentation patterns have been developed with appropriate storage conditions, technical manipulations and additional accelerated processes. For years, traditional food fermentation application of various raw food items (fruits, cereals, vegetables, milk, meat and fish) has been provided with durability. Later, different foods

were produced by using different starter cultures by providing different fermentation conditions (19).

In recent years, besides traditional fermented products, there has been an increased interest in many fermented foods and beverages produced by using various raw materials, production techniques and microorganisms. There is an estimation about more than 3500 fermented foods and beverages are produced all over the world, including fruit and vegetables and milk based products. Most of these products are produced in Asian or African countries, at homes and also in small-scale industrial enterprises (13).

2.5. Fermented Products Consumed Worldwide

Fermented foods and beverages are produced and consumed by millions of people from several societies and ethnic groups around the world. Approximately 5% - 40% of the total food consumption about 50-400 grams per person per day is composed of fermented foods and alcoholic beverages in the world. Fermented vegetables, soya and other legumes, fermented dairy products, fermented fish and meat products, fermented cereals are some of commonly consumed fermented products all over the world (12).

2.6. Traditional Fermented Beverages Consumed in Turkey

Production and consumption of traditional fermented beverages is quite high in our country as in the whole world (12). In addition to milk-based ones, there are also fruit and vegetable based ones. Some of them are produced according to traditional methods while others are produced industrially (21). Significant health promotion benefits have been demonstrated by the functional microorganisms they contain (12). Interest in the consumption of fermented beverages has increased in line with the information revealed by recent microbiota research. Milk-based kefir, cereal-based boza, fruit-based hardaliye, vegetable-based şalgam suyu are widely consumed in our country and are also industrially produced fermented beverages (12, 21, 22). Beverages that form the basis of our research are generally fermented beverages produced by traditional methods and are about to disappear gradually.

2.7.Importance of Fermented Products for Health

Fermented foods produced by LABs have been revealed to cause some positive changes in cholesterol which is one of the major causes of coronary heart disease. In addition, it has been demonstrated that LABs support the production of immunoglobulin-

A and gamma interferon stimulated by the immune system. This condition increases the resistance of the human body against pathogens and increases its antitumor activity. Lactic acid bacteria taken into the digestive system with fermented foods; causes a decrease in the activity of enzymes in the intestine such as azoreductase, β-glucuronidase and nitroreductase (23). These enzymes are enzymes that convert prokarsinogen substances into carcinogenic structure. Therefore, the decrease in the activity of these enzymes creates anticarcinogenic effect (23, 24).

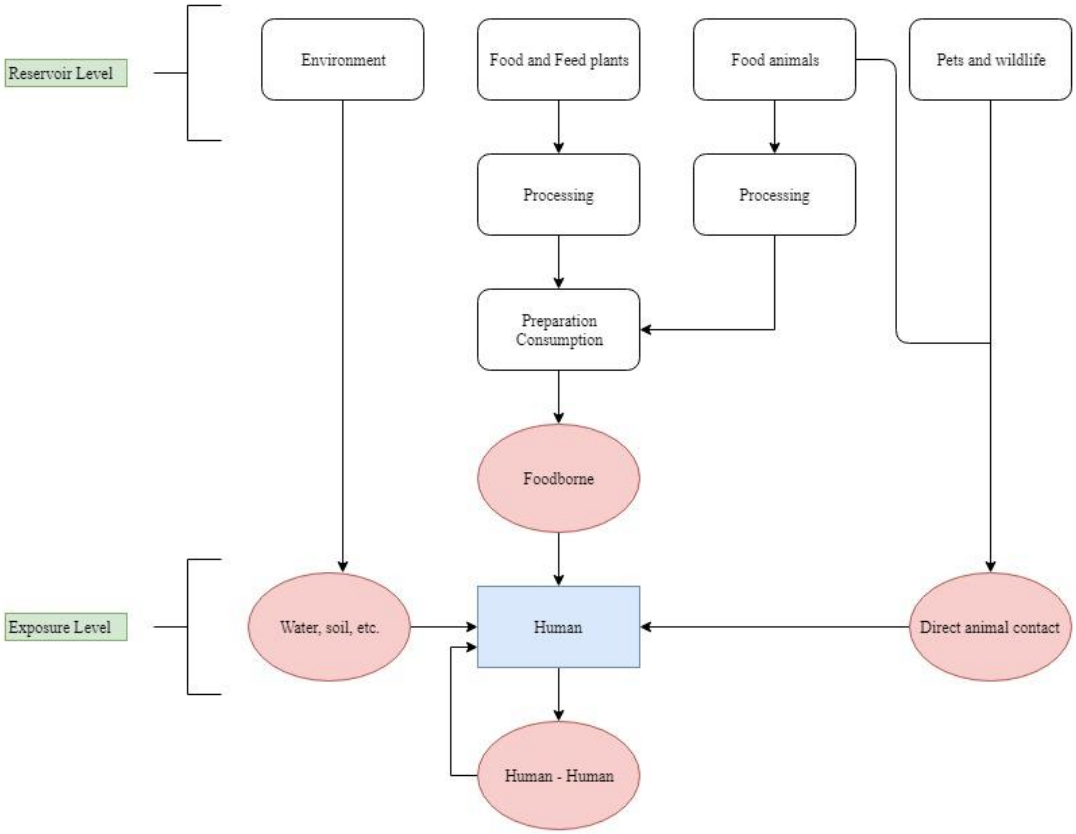
It has been proposed that the fermented products have functional and therapeutic effects due to the antimicrobial, antioxidant, probiotic, cholesterol-lowering and health-beneficial compounds in humans (25). The antihypertensive effects of milk products fermented by LAB have recently been remarkable. In the beginning, laboratory and animal experiments have been done, however studies on people have been published in recent years (26, 27). According to the study performed in elderly individuals with hypertension, diastolic and systolic blood pressure decreased in patients who consumed fermented milk containing *Saccharomyces cerevisiae* (25).

Fermented products can be effective in providing intestinal detoxification associated with colon cancer development and supporting immune system (28). Probiotics have a protective role in decreasing the risk of colon cancer (28, 29). Epidemiological and community-based control studies have demonstrated an contrary relationship between the consumption of fermented dairy products (containing *Bifidiobacteria* or *Lactobacilli*) and the incidence of breast and colon cancers (25). Kefir is used in various health conditions such as allergic disease, atherosclerosis and metabolic disorders (30). Probiotics exert a modifying influence on allergic reactions. They provide positive effects thanks to improve microbial stimulation of the immune system and mucosal barrier functions (31).

2.8. Food Hazards

NACMCF (National Advisory Committee on Microbiological Criteria for Foods) defines hazard: a physical, chemical, biological agent which causes injury or disease despite its prevention (32). Food hazards that cause food-borne diseases can be classified as biological, chemical and physical hazards (33).

Major transmission routes of human foodborne diseases (34)



2.8.1. Biological Hazards

Food-borne diseases are generally defined as an incident of two or more individuals showing illness after ingestion of the same water, food or meal and occur through two different pathways: food intoxication and food infection.

Food Intoxication: It is the type of poisoning caused by the toxins released by some bacteria during their growth. For example; *Staphylococcus aureus* and *Clostridium botulinum* (35–37).

Food Infection; It is caused by the proliferation of the bacteria taken into the body with food in the digestive system and causing food poisoning due to the wastes they leave when they die. For example; *Salmonella spp.* and *Clostridium perfringens* (35–37).

Food infections vary according to the type of bacteria, it occurs 6-8 hours after food consumption and lasts 2-3 days / 1 week. Food intoxications occur relatively more quick, about 2-4 hours (35–37).

The most significant bacteria species that leads to poisoning in food are *Staphylococci, Salmonella* and some *Clostridium*. Several bacteria toxins or itself are led to diseases when ingested with food. Bacteria like typhoid, cholera, etc. have more virulence. Thus, these microorganisms can cause vital diseases even a few amount (36, 37).

Norwalk and *Norwalk-like viruses, Hepatitis A, Poliovirus, Rotavirus* and *Astrovirus* are viruses which can be transmitted to humans via foods. Viruses are usually transmitted to the foods by contaminated water or fecal-oral route. Fruits and vegetables contaminated with polluted water especially used in agricultural areas and marine products are effective in spreading infections. The basic way to prevent infections from viruses is closely related to personal hygiene and particularly to hand hygiene. And also; the use of controlled water in food and beverage production areas is also of great importance. Chlorination can only neutralize viruses on surfaces in contact with food and water. High cooking temperatures where pathogenic bacteria are killed are needed to make them ineffective in foods (35–38).

There are some important internal parasites that are transmitted to humans via food and water and cause serious diseases. These are two groups of protozoa and worms. Worms are divided into three groups as trematodes (butterflies), nematodes (round worms) and cestodes (tapes, tapeworms). Examples of protozoa are *Entamoeba histolytica*, Toxoplasma gondii. Examples of worms are *Taenia saginata, Taenia solium* and *Trichinella spiralis* (38).

Biological hazards are grouped in terms of the severity and incidence of effects;

Severe Hazards: *Clostridium botulinum, Shigella dysenterae, Hepatit A, E, Brucella abortis, Vibrio cholera* and *Trichinella spiralis*

Moderately severe but common hazards: *Listeria monocytogenes, Streptococcus pyogenes, Norwalk virüs, Diphllobothrium latum, Cryptosporiudium parvum* and *Ascaris limricoides*

Moderately sever but uncommon hazards: *Bacillus cereus, Campylobacter jejuni, Staphylococcus aureus, Vibrio parahaemolyticus, Giardia lamblia, Clostridium perfringens* and *Yersinia enterocolitica*

2.8.2. Chemical Hazards

Allergen compounds, disinfectant residues, polycyclic aromatic hydrocarbons, histamine, veterinary drugs, mycotoxins, pesticides, antibiotics, toxic minerals, dioxin, additives, nitrosamines, contaminants from inappropriate plastic packaging detergents are some of food-borne chemical hazards (38).

Mycotoxins, not molds themselves, are considered to be dangerous. Mycotoxin formation in some agricultural products without any visible damage to the plant, can start in the field, sometimes as in peanuts, as the systemic infection may affect the whole plant. Mycotoxins can be formed as a result of the direct ingestion and growth of mold in food and feed as well as indirectly in the meat, milk and eggs of the animals fed mycotoxin containing feed (38).

Although the number of mycotoxins defined is over 300, the main mycotoxins which are emphasized today are; aflatoxins, ochratoxin A, patulin, sterigmatocystine, trichothecenes and zearalenone.

Among the mycotoxins, the most known ones are aflatoxins. Poisoning due to aflatoxins is known as “aflatoxicosis”. Aflatoxins are toxic compounds formed by *Aspergillus flavus* and *Aspergillus parasiticus* molds. Aflatoxins are formed due to the molds that are formed as a result of the storage of many foods and animal feed products at inappropriate humidity and temperatures. There are 6 types of aflatoxins that are important today. Of these, B1, B2, G1, G2 are found in various foods, while M1 and M2 are mostly found in animal feeds. Although the target organ of aflatoxins is liver, it may cause damage or tumors in other tissues (32, 35). A significant correlation was found between the aflatoxin levels detected in foods and the incidence of hepatitis B and liver cancer (38).

Ochratoxin A is also among the most frequently studied mycotoxins in foods (38). Ochratoxin A is formed by the growth of molds in foods such as corn, beans, cocoa and coffee beans, soybeans, barley, oats, citrus fruits, peanuts. Toxin causes reduction in the kidneys and formation of tumors (35).

Patulin, another mold toxin, can maintain its stability even in liquid environments and low pH values at high temperatures. Patulin formation in apples is related to decay caused by spoilage (38). Patulin occurs most often in apple juices, moldy bread and other

fruit juices (grapes, peaches, etc.) as a result of the growth of molds. It has been reported that patulin causes symptoms of edema, hemorrhage, nausea and vomiting in addition to carcinogenic effects. By cutting and removing the spoiled parts of apples, patulin levels in apple juice can be eliminated by 93% (35, 38).

Pesticides: Good Agricultural Practices (GAP) define which pesticide in which agricultural product should be used and how often. If used in accordance with these conditions, pesticides do not pose a significant danger to the food chain. Pesticides that are found to be inconvenient for any type of agricultural product and their permissible residue limits in the relevant food product are included in the relevant codex standards and relevant legislation. Regarding the use of pesticides in farm and field in the production of plant raw materials, the legal regulations related to the subject (e.g. Turkish Food Codex Regulation) must be taken into consideration by the agricultural product growers. The new approaches obligate food industry organizations to ensure that their vendors supplying agricultural raw materials strictly adhere to these issues and to implement them in the recommended manner, if necessary, through vendor training. This proactive method is the most effective way to eliminate the health risks of pesticides (38).

The increase in the use of nitrogen fertilizers in agriculture caused the rise in the amounts of nitrate and nitrite taken by diet. These values can be very high from time to time in both spring waters and plant crops in areas where intensive agricultural production is performed. Organic fertilizers used for organic products can also be biological and microbial contamination agents. The use of untreated sewage water and direct animal manure in field-garden irrigation can cause pathogenic bacteria and parasitic contamination in plant food raw materials (38).

Antibiotics are also used in animal husbandry to treat and prevent animal diseases, as well as to promote growth and development. The use of growth-enhancing hormones and similar growth-enhancing compounds in livestock for livestock breeders is prohibited in some countries due to the risks posed by human health. The Turkish Food Codex Regulation includes residual limits that can be tolerated in animal food products of veterinary drugs which are agreed upon in this respect (38).

Some natural food components and subsequent food additives (fish-egg-milk components, sulphides, some synthetic food dyes, etc.) may cause allergic reactions depending on the dose received and the specific sensitivity of the individual. For this

reason, the contents and additives of the product has to be fully contained on the label of food product. It should be indicated with a special warning if there is a substance known to be an allergen in some sensitive groups (38).

Compounds of this nature can be found in grains, vegetables and fruits as a result of accumulation of contaminated air components in plant products in industrial production areas. Also in distant lands from areas where people live it is determined that even as a result of the decay of plant constitutes some (Polycyclic Aromatic Hydrocarbons) PAH compounds. Pyrolytic products of PAH compound benzo [a] pyrene (BP) and some amino acids which are found to be carcinogenic in animal studies. These compounds can be found at μg / g level in various foods such as grilled meat, fish and mushroom. In many studies, it was reported that the mutagenic properties of these substances were strong but their carcinogenic effects were weak (38).

Heavy metals such as mercury, lead, cadmium, and arsenic should preferably not be present in foods and not surpass the limit values specified in Turkish Food Codex Regulation. Toxic metals can be transmitted to food from air, water, soil, or equipment used in production, as a result of environmental pollution. Arsenic is also known as carcinogen, and epidemiological studies show the presence of high rates of arsenic in drinking water and a relationship between lung, liver, colon and bladder cancers (38).

These organic compounds, which are used in various industrial applications, can be transmitted from environmental waste to food chain. In some countries, their production and use has been banned because of their toxic effect and non-degradable properties in nature. Among the foods, the products where Polychlorinated Biphenyls (PCBs) contamination is most frequently observed are fish. The highest permitted levels of PCBs in fish are 2 mg / kg in fish and seafoods, 1.5 mg / kg in milk fat and dairy products, and 0.3 mg / kg in eggs (38).

Maillard reaction occurs when foods containing high protein and carbohydrates are treated with heat (e.g. coffee, dairy products, bakery products) (39). Maillard is a non-enzymatic reaction between the carbonyl group and the amine group. The final products of this reaction consist of Advanced Glycation End-products (AGEs) (39). It has been demonstrated that AGEs may cause oxidative stress, diabetes and cancer as well as potential endocrine disruptive effects (39, 40).

A group of organic chemicals, reveal due to the natural fires, such as forest fires and volcanic eruptions, some of which occur with synthetic formations in the production processes of the organic chemistry industry, and which contain many toxic compounds found in the water, air and soil. Among them tetrachlorodibenzo-para-dioxin is known as the most toxic and carcinogenic substance. Developed and industrialized countries are reported to be at higher risk in terms of these latter two groups (38).

Some plastic packaging materials may be migrated from substances in their compositions to foods. The level of migration can differ according to the type of plastic and food. Generally, the polymeric packaging materials are inert. However, there may be transition from monomers, such as vinyl chloride and acrylonitrile which remain in the polymer. Most of these compounds have been observed to have carcinogenic and mutagenic effects in laboratory animals. Both the Turkish Food Codex Regulation and the regulations on plastics contact with food indicate acceptable limits on this issue (38).

2.8.3. Physical Hazards

Physical hazards can be defined as physical materials which should not normally be present in a food, and which can cause disease in humans when food is consumed (5, 38, 41).

Diseases and problems caused by physical hazards are less than the health parameters caused by microorganisms.

There are four sources of physical hazards.

1. Contamination during cultivation and harvesting (such as stones, metal, insects, unwanted grass, thorn, wood, dust or small animals),

2. Contamination during the process (Bone, glass, metal, wood, wire, clothes, bolts, machine oil, dyes, rust, insulation etc.),

3. The placing of materials into the food during distribution (insects, wire, dirt, stone, various other objects),

4. Particular placement of materials into food (sabotaging),

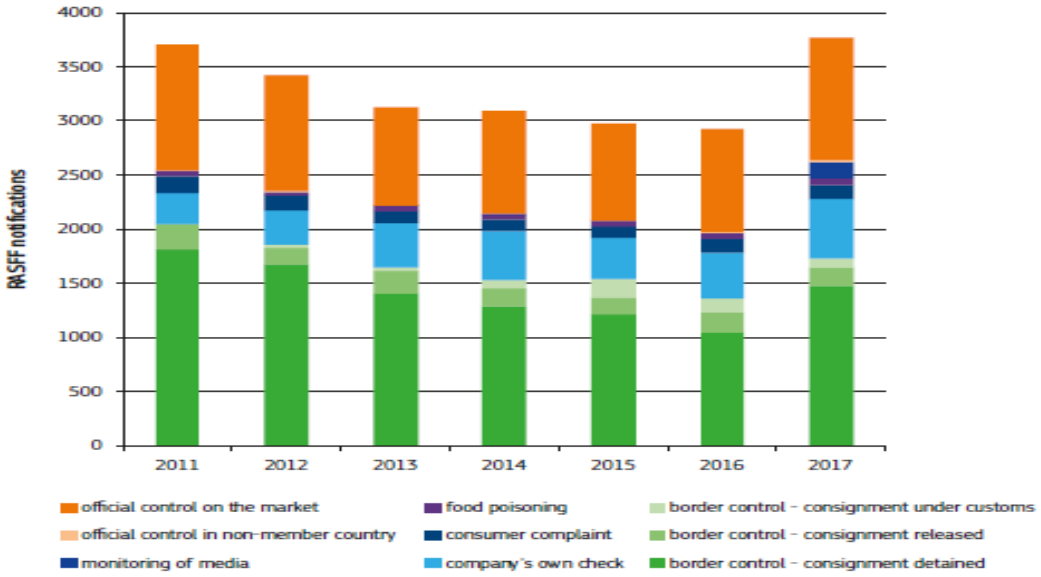
Summary of the types of physical hazards, the health problems they can create and the sources of contamination is given below (5, 35, 38, 42).

Physical Hazard	Injury Potential	Resource
Glass	Cuts, Bleeding	Bottles, Jars, Electrical Equipment, Containers, Cups, Thermometers, Measuring Instruments
Wood	Infection, Obstruction	Fields, Herbs, Boxes, Crates, Construction Materials
Stones	Obstruction, Broken Teeth	Agricultural Products, Fields
Metal	Cuts, Infection	Metal, Field Crop, Raw-Food Material Wire
Insects	Disease, Trauma Obstruction	Agricultural Products, Fields, Packaging Zones, Open Doors
Bone, fruit kernel	Obstruction, Trauma	Meat and poultry and fish products, Various fruits
Bullets / needle	Cuts, Bleeding, Obstruction	Needles for animal vaccines, Injection

2.9. Food Safety

Unsafe foods endanger everyone and create worldwide health threats. The elderly, pregnant, young children, infants and those with underlying diseases are predominantly at risk groups. Each year, 220 million children are suffering from diarrhea diseases due to unsafe foods and 96 000 children die (43). Consumption of unsafe foods leads to atrocious malnutrition and diarrhea cycle that endangers nutritional status. Where food is unsafe, people tend to switch to less healthy diets and consume more insecure foods that may threaten health (43).

The Rapid Alert System for Food and Feed (RASFF) was established to exchange information with food and feed control authorities on measures taken in reaction to serious risks associated with food or feed. Member States can act more quickly and synchronized to the health threat caused by food or feed thanks to this exchange of information. Its simple structure aids to improve its efficiency. It involves mainly of apparently defined contacts at the Commission, the European Food Safety Authority (EFSA), the European Economic Area (EEA) and the member states, which exchange clear and structured information at national level. IRASFF is the online platform of RASFF.



Some of top notifications by country according to the 2017 guide published by RASFF (44)**:**

320 notification from **poultry meat and products** due to ***Salmonella*** detection in **Brazil.**

83 notification from **fruit and vegetables** due to **pesticide residues** detection in **Turkey.**

70 notification from **fruit and vegetables** due to **aflatoxin** detection in **Turkey.**

65 notification from **nuts and seeds** due to **aflatoxin** detection in **Turkey.**

Recurring notifications (44):

30 of 33 hazelnuts from Turkey were rejected from border.

25 of 26 pistachio nuts from Turkey were rejected from border.

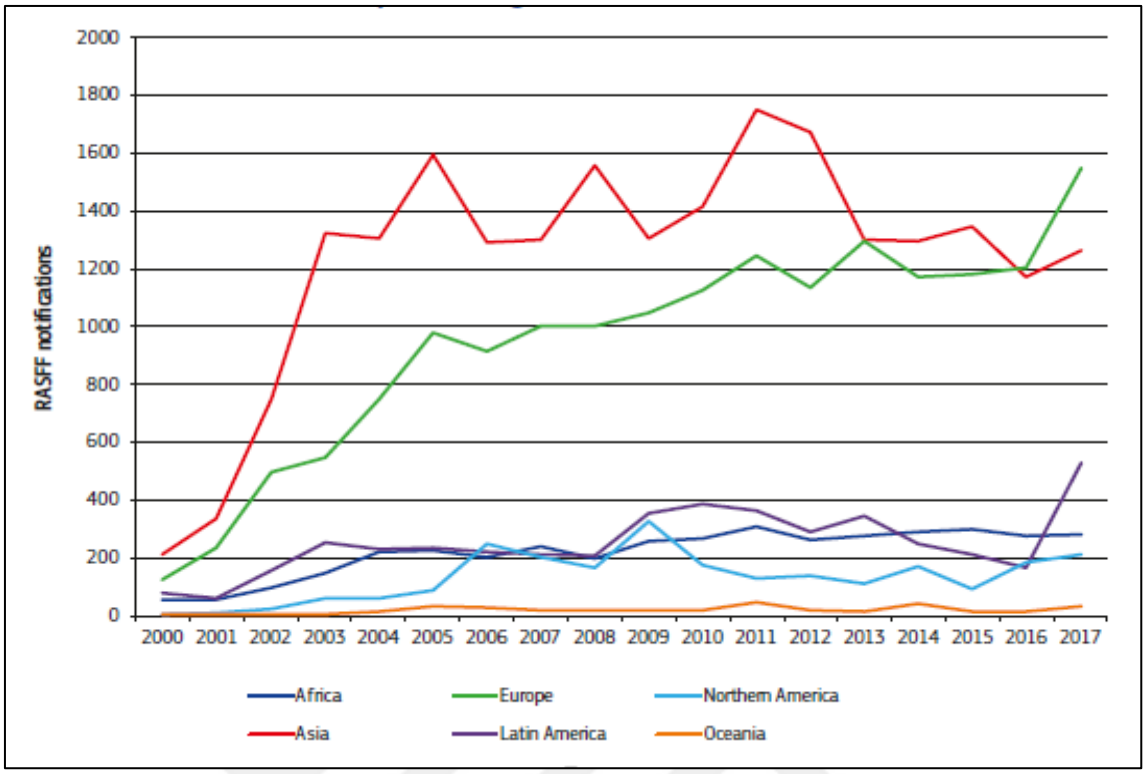
59 of 70 dried figs from Turkey were rejected from border.

55 of 57 sweet peppers from Turkey were rejected from border.

34 of 36 dried apricots from Turkey were rejected from border due to high content of sulphite.

Country	**2015**	**2016**	**2017**
Tunisia	21	18	24
Turkey	281	274	316
Nigeria	42	25	47
Norway	8	5	10

2000-2017 notifications by world region (44)



2.10. Food Safety Management Systems

2.10.1. Hazard Analysis and Critical Control Point (HACCP)

The Hazard Analysis of Critical Control Points (HACCP) is a standard based on the determination of whether any food is suitable and safe for human consumption. This system is applied on the basis of the determination and control of the critical points where the factors that may adversely affect the product quality and human health during the production stage. Thus, it is aimed to ensure product quality and consumer health by determining the foci of intolerable risks arising from process errors in the production (45).

HACCP system is a systematic approach to identifying all hazards related to food, identifying damages and controlling risk-bearing points (45). It ensures that all kinds of hazards that will endanger the health of the consumer in the process starting from the raw material to the last stage of production are eliminated (46).

As a result, HACCP is a quality assurance system that helps prevent problems that may arise in product safety, reduces the importance of end product control, can be applied in all sizes of enterprises, can be integrated into every process of the food chain, warns about hazards before an error occurs and facilitates international audits.

The HACCP system involves the seven principles below [57]:

- To carry out hazard analysis.

- Determination of Critical Control Points (CCP).

- Establishment of critical limit (s).

- Create a system to monitor the management of the CCP.

- Taking corrective action when monitoring shows that certain CCP cannot be controlled.

- Generate validation procedures to verify the HACCP system operates efficiently.

- Create documentation on entire actions and records in accordance with these practices.

2.10.2. ISO 22000

ISO 22000 is a standard planned to guarantee safe food delivery worldwide. It was established by ISO Technical Team thirty four Working Group eight in line with the ISO-72 guide. This standard was publicized in September 2005 with the aim of taking necessary precautions for diseases caused by foods in developing countries and related deaths, and establishing a common framework that will enable producers and consumer firms to trust each other at the global basis (47).

This standard covers all the necessities of the food safety management system which are necessary to make certain that food is safe for consumption and to control threats to food safety. It includes all organizations directly or indirectly involved in any stage of the food chain. Within this framework, organizations directly involved; farmers, food producers, feed producers, food component producers, harvesters, food service providers, foodstuffs manufacturers, cleaning and sanitation facilities, carriers, distribution and storage companies.

2.10.3. Failure Mode and Effect Analysis

Failure Mode and Effect Analysis (FMEA) is a systematic method designed to detect and prevent hazards that may occur in the production processes of the product before they take place (48). FMEA focuses on avoiding errors, increasing customer satisfaction and increasing food safety. FMEA is useful and important for new product

design and process development. However, it also provides significant benefits when implemented in existing products and processes (49).

The main objective of FMEA is to prevent production or procedural errors by controlling them before they take place. It can be used in both product design and production processes. It helps reduce costs by identifying improvement activities that need to be done at the beginning of production through relatively inexpensive and simple alterations. Thus, problems or crises that may occur after the production process completed are reduced or prevented (49).

The FMEA technique encompasses all of the tools, items and raw materials involved in each of the production stages. In addition to expert opinion, information obtained from studies in the past was also used in the analysis (42, 47, 48, 50).

FMEA differs from other food safety programs in some aspects. While there are specific CCPs in HACCP, each stages of production in FMEA are critical points. FMEA is a bottom-up system. Before the potential hazard in one production stage is eliminated, the next stage is not passed (5). In addition, HACCP has a qualitative analysis, while the analysis of FMEA is quantitative. In FMEA, the Risk Priority Number (RPN) of each potential hazard is determined and corrective action is implemented accordingly (5).

Occurrence frequency (O), Detection probability (D), Severity of failure (S) are three variables utilized to identify risk degree for each potential failure. For variables O, S and D, a numbering from 1 to 10 is estimated. This constructs a unique O, S and D variable for each failure mode. As the Occurence variable approaches 10, the chance of occurrence of the identified hazard increases. As the Severity variable approaches 10, the seriousness of the situations to the consumer increases. As the detection variable approaches 10, the likelihood of detecting the hazard before it occurs is near impossible. RPN is the result of multiplying the determined values of variables S, O and D with each other. A RPN value greater than 100 indicates that there is a potential hazard. Therefore, corrective action is needed to reduce or eliminate this risk. After corrective actions are proposed for each potential failure mode, the efficiency of these interventions should be checked. For this purpose, RPN values are recalculated after corrective interventions. This supports understanding the impact of the proposed corrective interventions on improving the quality of the process (5, 42, 50). Corrective actions dramatically alter the likelihood and detection of identified hazards. In this way, RPN values fall below the safe

limit of 100. However, a reduction in the risk of contamination as a result of corrective intervention is very exceptional (47–49, 51).

Pareto diagrams are an important tool for determining which processing step is at risk or at extreme risk. Processing steps in traditional fermented beverage production with a cumulative RPN of 80 percent indicate excessive risk, while the other up to 100 percent indicate steps at risk (49).

Several controls are required to prevent before a potential hazard arises, eliminate hazard, or maintain a tolerable level of hazard in order to ensure product safety. The point where such controls are made is called the Critical Control Point (CCP). Therefore, the risk analysis by identifying CCP in the production stages of fermented beverages has helped us to determine the critical limits or product suitability criteria for each CCP (47, 48). In FMEA analysis, the risk of contamination and the determination of the existence of this risk in the end product is expressed by RPN.

$$RPN = [O \times S \times D]$$

O reflects probability Occurrence of the contaminated part.

S reflects the Severity of contamination risk.

D reflects the probability Detection of the contaminated part.

Risk Priority Number (RPN) is important data for the assessment of FMEA. It is used to determine the severity of possible errors. It is a value between 1 and 1000. As it approaches 1000, the risk increases and corrective action is essential. The risk priority number is recalculated after corrective action is implemented. Corrective actions should be developed and implemented until the RPN reaches the desired level (<100) (42, 51).

2.11. Food Composition Databases

Turkish National Food Composition Database (TürKomp) is the result of a research and development project started at 2008, lasting 5 years, supported by TUBITAK 1007 Program with “107G208” project number [64]. TürKomp contains the processed and unprocessed agricultural products, nutrient components and energy values produced and consumed in our country's geography. It includes thousands of food components and energy value data for various food components of foods from the 14 food group [64]. A system similar to Turkey was established for the same purpose in the United States of

America named as United States Department of Agriculture (USDA) Food Composition Database [65]. The data needed to calculate the nutritional compositions of traditional beverages are provided from these two systems.

3. MATERIAL AND METHOD

3.1. Production Processes of Turkish Traditional Fermented Beverages

3.1.1. Ekşi Ayran Production

Ayran is produced most part of the Turkey. There is a traditional method to produce ekşi ayran which is not common and little-known. To produce ekşi ayran, first the sheep's yogurt is added to the churning machine and mixed without stopping. Cold water is added by checking the churn occasionally. Churn fat on top is collected and washed in a separate container with 4 liters of cold water. If this fat is to be used later, can be stored in the refrigerator by mixing with 1 teaspoon of salt.

Water in churn and water in the fat washing container is mixed in an appropriate-size pot by adding half a lemon juice. It is provided to be curdling by boiling. The curd is removed by filtration. After filtration, the remaining water is usually stored in the bottle without salt and the mouth closed for 3 weeks to 3 months. Flow diagram for the production is given in Figure A. 1.

3.1.2. Çükündür Suyu Production

Çükündür suyu is often produced in Southeastern Anatolia and its surroundings. First, the beets are thinly peeled and chopped as mirepoix. It is filled into the wide-mouth jar. Dried peppers, molasses and salt are added. A hard dough is made by adding stale bread, salt and water into the flour. The dough is wrapped with a cloth pouch and put into the jar. Water is added. Ingredients are mixed and the mouth of the jar is closed tightly. It is stored in a warm place without sunshine for three weeks. Optionally, it can be consumed with or without grain. It is especially consumed as a cold or hot with pilaf. In many regions, white beets are called sugar beet and red ones called Çükündür. It can be also consumed as sherbet, pickle, molasses and dinner (52). Flow diagram for the production is given in Figure A. 2.

Rumor: It was believed in Southeastern Anatolia that the blood of those who drink çükündür suyu was cleared (52).

3.1.3. Gilaburu Production

Gilaburu juice is a traditional non-alcoholic fermented beverages. Main ingredients for the fermentation are European cranberry bush botanically known as

Viburnum opulus L. and water. In the Middle Anatolian territory of Turkey, European cranberry bush is known as gilaburu and particularly grown in Kayseri, Turkey (53, 54). It belongs to the Caprifoliaceae family. Shells, flowers, fruit and juice are widely used in various fields, especially in traditional medicine. Gilaburu is an edible or drinkable cluster of red fruits collected in autumn. (55). Sugar can be added to keep away from astringent taste and its juice is rich in ascorbic acid and L‑malic acid (54, 56). Gilaburu juice has been produced by a company originating from Kayseri as a commercial product (57).

For gilaburu production, the fruits are placed in water and stored in a dark place at 25 °C room temperature. Approximately 3 or 4 months are adequate for the fermentation. The fruits of gilaburu ripen after these processes. For the aim of obtaining juice of gilaburu ripened fruits are pressed. After that ratio of 1:4 dilution is provided by water and sugar is added to this solution before ready for drink (58).

Lactobacilli species such as *Lb. brevis, Lb. hordei, Lb. parabuchneri, Lb. harbinensis, Lb. plantarum, Lb. casei, Lb. paraplantarum, Lb. coryniformis, Lb. buchneri* and *Lb. pantheris* are LAB species that have been mostly identified in Gilaburu. Additionally *Leuconostoc mesenteroides* and *Leuconostoc pseudomesenteroides* are some of the observed species (54).

Karataş and Çöteli (2016) has conducted research about the vitamins A, E, β, carotene and lycopene content of red fruits cherry, strawberry, grapefruit, red grape, black grapes, blackberries, gilaburu. The amounts of lycopene, β-carotene and vitamins A, E were determined by high-performance-liquid-chromatography. They demonstrated that grapefruit, gilaburu, blackberry are respectively richest red fruits in terms of vitamin A, vitamin E, beta-carotene and lycopene (59). Thus, it may be said that gilaburu is consumed as a source of antioxidant to cope with oxidative stress. Flow diagram for the production is given in Figure A. 3.

3.1.4. Hardaliye Production

Hardaliye is often produced in Trakya region. First, grapes are washed with the stalk thoroughly. Barley and mustard are wrapped with a cloth pouch and put into the clay. Water is slowly added and during this step, tell the name of 7 carefree people who live in same place. It is believed in Trakya region that sherbet or pickle of carefree people will be delicious. Grapes rising upwards are pressed and closed the mouth of the clay with grape leaves by tying. It is dug 1 meter pit in the shade of a tree and embedded clay into

the soil. The storage (fermentation) duration of the hardaliye is 3 weeks. After 3 weeks, it is filtrated and stored cold with close-mouth container (60). Flow diagram for the production is given in Figure A. 4.

Rumor: When the hardaliye clay is removed from the soil and grape leaves are opened, if foam formation is observed it means that this Hardaliye is undrinkable and poured. It is referred that person who produces hardaliye has a bad thought. Hardaliye should be clear appearance and without foam. Oldest person in the family drinks first and others taste it according to their age. Every summer it is produced at least 10 times and said in Trakya region that it can be cure for diseases (60).

3.1.5. Hayva Şerbeti Production

Hayva şerbeti is often produced in Van and surroundings. First, quince is crushed with peel and kernel. Quince is boiled up to 1 hour in a copper pot. During this step, it should be stirred and foams should be removed. After saffron is added, it is removed from the stove and mixed for ten minutes with the help of wooden spoon. And then, the honey and vinegar is added into it and mixed. Finally, it is poured into the closed-mouth jar without filtration and stored in a cool place for 7 days. Then it is ready for serving with meal especially pilaf (61). Flow diagram for the production is given in Figure A. 5.

Rumor: It is said in Eastern Anatolia that the hayva şerbeti is good for nausea and strengthens the heart (61).

3.1.6. Kefir Production

Kefir, one of the most popular fermented dairy products in the world, has the potential to improve health through the microbial species responsible for its production (62).

There are lots of methods for production of kefir. Methods applied change according to tradition of territory where the production is occured. Russian researcher Koroleva demonstrated that two types of kefir starter is used (63). First starter is prepared by fermenting milk with kefir grains. Second starter is prepared by fermenting milk with first starter. The starter is prepared in a vessel with the help of stirrer. In summer, milk is pasteurized and then cooled to 18 °C, but in winter it should be 22 °C. The milk is inoculated with 2-3% of the starter I. After 18 hours fermentation, starter ripens during the slow cooling to 8 °C over 12-24 hours. 1-3% of starter I or 3-5% of starter II is added

to the new supply of pasteurised milk to make kefir. Fermantation lasts approximately 8-12 hours. Slow cooling procedure is applied to fermented milk during 10-12 hours to 8-10 °C before distribution to the retailers. Ripening gives specific taste and aroma to the compound. Packaging is completed and stored at 4-5 °C. Kefir made from starter I has specific taste and aroma (63). Thus, starter I advised in kefir production to the manufacturer even on a industrial scale. However, some researchers have demonstrated that kefir grains have to be used for the production of traditional kefir (64).

Dertli and Çon (2017) examined four different kefir grains collected from diverse sections of Turkey. They demonstrated that all kefir grains include significant level of *Lactobacillus kefiranofaciens*. *Pseudomonas spp., Acinetobacter, Enterococcus* and *Enterobacter* are mostly observed species in traditional kefir grains. Yeast species mainly Dipodascaceae family constituted the fungal microflora of kefir grains. Although, *Saccharomyces cerevisiae* was dominantly identified in all four kefir grains, *Rhodotorula, Kazachstania, Issatchenkia* and *Candida* were additional identified yeast species of some kefir grains (62). Flow diagram for the production is given in Figure A. 6.

3.1.7. Mişmiş Şerbeti Production

Mişmiş şerbeti is often produced in Malatya and surroundings. First, the apricot kernels are removed. Apricots is aligned on a tray that the inner part of apricots to be upward facing. Sugar is sprinkled to the kernel place of the apricots. Apricots are kept in the sun for about 2 days. The remaining sugar is boiled in water for 5 minutes. This sugary water is poured on apricots kept in the sun. After waiting for 1 day, apricots are observed to be enhanced with water. They are thoroughly kneaded and filtered through the cheesecloth. They are placed in bottles and their mouths are closed. Bottles are stored in the sun about 5 days. It should be consumed as cold. Generally it is consumed with two centimeters of snow from the bottom of the glass (65). Flow diagram for the production is given in Figure A. 7.

Rumor: It is said in Malatya region that this beverage is generally served for an important guests. Because it was a special taste, it could not be placed in front of every person (65).

3.1.8. Şalgam Suyu Production

Şalgam suyu is often produced in Çukurova, Hatay and surroundings. First, 130 mL of water with 5 g of salt is added to the bulgur flour and prepared a hard dough. After

kneading, it is wrapped in a cheesecloth and stored for 3 days at room temperature. Meanwhile, turnips are peeled and chopped. Chopped turnips are salted and mixed with water. And then previously prepared bulgur flour yeast is added into the mixture. It is kept closed-mouth for 3 days in this way. Subsequently carrots are peeled and chopped. They are added into the same ceramic cube with hot pepper optionally. After the mouth is tightly closed, ceramic cube is stored for 1 month at room temperature. Finally, the bulgur flour wrapped with cheesecloth is removed from the ceramic cube. Şalgam suyu is ready to consume cold. Flow diagram for the production is given in Figure A. 8.

3.1.9. Töngel Şerbeti Production

Töngel şerbeti is often produced in Giresun, Bahçeliköy, Karabıyık village and surroundings. Medlars are washed by removing the head parts in a wooden bucket. Barleys are sprinkled into the medlars. Honey is added, the mouth of the wooden bucket is closed to protect from bees. It is stored for 2 days. After waiting 2 days, 1 liter water is added into wooden and kneaded like a dough. It is kept for one day as an open-mouthed. Next day remaining water is added, mixed and filtrated with the help of cheesecloth. Töngel şerbeti is stored in a closed wooden külek in a cool place. A little amount of hazelnuts can be placed on cup while consuming. Most known names of töngel are respectively döngel, muşmula and beşbıyık. Black Sea and Marmara are the most consumed regions for töngel and its molasses (66). Flow diagram for the production is given in Figure A. 9.

Rumor: It is said in North Anatolia that bride and groom consume töngel şerbeti from same glass to increase their sexual performance during the nuptial night (66).

3.1.10. Tükenmez Production

Tükenmez is often produced in and around the Marmara region. First, fruits are chopped into a 30-liter cube without peeling. Barley and juniper seeds are wrapped in a cloth pouch and placed at the bottom of the cube. Chopped quince, apples and pears are stacked on the floor. Sprinkle a handful of the medlar between each layer. This process is continued until all the fruits are finished. Then put water on it and the mouth of the cube is not covered, wrapped with a cloth. After this process, the cube is put into the jute sack and placed in a cool ground of the garden. It is stored in a closed-mouth position for almost one month. The holding time is arbitrary, but it should be kept without moving. As the fermentation time increases, the amount of acidity and tartness increases. After

this process, cloth pouch wrapped with the barley and juniper seed is removed. There is a hole of 1 centimeter in diameter, 5 centimeters high at the bottom of the cube closed with licorice stopper. It is ready for drinking whenever remove the licorice stopper. Sugar can be added into the tükenmez for children. The part of the pulp is treated as bakery (67). Flow diagram for the production is given in Figure A. 10.

Rumor: When drinking 1 cup, one or more cup of water is added. Therefore, it is said that the name is Tükenmez. This process can be applied until the taste is broken (67).

3.2. FMEA Methodology

FMEA tables were tables that assess hazardous constituents and also include RPN values. The maximum value for RPN was 1000 by multiplying the highest possible O, S, and D values. 100 was 10% of this value and provides 90% statistical confidence. The analysis was based on studies on similar foods in the literature. The Pareto diagrams created according to the methods proposed by Arvanitoyannis and Savelides (2007) were utilized to visualize the percentage of the contribution of the RPN of each process step to the total RPN of the process before and after the application of corrective interventions (42).

Process flow charts including materials and methods for the production of each traditional fermented beverages were developed. Critical points (also Potential Failure Modes) were marked in these flow charts. Critical points were determined according to the risks that may occur due to internal and external sources were defined numerically. Potential hazards and sources were identified for each failure mode. The hazards/failures were classified as biological (B), chemical (C) and physical (P) respectively (5, 51).

Rank	Occurrence probability
1	Negligible (1 in 1 500 000)
2	Low (1 in 150 000)
3	Low (1 in 15 000)
4	Possible (1 in 2000)
5	Possible (1 in 400)
6	Possible (1 in 80)
7	Very possible (1 in 20)
8	Very possible (1 in 8)
9	Certain (1 in 3)
10	Certain (>1 in 2)

Rank	Severity
1	None
2	Very minor
3	Minor
4	Very low
5	Low
6	Medium importance
7	Important
8	Very important
9	Hazardous
10	Severe

Rank	Detection probability
1	Certain detection
2	Very high detection probability
3	High detection probability
4	Quite high detection probability
5	Possible detection
6	Low detection probability
7	Very low detection probability
8	Particularly low detection probability
9	Almost impossible detection
10	Impossible detection

3.3. Nutritional Values of Turkish Traditional Fermented Beverages

The quantities of each raw materials included in the standard recipes of beverages were determined. These raw materials were searched in USDA and TÜRKOMP food composition databases. The amount of macro and micro elements in 100 mL of raw materials were obtained from these databases. Ratio calculations were made with Microsoft Office Excel Program. During the calculations, 1 portion of each beverages was determined as 200 mL. The amounts of common macro and micro elements [Water (g), CHO (g), Total Dietary Fiber (g), Calcium (mg), Sodium (mg), Potassium (mg), Phosphorus (mg), Magnesium (mg), Vitamin C (mg), Vitamin D (IU), Isoleucine (mg), Leucine (mg), Valine (mg), Niacin (mg)] found in 1 portion of each beverages were demonstrated in nutritional value tables (Appendix D: Nutrional Value Tables).

4. RESULTS AND DISCUSSION

4.1. Ekşi Ayran

Water supply is the common stage for all fermented beverages except kefir because it is the main ingredient for almost all traditional beverages. It also carry the greatest risk for all traditional beverages except kefir. Water supply is the first highest failure mode with the RPN value of 1569 and 17.60% of total RPN (Table C. 1). Water may contain and convey several pathogenic microorganisms such as *Cryptosporidium parvum, Salmonella spp., Cyclospora cayetanensis, Vibrio cholera, Hepatitis A, Escherichia coli, Shigella spp., Toxoplasma gondii, Giardia lamblia* and *Norwalk* viruses. It can be also carriers of parasites. These are all biological hazards for water. There are also chemical hazards which can be dangerous for human health that chemical substances such as benzene, bromate RPN=224, nitrate or fertilisers containing nitrate (RPN=168), heavy metal residues such as lead, antimony, arsenic (RPN=288), high chlorine concentration (RPN=126), and pesticide contamination through soil erosion (RPN=189). To decrease the risk stems from these failures, potable water from the local authority must be used and regular laboratory tests must be implemented. Chlorine (chemical agent), ozone or Ultra Violet based systems should be applied to water for microbiological treatment (Appendix B: FMEA Tables).

Bottling is the second highest RPN value of 1358 and 15.23% of total RPN. Biological contamination due to the insufficient cleaning of the bottle by manual cleaning (38, 68) (RPN=288), improper sealing/closing of bottle (RPN=320), incorrect handling of personnel during food processing (RPN=336). Improper practices of staff leads to physical hazards (RPN=120). Nerín et al. (2016) have demonstrated that metal and glass cleaner products can leave dangerous and unsafe residues on food (68). The use of disinfectants in quantities above the permissible values is likely to result in residues on foods. It is important to confirm the compatibility of such substances with food contact through legislation (68).

To decrease the risk stems from these failures most important thing to do is that training of staff. Especially hand washing procedure must be taught in the full sense. Food processors handling with food must be required to wear bonnet, gloves and arm sleeve covers. Equipments used during process has to be provided from reliable vendor (38) (Table B. 1).

Receiving lemon is the third highest RPN value of 1168 and 13.10% of total RPN. Aneja et al. (2014) proposed that molds such as *Penicillium sp., Aspergillus sp.* bacteria such as *Acetobacter, Alicyclobacillus, Bacillus* and yeasts such as *Saccharomyces, Pichia, Candida* (RPN=288) can be found in lemon as a biological hazards (69). Mycotoxins produced by molds such as citrinin (*Penicillium citrinum*), byssochlamic acid (*Byssochlamys fulva*), ochratoxin (*Aspergillus carbonarius*) and patulin (*B. nivea*) (RPN=288) are the failures described as chemical hazards (70, 71). To decrease the risk stems from these failures lemon vendor must be reliable. Water activity and pH of lemon regularly be checked. It can be prepared guidelines to prevent possible food poisoning and found natural antimicrobials of plant origin that control pathogen microorganisms and spoilage (Table B. 1).

Total RPN value for ekşi ayran production is calculated as 8915. After implementation of corrective actions mentioned above RPN decreased to the 1862. Thus, 79.1% improvement is achieved (Appendix C: Pareto Tables and Diagrams). Nutritional values of ekşi ayran is given in Table D. 1.

4.2. Çükündür Suyu

Water supply mentioned before is again the first highest failure mode with the RPN value of 1569 and 15.32% of total RPN. Receiving barley flour second highest failure mode with the RPN value of 1242 and 12.13% of total RPN (Table C. 2). *Alternaria, Fusarium, Aspergillus, Penicillium* are the toxigenic genera for the barley flour defined as biological hazard (72, 73) (RPN=270). They can be very dangerous for human health via their seconder metabolites. Environmental situations throughout growth term of the crop and poor storage conditions during the postharvest period leads to formation of mycotoxins by molds defined as chemical hazard such as Deoxynivalenol/nivalenol, Ochratoxin A, Zearalenone (RPN=216) (74). Another chemical hazard for barley flour is pesticide contamination. Pesticide residues can accumulate due to the excessive use of insecticides like organophosphorous and fungicides like triazoles (RPN=270). To eliminate the biological and chemical failure modes barley must be purchased from reliable vendors. The purchased product must have a quality certificates. Moisture content of grains must be reported in these certificates. Defective portion must be rejected. In addition, Stejskal and Aulicky (2014) constructed a study at the Czech Republic on barley grain kept in silos and demonstrated that rodents lead to chemical and physical hazards due to their urinary aeroallergens (RPN=270) and via hairs, urine and faeces (RPN=216)

(75). In order to eliminate the risks from rodents, an Integrated Pest Management (IPM) program that uses feed and traps as well as accurate monitoring methods must be used (Table B. 2).

Peeling and cutting is another one of highest RPN value of 1080 and 10.55% of total RPN. During this process personnel hygiene is the most important issue. Lack of personal hygiene and inappropriate hygiene practices lead to biological hazard that can threat the human health (RPN=216). Incorrect handling of personnel during food processing is also the significant failure may lead to biological contamination and poisoning (RPN=336). Personnel education on personnel hygiene and proper washing of hands is essential to eliminate these potential risks and produce safe food. Cross-contamination as a result of poor manual cleaning and storage of kitchen equipment used for stirring is also another significant failure mode during cutting process (RPN=288).

Cortese et al. (2016) carried out study on vendors of street food production in Brazil. Interviews revealed that 33% of food handler never washed their hands, 24% solely utilized water for washing their hands; 33% never attended the necessary food processing program. (76). This work demonstrates the necessity to improve environmental conditions in these regions to inhibit foodborne diseases same as in current study. Certain local and national rules and regulations have to be established for consumer protection for food and beverages and continuous training of food personnel.

To eliminate the risk stems from cross-contamination personnel hygiene important as mentioned before. It is also important to disinfect equipments in a regular way and provide proper storage conditions. Cutting boards and knives must be color-coded, so different utensils and cutting will be used when preparing cooked and raw food simultaneously (Table B. 2).

Total RPN value for çükündür suyu production is calculated as 10240. After implementation of corrective actions mentioned above RPN decreased to the 2015. Thus, 80.3% improvement is achieved (Appendix C: Pareto Tables and Diagrams). Nutritional values of çükündür suyu is given in Table D. 2.

4.3. Gilaburu

Water supply mentioned before is again the first highest failure mode with the RPN value of 1569 and 21.72% of total RPN. Manual bottling is the second highest RPN value

of 1358 and 18.80% of total RPN. Manual bottling process is an important stage. Similar to gilaburu, 15.23% of total RPN comes from manual bottling in the ekşi ayran production (Table C. 3).

Pressing by hand is another one of highest RPN value of 776 and 10.74% of total RPN. During this process personnel hygiene is the most important issue. Lack of personal hygiene and inappropriate hygiene practices lead to biological hazard that can threat the human health via food poisoning (5, 77, 78) (RPN=392). Personnel education on personnel hygiene and proper washing of hands is essential to eliminate these potential risks and produce safe food. Contamination from hair, nail and jewelleries of staff are the physical hazards interfere food via improper practices of staff during process (79, 80) (RPN=120). Foreign objects such as dust and sand which transferred by air and insect fragments are another physical failure during pressing by hand (RPN=48) (Table B. 3).

Aguiar et al. (2018) were conducted a study between 2012 and 2016 on dairy products to determine the incidence of physical hazards. It was examined through website utilized by Brazilian consumers. They proposed that physical hazards ordered from small to large were 1.8% fabric, 6.2% metal, 11.1% plastics, 15.2% hair, 23.3% insects, 42.4% foreign objects (81). Risks from this failure can be eliminated by food handlers thanks to usage of bonnets, gloves and arm sleeve covers.

In addition, filling into the plastic drums can be more dangerous with the RPN value of 855 and 11.84% of total RPN because of endocrine-disrupting chemicals derived from plastic food containers such as styrene, bisphenol A and phthalate (RPN=324). These compounds commonly found in food have been associated with the human health problems including testicular dysgenesis, premature breast development, recurrent miscarriage and infertility (82). Thus, it can be thought that using glass containers during this stage can be healthier than plastic containers to eliminate riks (Table B. 3).

Total RPN value for gilaburu production is calculated as 7224. After implementation of corrective actions mentioned above RPN decreased to the 1686. Thus, 76.7% improvement is achieved (Appendix C: Pareto Tables and Diagrams). Nutritional values of gilaburu is given in Table D. 3.

4.4. Hardaliye

Water supply mentioned before is again the first highest failure mode with the RPN value of 1569 and 15.12% of total RPN. Similar to the all other beverages, manual bottling is a stage that has a higher possible risk with the RPN value of 1358 and 13.08% of total RPN (Table C. 4).

Storage for 3 weeks stage is another one of highest RPN value of 948 and 9.13% of total RPN. Fermentation of hardaliye is occurred under the soil in the traditional production method. Therefore, this poses some important risks in terms of biological and chemical safety. Improper storage conditions and storage temperature may lead to microbiological contamination (83, 84) (RPN=252). Mold growth may occur due to fluctuation of humidity (RPN=162). Mycotoxins such as Byssoclamic acid, Citrinin, Patulin, Ochratoxin A can be produced via uncontrolled growth of fungus during fermentation (85, 86) (RPN=294). To minimize these risks adequate facilities need to be provided for hygienic storage and calibration of thermometers / probes used for temperature measurements have to be checked regularly (Table B. 4) (83–85).

In addition, receiving grape has one of the highest RPN value of 804 and 7.75% of total RPN. Damaged grapes are significant vehicles of dangerous spoilage microorganisms. Dangerous yeast *Aspergillus carbonarius* and *Aspergillus niger* can be found in grapes and may lead to formation of toxic seconder metabolites (87–89) (RPN=189). There are also chemical failures such as presence of Ochratoxin A and fungicide residues like Sulphur dioxide on the grapes (88, 90) (RPN=189). To eliminate these possible risks, contaminated portion of the grapes must be rejected, optimization of the storage conditions (0-2 °C) provided and humidity checked regularly. Certified products from reliable vendors have to be used. The contaminated parts have to be removed. Storage conditions have to be held at an optimal degree (Table B. 4).

Total RPN value for hardaliye production is calculated as 10379. After implementation of corrective actions mentioned above RPN decreased to the 2020. Thus, 80.5% improvement is achieved (Appendix C: Pareto Tables and Diagrams). Nutritional values of hardaliye is given in Table D. 4.

4.5. Hayva Şerbeti

Water supply mentioned before is again the first highest failure mode with the RPN value of 1569 and 18.10% of total RPN. Receiving honey is the second highest failure

mode with the RPN value of 1317 and 15.20% of total RPN (Table C. 5). *Bacillus genus, Clostridium botulinum* are spore-forming bacterias can find in honey due to inappropriate storage conditions (RPN=300). Especially, *Clostridium botulinum* as a neurotoxin-forming bacteria may paralyze the neurons in human via food intoxication (91, 92). Antibiotics, pesticides, herbicides and metal contamination such as copper (Cu), cobalt (Co) and nickel (Ni) are the food contaminants described as chemical that can be found in the honey (RPN=270) (91, 92).

Bauer et al. (1996) demonstrated that allergen proteins derived from the proteins secreted by the bees responsible for honey allergy (93) can also cause the chemical contamination of honey (RPN=216). In addition, Islam et al. (2013) mentioned that phytotoxins like pyrrolizidine alkaloids, GTXs, hyoscyamine, hyoscine, saponin, strychnine and chemical formation of 5- hydroxymethylfurfural (HMF) during the heating or preservation processes are the chemical hazards in the honey (91) (RPN=270, RPN=216 respectively). To eliminate these risks needed to the corrective action by government and also food handler: Health authorities should establish regulations that guarantee and control the production, processing and analysis of honey. The safety of honeys must be verified with correct analysis and labeled. Degree of heat exposed to the honey have to be under control during the food processes (Table B. 5).

Total RPN value for hayva şerbeti production is calculated as 8667. After implementation of corrective actions mentioned above RPN decreased to the 1762. Thus, 79.7% improvement is achieved (Appendix C: Pareto Tables and Diagrams). Nutritional values of hayva şerbeti is given in Table D. 5.

4.6. Kefir

Raw milk is the first highest failure mode for the kefir production with the RPN value of 2823 and 41.05% of total RPN. Manual bottling mentioned before in ekşi ayran production is the second highest failure mode with the RPN value of 1358 and 19.75% of total RPN (Table C. 6). This risk priority is similar to other beverages wich ekşi ayran and gilaburu.

Raw milk supply carries a high degree of biological risks. High number of pathogens generally *E.coli O157:H7, Mycobacterium tuberculosis, Shigella dysenteria, Salmonella spp*. can be grow in milk stem from inappropriate handling during the process and storage (5) (RPN=720). Mastitis disease of bovine can contaminate raw milk with enterotoxin

producing *S. Aureus* (RPN=200). Joffe and Baranovičs (2006) conducted a study and examined samples of raw milk of bovine mastitis from Latvian farms. They found that the enterotoxin producing *S. aureus* in milk of bovine mastitis existing in 77.3% of samples examined.

It can be also occurred parasitic contamination such as *Cryptosporidium spp., Protozoa* in milk due to the unhealthy animal sources (RPN=192). In addition to the biological hazards in milk there are also chemical hazards: Veterinary drug residues stem from inappropriate veterinary practices (RPN=392), environmental contaminants such as primarily dioxin and dioxin-like compounds (RPN=392), high amount of aflatoxin M_1 in milk which stems from inappropriate agricultural practices and contaminated feed using in cattle farms (RPN=360), pesticide contamination caused by organophosphorus and carbamates residues in milk and food provided for cattle (RPN=192) (5, 94, 95) To eliminate these hazards, milk vendor must be reliable. Precautions must be taken to prevent breakage of the cold chain from farm to receiving. Microbiological analysis, drug and pesticide residue controls must be done regularly. Veterinary controls in cattle farms must be done periodically (Table B. 6).

Storage in refrigerator is another higher risky stage with the RPN value of 615 and 8.94% of total RPN. Inappropriate storage conditions and excessive storage time may cause pathogen growth (RPN=300). Cross contamination is also the risk of biological contamination (RPN=270). Food personnel has to be trained in food safety. Process control should be carried to computer as much as possible. Maintenance and control of the thermometer and probe have to be performed regularly. Foods must be properly placed in the refrigerator to eliminate cross-contamination. Storing in sealed containers provides high protection against physical hazards (Table B. 6).

Total RPN value for kefir production is calculated as 6877. After implementation of corrective action mentioned above RPN decreased to the 1168. Thus, 83.02% improvement is achieved (Appendix C: Pareto Tables and Diagrams). Nutritional values of kefir is given in Table D. 6.

4.7. Mişmiş Şerbeti

Water supply mentioned before is again the first highest failure mode with the RPN value of 1569 and 16.85% of total RPN. Similar to the almost all other beverages, manual

bottling is a stage that has a higher possible risk with the RPN value of 1358 and 14.58% of total RPN (Table C. 7).

Kneading is one of the highest failure modes for the mişmiş şerbeti production with the RPN value of 968 and 10.39% of total RPN. Since it is a manual process, great importance should be given to personnel hygiene. Lack of personal hygiene and inappropriate hygiene practices can cause microbiological contamination (RPN=392). Coutts et al. (2014) conducted a study to investigate an outbreak of norovirus occurred among customers of a restaurant in Melbourne, Australia (96). They found that the outbreak was possibly reasoned by person-to-food-to-person transmission (96). It is revealed that staff was not always wore gloves during the mixing and hand-washing facilities were limited in food preparation areas not supplied with even soap (96).

Foreign materials from the kneading box due to improper cleaning and hair, nail, jewelleries from the staff because of inappropriate implementations throughout process are the source of physical hazards (RPN=120). At this point, the largest share should be allocated to personnel training to minimize food hazards. Especially hand washing procedure must be taught in the full sense. Food processors handling with food must be required to wear bonnet, gloves and arm sleeve covers. A control mechanism should be established for the personnel. Equipments used during process has to be provided from reliable vendor (Table B. 7).

Receiving apricot is another one of the highest failure modes for the mişmiş şerbeti production with the RPN value of 963 and 10.34% of total RPN. *Penicillium Expansum* mold and postharvest appricot pathogens like *A. alternata, R. nigricans and T. Roseum* poses biological hazard (RPN=216, RPN=162 respectively). Patulin, Ochratoxin A, Aflatoxin are the seconder metabolites of this microbiological hazards and they can contaminate apricot fruit chemically (RPN=270).

Bakırcı et al. (2014) conducted a study with the aim of investigating fruits and vegetables growing in Aegean region of Turkey in terms of pesticide residues (97). They found that chlorpyriphos, carbendazim and acetamiprid were the most identified pesticide residues (97) (RPN=270). Researchers have made some recommendations to decrease exposure by reducing pesticide residues in food. Controlled sale of pesticides, promotion of organic agriculture, implementation of IPM system and training of agricultural personnel are of great importance in this regard (97). Certified products from reliable

vendors have to be used. The contaminated parts have to be removed. Storage conditions have to be held at an optimal degree. Humidity needs to be checked. Effective washing procedure must be implemented. Low doses of UV-C (below 280 nm), chitosans, propolis, and glucosinolates shoul be used to induce resistance against pathogens in harvested fruits. Thus, hazards from apricot will be eliminated in mişmiş şerbeti production (Table B. 7).

Total RPN value for mişmiş şerbeti production is calculated as 9314. After implementation of corrective action mentioned above RPN decreased to the 1630. Thus, 82.5% improvement is achieved (Appendix C: Pareto Tables and Diagrams). Nutritional values of mişmiş şerbeti is given in Table D. 7.

4.8. Şalgam Suyu

Water supply mentioned before is again the first highest failure mode with the RPN value of 1569 and 13.21% of total RPN. Receiving carrot is the second highest failure mode with the RPN value of 1395 and 11.74% of total RPN. *L. Monocytogenes, E. coli,* and *Salmonella spp.* from irrigation water and manure can contaminate carrots (98) (RPN=288). There is also another biological hazard for carrot which comes from zoonotic parasite geohelminth eggs such as *Toxocara spp.* (99) (RPN=270). In addition, using contaminated soil (RPN=252), pesticide contamination such as acetamiprid, chlorpyriphos and carbendazim (RPN=270) and environmental pollution due to the Cu, Mo and Se (RPN=270) classified as chemical hazards for carrot cultivation.

Kandic et al. (2019) designed a study to determine related factors with urban metal contamination in vegetable garden soils in Australia. The results of the study demonstrated that vegetable gardens with high Pb and Cd were more likely to be found in adjacent, older houses, painted and closer to arterial roads with high frequency traffic houses (100).

Hygiene practices during selling, processing and consuming food must be encouraged to eliminate the potential hazards from vegetables. The government should improve the oversight and supervision of the activities of vegetable vendors. The soil protection requirements for the application of liquid manure, sewage sludge and fertilizers must be updated. Advising on needs based use of fertilizers and pesticides must be considered. Financial incentives has to be created to minimize them. Critical loads must be determined by government (Table B. 8).

Peeling and cutting stage mentioned before in çüküdür suyu production compose of 9.09% of total RPN in şalgam suyu production parallel to the çüküdür suyu and tükenmez production in terms of risk priority (Table C. 8).

Receiving dried pepper is also another one of the highest failure modes with the RPN value of 1008 and 8.48% of total RPN. *Aspergillus ochraceus, A. niger, A. flavus* and *A. fumigatus* are fungi that can be grow in pepper and contaminate it (101) (RPN=378). Mycotoxins OTA and mainly Aflatoxin B_1 may contaminate pepper chemically as a seconder metabolites of fungi (101, 102) (RPN=315).

Set and Erkmen (2010) conducted a study on red pepper retailed in Turkey to identify aflatoxin contamination (103). Mold and yeast count in unpacked red pepper were detected over the legal limits. The highest limits of red pepper content of AFT and AFB1 and the highest amount of aflatoxin were detected in red pepper. It is thought that inappropriate harvesting, unhealthy production techniques and unfavorable storage conditions and relative humidity may be caused (103).

Bakırcı et al. (2014) demonstrated that excessive accumulation of pesticide such as insecticide (organophosphorous) and fungicides (triazoles) in pepper can be toxic and harmful for human health (97) (RPN=270). Contamination which stems from physical environment due to the dust and impurities can also be physical hazard in pepper. To minimize or eliminate the potential risk, it can be taken precautions: After harvesting, the peppers should be washed thoroughly to remove dirt. Reliable vendor must be preferred when purchasing. Optimize the storage conditions and humidity of the environment needs to be checked. Before packaging and storage aflatoxin analysis must be done to determine the contamination levels of aflatoxins. In Turkey, 10 ppb total aflatoxin for red dried chili pepper is the permissible maximum legal limits (101) (Table B. 8).

Total RPN value for şalgam suyu production is calculated as 11881. After implementation of corrective action mentioned above RPN decreased to the 2269. Thus, 80.9% improvement is achieved (Appendix C: Pareto Tables and Diagrams). Nutritional values of şalgam suyu is given in Table D. 8.

4.9. Töngel Şerbeti

Water supply mentioned before is again the first highest failure mode with the RPN value of 1569 and 15.55% of total RPN. Similar to the hayva şerbeti production, receiving

honey is the second highest failure mode with the RPN value of 1371 and 13.59% of total RPN. Receiving barley as mentioned in çükündür suyu production is one of the highest RPN value of 1134 and 11.24% of total RPN. Kneading process has another high RPN value of 968 and 9.59% of total RPN as mentioned in mişmiş şerbeti production (Table C. 9).

Stirring is another one of the stages which has high failure mode with the RPN value of 723 and 7.16% of total RPN. Cross-contamination as a result of poor manual cleaning and storage of kitchen equipment used for stirring (76, 104–107) (RPN=288). Poor personal hygiene during stirring can cause pass microorganism from food handler to the product or mixture (RPN=216). Nerín et al. (2016) mentioned that equipment used for stirring may carry cleaning agent residues of quaternary ammonium compounds such as dodecyl-trimethyl-ammoniumchloride due to the improper rinsing (RPN=216) (68). Torn or damaged stirring tool, dust and sand transferred by air and insect fragments constitute possible physical hazards for production (RPN=48). Proper cleaning procedure for equipment used for stirring must be applied. Especially hand washing procedure must be taught in the full sense to the food handler. Food processors handling with food must be required to wear bonnet, gloves and arm sleeve covers. Equipments must be purchased from reliable vendor and periodically checked their hygiene and quality. Using food grade and edible surfactants allowed by FDA can be solving option for cleaning agent residues of quaternary ammonium compounds such as dodecyl-trimethyl-ammoniumchloride (68) (Table B. 9).

Total RPN value for töngel şerbeti production is calculated as 10091. After implementation of corrective action mentioned above RPN decreased to the 1868. Thus, 81.5% improvement is achieved (Appendix C: Pareto Tables and Diagrams). Nutritional values of töngel şerbeti is given in Table D. 9.

4.10. Tükenmez

Water supply mentioned before is again the first highest failure mode with the RPN value of 1569 and 16.50% of total RPN. Receiving barley as mentioned in çükündür suyu production is the second highest failure mode with the RPN value of 1134 and 11.93% of total RPN. Thus, it is parallel to the çükündür suyu and töngel şerbeti production in terms of higher-order failure mode. Cutting stage mentioned before in çükündür suyu production has another higher risk of failure with the RPN value of 1080 and 11.36% of

total RPN (Table C. 10). In addition, wrapping in cloth pouch has one of the highest RPN value of 906 and 9.53% of total RPN. Microorganisms *(Pseudomonas aeruginosa, Klebsiella aerogenes, Staphylococcus saprophyticus, E. coli) c*an pass from a poorly cleaned or contaminated cloth to hands (108) (RPN=225). Lack of personal hygiene and inappropriate hygiene practices can also cause microbiological contamination (RPN=216). The various pesticides are utilized in the processing phases of natural fabrics like cotton (storage) and they can pose the risks of chemical contamination (RPN=240). Iadaresta et al. (2018) conducted a study to evaluate the penetration and accumulation of pollutants in the skin after long contact with textile materials (109). The results show that benzothiazole can be released from textile materials, can pass through the skin, and then enter the human body (109). This suggests that the presence of textile contaminants may pose potential health risks. Thus, attention should be paid to the cloth pouch used for wrapping.

Foreign materials from the cloth pouch, dust and impurities from the physical environment, hair, nail, jewelleries from the staff because of inappropriate implementations throughout process are classified as physical hazards for production of tükenmez (RPN=60, 45, 120, respectively). To eliminate the risks from these hazards, reliable vendor for cloth pouch must be prefered. Food handlers has to be trained in protective equipment such as bonnets, gloves and arm sleeve covers, and regular control of their use should be ensured (Table B. 10).

Total RPN value for tükenmez production is calculated as 9507. After implementation of corrective action mentioned above RPN decreased to the 2066. Thus, 79.7% improvement is achieved (Appendix C: Pareto Tables and Diagrams). Nutritional values of tükenmez is given in Table D. 10.

5. CONCLUSION AND RECOMMENDATIONS

5.1. CONCLUSION

In the existing study, Occurrence frequency, Detection probability, Severity of failure were the three variables utilized to identify risk degree for each potential failure. For variables O, S and D, a numbering from 1 to 10 was estimated. This constructed a unique O, S and D variable for each failure mode. As the Occurence variable approaches 10, the chance of occurrence of the identified hazard increased. As the Severity variable approaches 10, the seriousness of the situations to the consumer increased. As the detection variable approaches 10, the likelihood of detecting the hazard before it occurs was near impossible. RPN was the result of multiplying the determined values of variables S, O and D with each other. A RPN value greater than 100 indicated that there was a potential hazard. Therefore, corrective action was needed to reduce or eliminate this risk. After corrective actions were proposed for each potential failure mode, the efficiency of these interventions should be checked. For this purpose, RPN values were recalculated after corrective interventions. Besides nutritional values of the beverages was calculated with the help of TürKomp and USDA.

In conclusion, Töngel şerbeti had the highest caloric value in 200 mL (1 portion) with 195.46 kcal while Şalgam suyu had the lowest caloric value with 34.32 kcal in a portion. The most carbohydrate-containing beverage was Hardaliye with 33.5 g. It was demonstrated that the majority of the risks related with the traditional production of 10 traditional fermented beverages stem from the supply of raw materials. Especially water supply was found to be the most significant danger. To avoid this reliable vendors must be preferred. This was followed by hazards from personnel involved in food production. As it can be understood from here, it is essential that the personnel in all stages of production has to be well trained. In the next row, hazards arising from the tools and equipment used during production were placed. Therefore, the durability and hygiene of the equipment must be kept under constant supervision. Approximately eighty percent improvement in risk priority numbers has been achieved after FMEA implementation. Therefore, it can be proposed that FMEA methodology is an effective approach for food quality management and food safety. It can be also applied to a traditional household food production.

5.2. RECOMMENDATIONS

In this study, FMEA method was applied to traditional production of 10 fermented beverages. In our country, it is of great importance in terms of bringing these disappearing beverages into the literature. It is thought that the establishment of FMEA groups of 4-6 people will increase the efficiency of both the study and the FMEA method. The inclusion of microbiologists and healthcare workers in addition to food engineers to members of the FMEA group will strengthen the data.

Besides, it is expected that the efficiency of the FMEA method will be further increased, as it focuses on a specific production rather than multiple productions. Nevertheless, this study is of great importance in terms of its contributions to the literature and guiding future studies.

In our country, there are many traditional foods and beverages produced in Anatolia even if not known by most of us. These non-standardized traditional productions can pose great threats to public health. In this respect, the statistical analysis methods used in the hazard analysis of FMEA studies should be further developed and supported by the government policies due to its contribution to the protection and improvement of public health.

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7. APPENDICES

Appendix A: Flow Diagrams

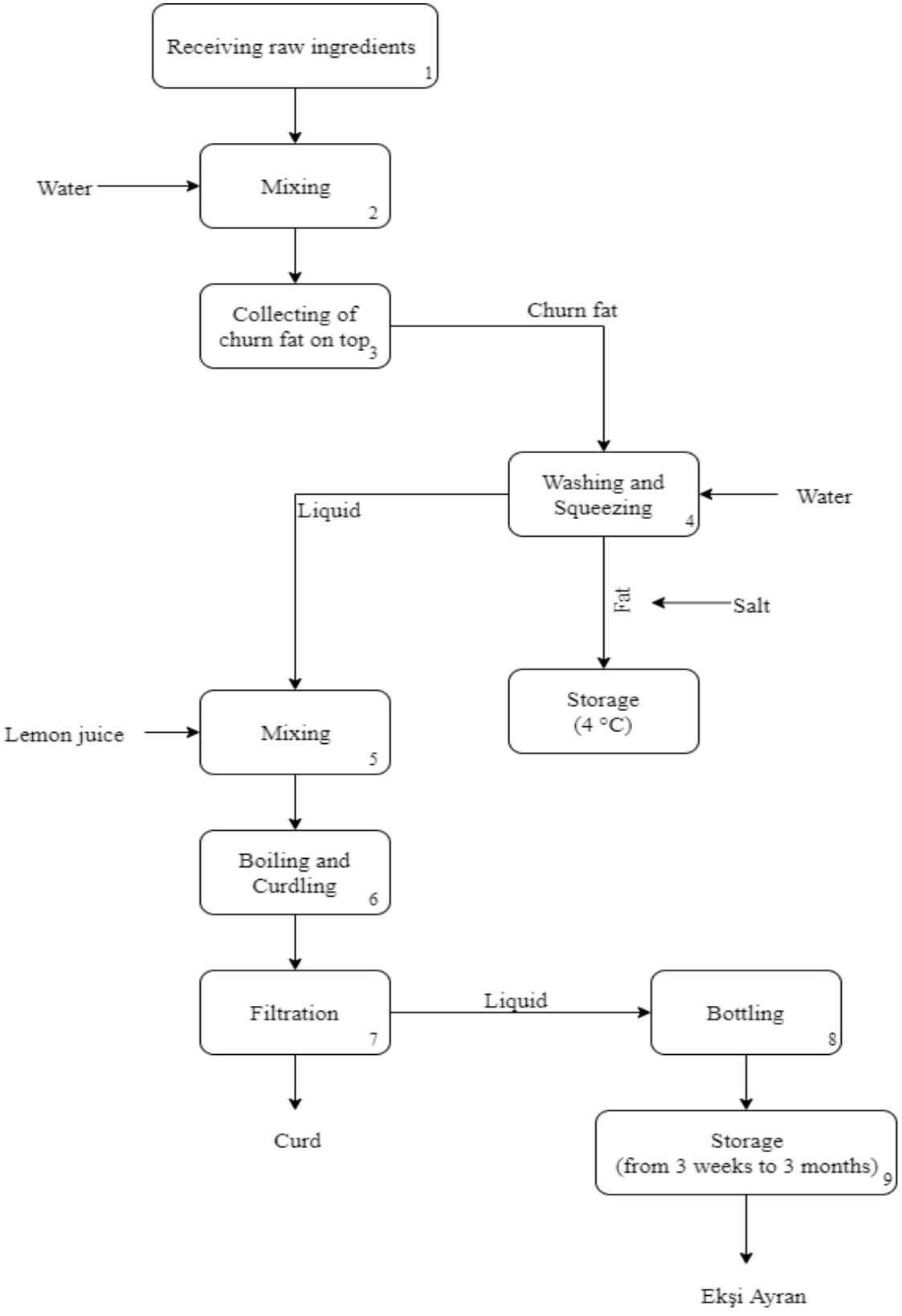

Figure A. 1. Ekşi Ayran production flow diagram

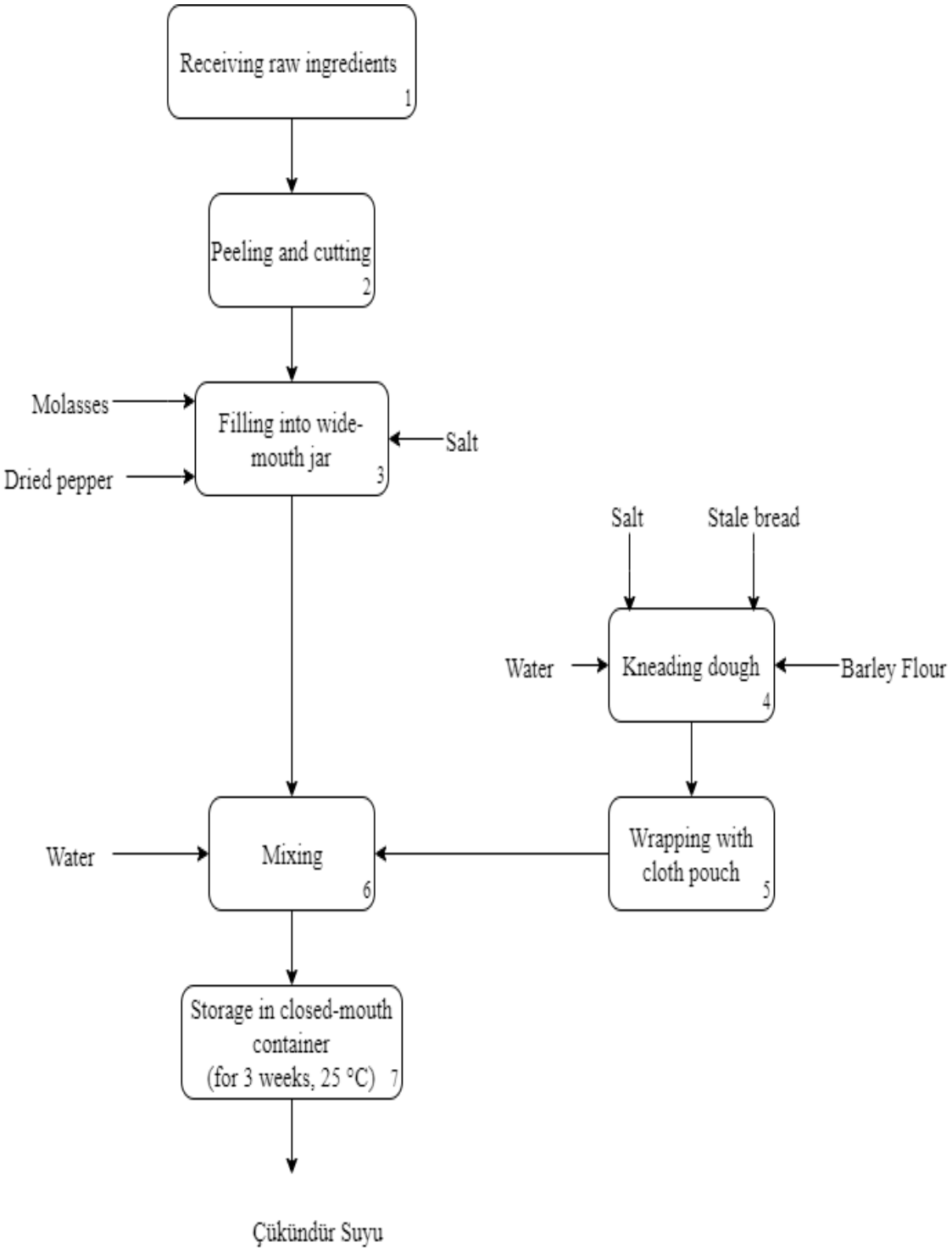

Figure A. 2. Çüküdür suyu production flow diagram

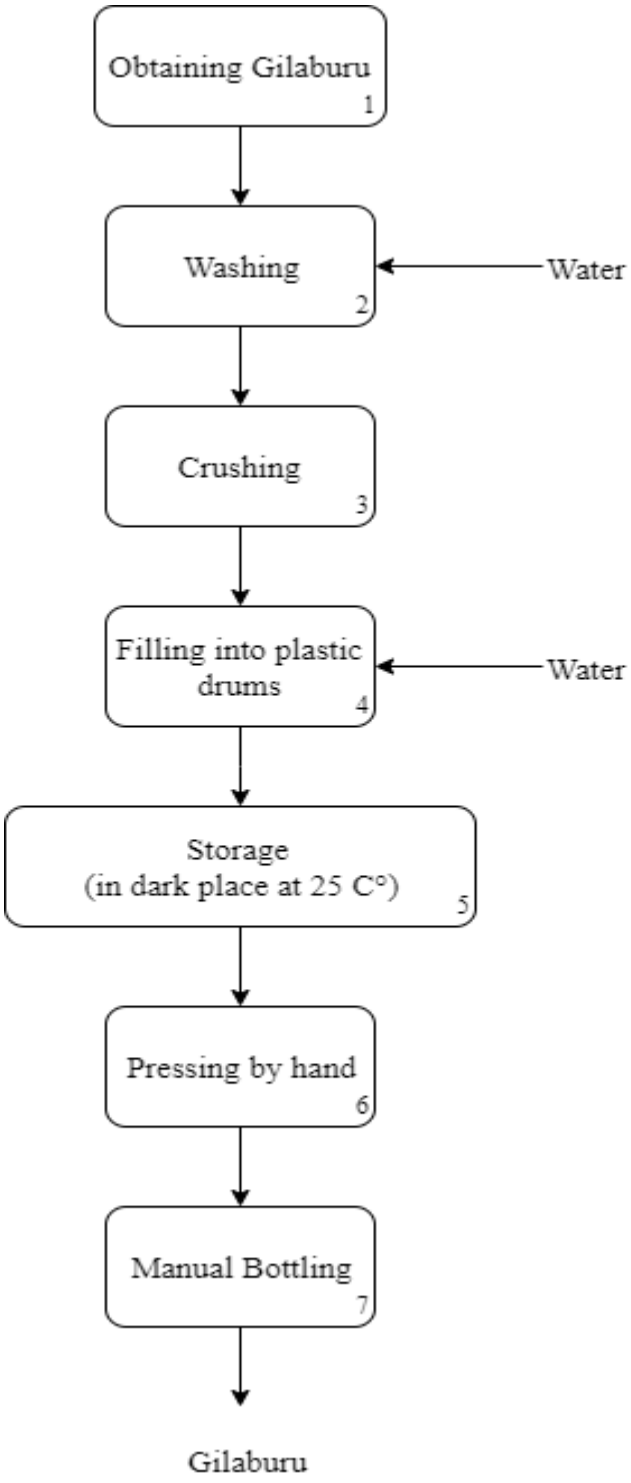

Figure A. 3. Gilaburu production flow diagram

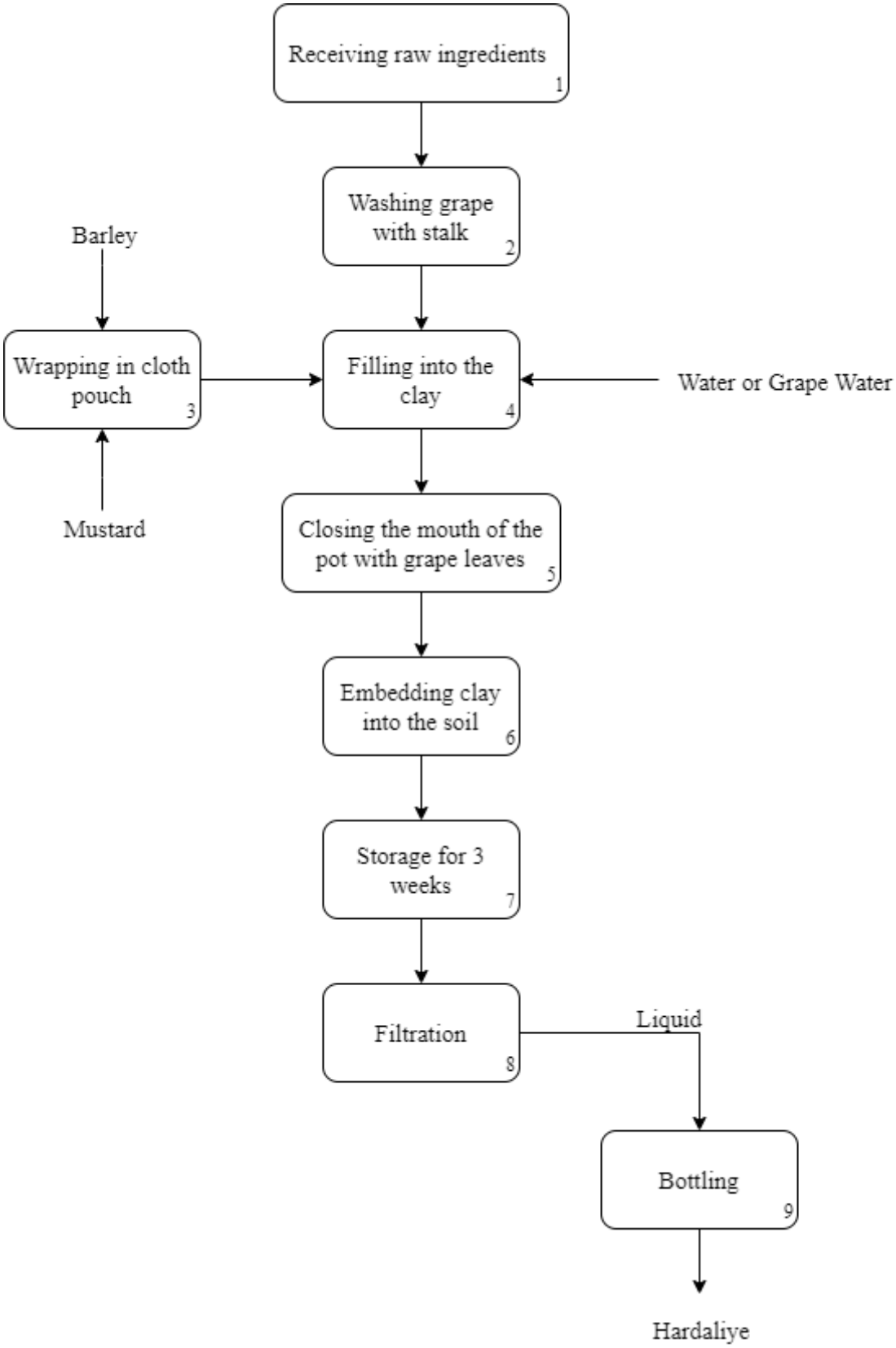

Figure A. 4. Hardaliye production flow diagram

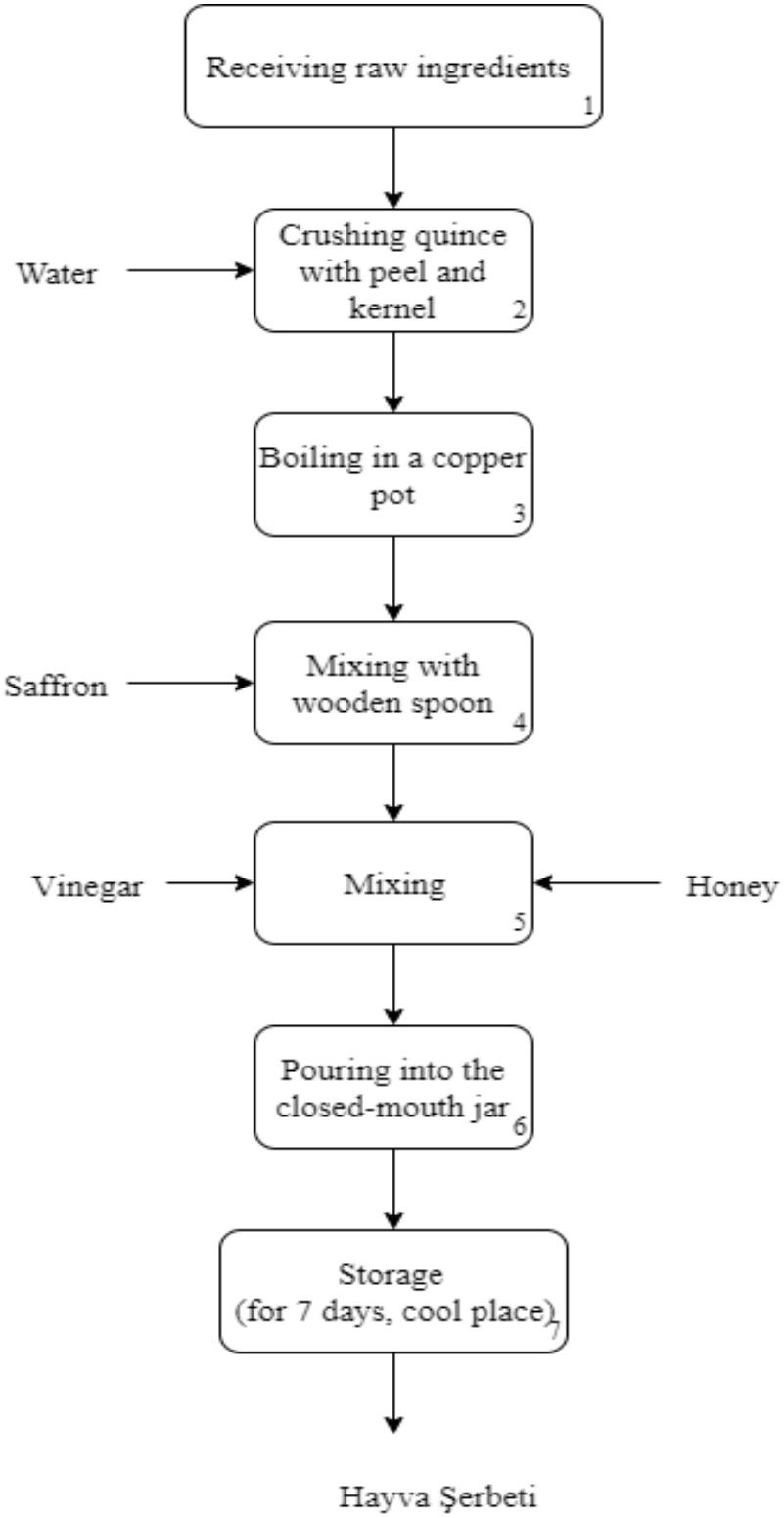

Figure A. 5. Hayva şerbeti production flow diagram

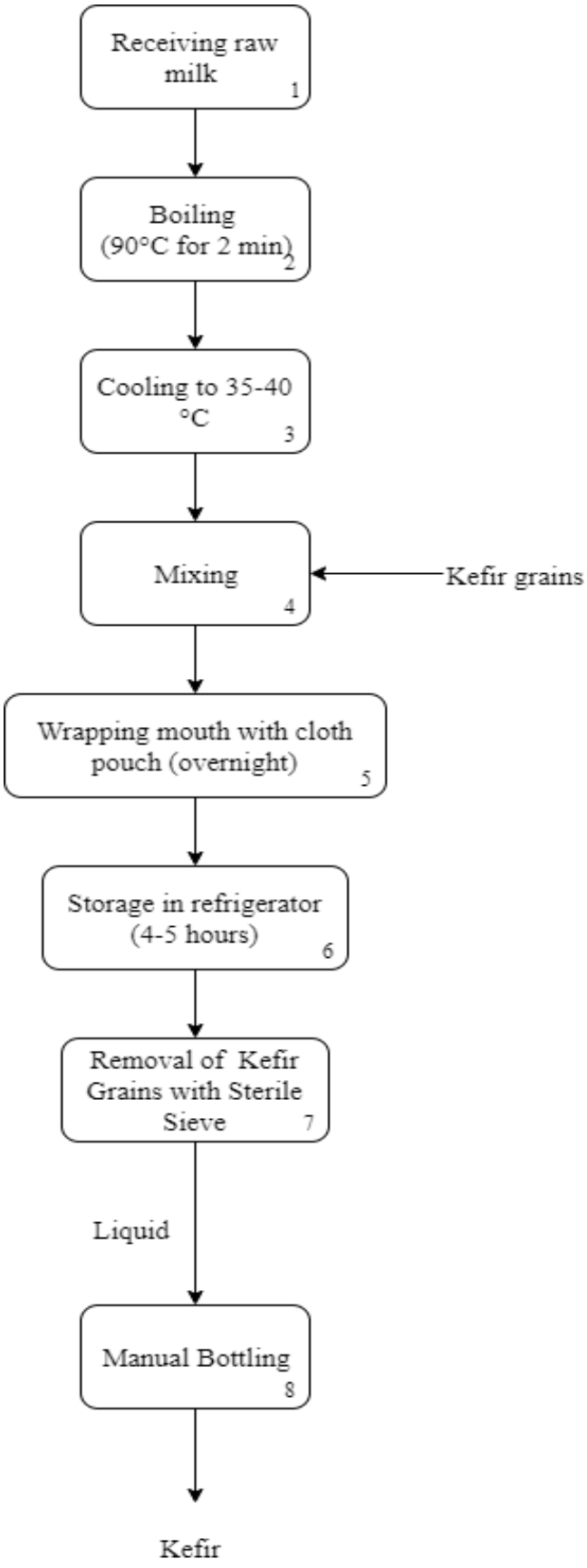

Figure A. 6. Kefir production flow diagram

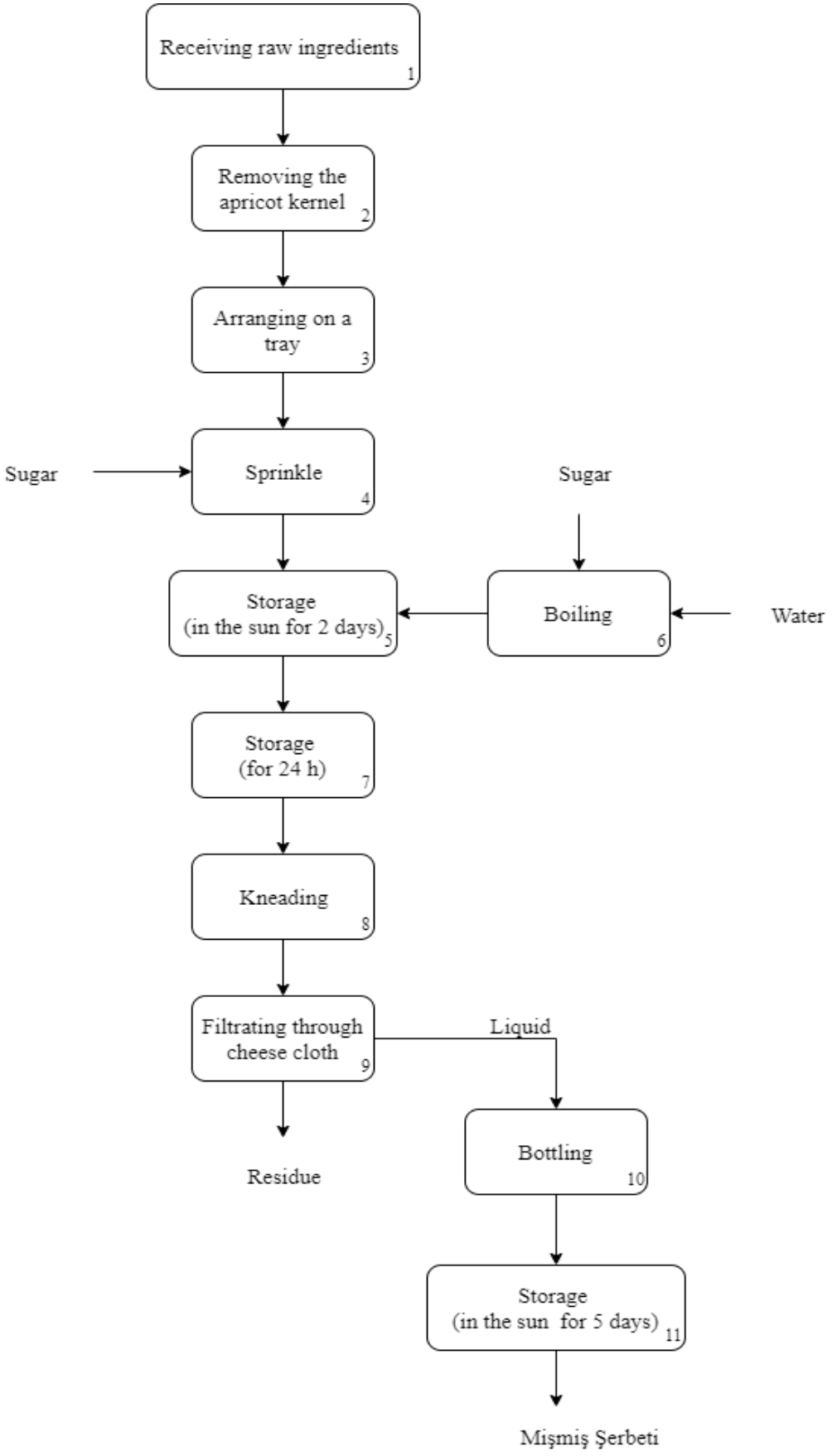

Figure A. 7. Mişmiş şerbeti production flow diagram

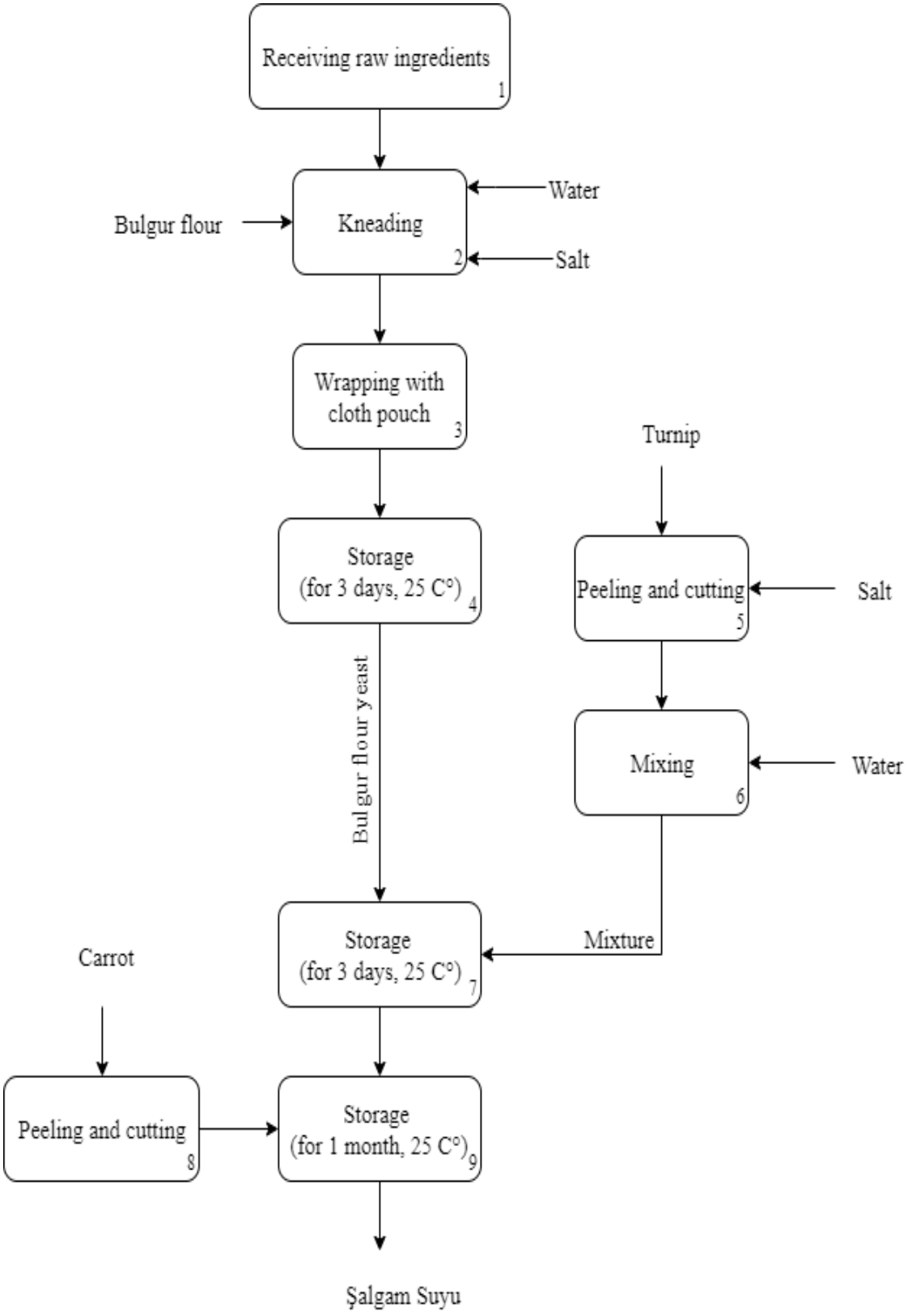

Figure A. 8. Şalgam suyu production flow diagram

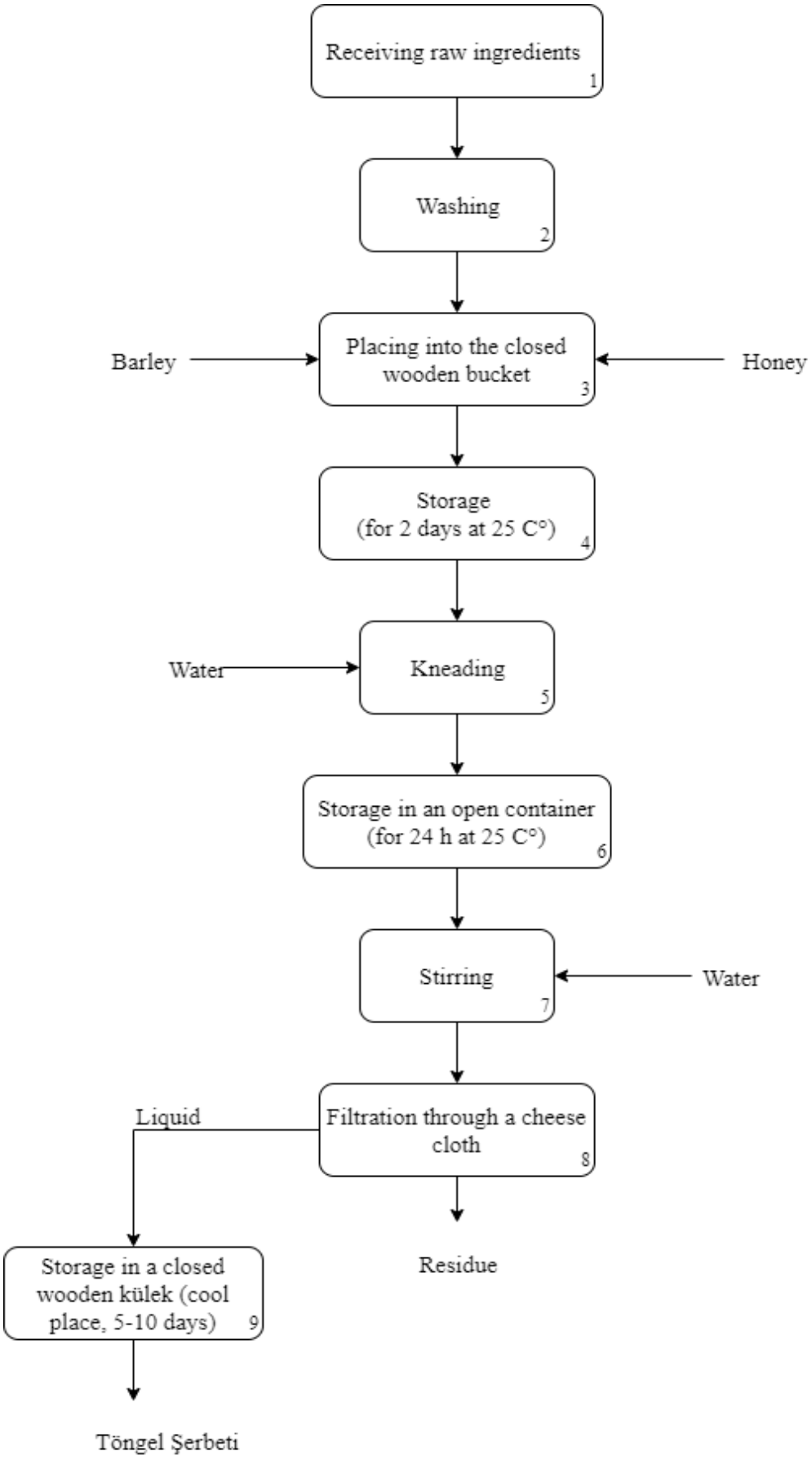

Figure A. 9. Töngel şerbeti production flow diagram

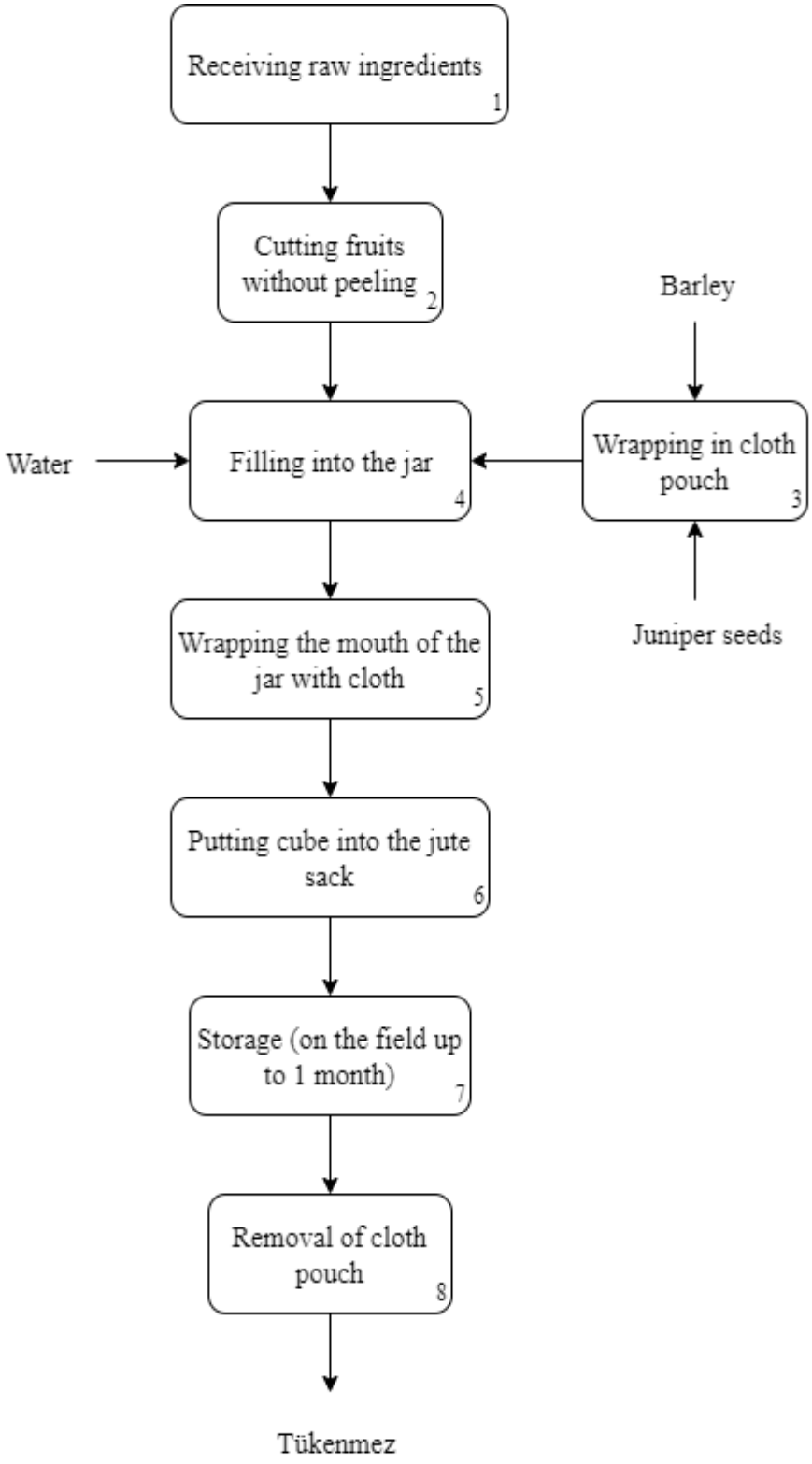

Figure A. 10. Tükenmez production flow diagram

Appendix B: FMEA Tables

Table B. 1. Implementation of FMEA to Ekşi Ayran Production

CP	Processing stage	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections	List of literatures
1	Receiving raw ingredients - Water supply	B: *Hepatitis A, Escherichia coli, Giardia lamblia, Vibrio cholera, Shigella spp., Cryptosporidium parvum, Cyclospora cayetanensis, Salmonella spp., Toxoplasma gondii* and *Norwalk*, viruses can carried by water	4	7	8	224	Analysis of microbiological reproduction must be performed periodically. With the help of chemical agents, microbiological treatment of water must be done with chlorine, ozone.	2	7	2	28	(5, 42, 110–112)
		B: Parasites in water	4	7	8	224	Analysis of microbiological reproduction must be performed periodically. With the help of chemical agents, microbiological treatment of water must be done with chlorine, ozone.	2	7	2	28	(5, 110–112)
		C: Chemical substance contamination like bromate, benzene, cyanide in water	4	8	7	224	Chemical analysis has to be performed periodically. Proper filtration system has to be utilized if necessary.	2	8	3	48	(5)
		C: Contamination of water by nitrate or fertilisers containing nitrate	4	7	6	168	Chemical analysis has to be performed periodically. Proper filtration system has to be utilized if necessary.	2	7	3	42	(5, 110)

CP	Processing stage	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections	List of literatures
		C: Water contaminated with heavy metal residues like lead, arsenic, cadmium	4	8	9	288	Chemical analysis has to be performed periodically. Proper filtration system has to be utilized if necessary.	2	8	3	48	(5, 42, 113)
		C: Uncontrolled water source with high chlorine concentration	6	7	3	126	Utilize drinkable water controlled by local authority. Perform regular laboratory examination.	2	7	3	42	(5, 42, 110–113)
		C: Pesticide contamination of water through soil erosion from the agricultural fields	7	9	3	189	Utilize drinkable water controlled by local authority. Perform regular laboratory examination.	2	9	2	36	(5, 42, 113)
		C: Contamination of water due to inappropriate or damaged metal pipe connections	6	7	3	126	Pipes and connectors must comply with standards.	2	7	3	42	(5, 42, 110)
	Receiving yoghurt	B: *Staphylococcus aureus* in raw milk is primarily due to intramammary infections, but also to skin and environmental contamination or poor hygiene conditions during the milking procedure.	8	9	4	288	Raw milk must come from animals that are in good general health condition and do not show any signs of udder wounds which may cause contamination of milk and have the potential to affect milk.	2	9	3	54	(114–116)
		C: Presence of Aflatoxin M_1 (AFM_1)	8	9	4	288	Regulation of legislations by the countries to establish the maximum permissible levels of (AFM1). Establish control mechanism to check the aflatoxin levels in milk and milk products.	2	9	3	54	(117)
		P: Contamination of raw materials by foreign objects.	4	2	2	16	Not significant	-	-	-	-	(5, 42)

Implementation of FMEA to Ekşi Ayran Production

CP	Processing stage	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections	List of literatures
	Receiving lemon	B: Presence of bacteria such as *Acetobacter, Alicyclobacillus, Bacillus, Gluconobacter, Lactobacillus, Leuconostoc, Zymomonas, and Zymobacter*.	8	9	4	288	Reliable vendor must be preferred. Water activity and pH regularly be checked. Guidelines should be prepared to prevent food poisoning. Pathogen reproduction and food deterioration should be inhibited with the help of natural antimicrobials.	2	9	3	54	(69, 118)
		B: Presence of yeasts such as *Pichia, Candida, Saccharomyces, and Rhodotorula*	8	9	4	288	Reliable vendor must be preferred. Water activity and pH regularly be checked. Guidelines should be prepared to prevent food poisoning. Pathogen reproduction and food deterioration should be inhibited with the help of natural antimicrobials.	2	9	3	54	(69, 118)
		B: Presence of molds such as *Penicillium sp., Aspergillus sp., Eurotium, Alternaria, Cladosporium, Paecilomyces, and Botrytis*	8	9	4	288	Reliable vendor must be preferred. Water activity and pH regularly be checked. Guidelines should be prepared to prevent food poisoning.	2	9	3	54	(70, 71)
		C: Mycotoxins produced by molds such as byssochlamic acid (*Byssochlamys fulva, B. nivea*), patulin (*P. expansum, B. nivea* and *B. fulva*) ochratoxin (*Aspergillus carbonarius*), and citrinin (*Penicillium citrinum*)	8	9	4	288	Reliable vendor must be preferred. Water activity and pH regularly be checked. Guidelines should be prepared to prevent food poisoning. Pathogen reproduction and food deterioration should be inhibited	2	9	3	54	(70, 71)

CP	Processing stage	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections	List of literatures
							with the help of natural antimicrobials.					
		P: Contamination of raw materials by foreign objects.	4	2	2	16	Not significant	-	-	-	-	(5, 42, 119)
2	Mixing	B: Microbial growth caused by unhealthy practices without attention to personal hygiene	8	9	3	216	Personnel should be developed through training, which highlights the significance of the utilization of food processor tools like gloves, arm sleeve covers and bonnet.	2	9	3	54	(5, 42, 47, 50, 96)
		C: Addition of machine oil in foods from the churn machine	4	7	6	168	The food grade oils must be used	2	4	5	40	(5)
		C: Heavy metal (lead) contamination from churn machine	4	8	6	192	Quality control of churn machine must be done periodically.	2	8	5	80	(5)
		P: Foreign materials from the churn machine due to improper cleaning.	5	4	6	120	Appropriate cleaning methods has to be applied. Food personnel has to be regularly checked in terms of hygiene and sanitary safety ensured.	2	4	5	40	(5, 42, 47, 120)
3	Collecting of churn fat on top	B: Microbial growth caused by unhealthy practices without attention to personal hygiene	8	9	3	216	Personnel should be developed through training, which highlights the significance of the utilization of food processor tools like gloves, arm sleeve covers and bonnet.	2	9	3	54	(5, 42, 47, 50, 96)
		C: Heavy metal (lead) contamination from churn machine	4	8	6	192	Quality control of churn machine must be done periodically.	2	8	5	80	(5)

CP	Processing stage	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections	List of literatures
		P: Contamination from the staff (Hair, nail, jewelleries, etc.) because of inappropriate implementations throughout process	5	4	6	120	Personnel should be developed through training, which highlights the significance of the utilization of food processor tools like gloves, arm sleeve covers and bonnet.	2	4	5	40	(77, 78, 121, 122)
4	Washing and Squeezing	B: *Hepatitis A, Escherichia coli, Giardia lamblia, Vibrio cholera, Shigella spp., Cryptosporidium parvum, Cyclospora cayetanensis, Salmonella spp., Toxoplasma gondii* and *Norwalk*, viruses can carried by water	4	7	8	224	Microbiological analysis has to be performed for verification. Systems such as ozone, chlorine and UV must be implemented for microbial treatment of water.	2	7	2	28	(5, 42, 110–112)
		B: Contamination stems from incorrect handling of personnel during food processing	6	8	7	336	Food personnel has to be taught the correct handwashing techniques and their importance along with hygiene training. Hands should be washed using quality approved disinfectants and personnel hygiene should be checked continuously.	2	8	3	48	(123–128)
		B: Contamination from the cloth squeezing material.	5	8	6	240	Periodic hygiene control must be done for cloth squeezing material.	2	8	4	64	(108)
		P: Contamination from the staff (Hair, nail, jewelleries, etc.) because of inappropriate implementations throughout process	5	4	6	120	Personnel should be developed through training, which highlights the significance of the utilization of food processor tools like gloves, arm sleeve covers and bonnet.	2	4	5	40	(77, 78, 121, 122)

Implementation of FMEA to Ekşi Ayran Production

CP	Processing stage	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections	List of literatures
		P: Contamination which stems from physical environment due to the dust and impurities.	5	3	3	45	Not significant	-	-	-	-	(79–81, 129)
5	Mixing	B: Contamination stems from incorrect handling of personnel during food processing	6	8	7	336	Food personnel has to be taught the correct handwashing techniques and their importance along with hygiene training. Hands should be washed using quality approved disinfectants and personnel hygiene should be checked continuously.	2	8	3	48	(123–128)
		P: Contamination which stems from physical environment due to the dust and impurities.	5	3	3	45	Not significant	-	-	-	-	(79–81, 129)
		P: Foreign materials from the boxes caused by poor cleaning.	5	5	3	75	Not significant	2	4	5	40	(79–81, 129)
6	Boiling and Curdling	B: Contamination stems from incorrect handling of personnel during food processing	6	8	7	336	Food personnel has to be taught the correct handwashing techniques and their importance along with hygiene training. Hands should be washed using quality approved disinfectants and personnel hygiene should be checked continuously.	2	8	3	48	(123–128)
		C: Detergent residue as a result of inadequate rinsing of boiler after manual cleaning	5	7	5	175	Appropriate cleaning methods has to be applied.	2	7	3	42	(38, 68)

CP	Processing stage	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections	List of literatures
		P: Contamination from the staff because of inappropriate implementations throughout process	5	4	6	120	Personnel should be developed through training, which highlights the significance of the utilization of food processor tools like gloves, arm sleeve covers and bonnet.	2	4	5	40	(77, 78, 121, 122)
7	Filtration	B: Microbiological contamination as a result of poor manual cleaning and storage of kitchen equipment	5	8	4	160	Appropriate cleaning methods has to be applied.	2	8	2	32	(38, 68)
		B: Microbiological contamination due to the use of inappropriate cleaning material.	6	7	2	84	Not significant	-	-	-	-	(130, 131)
		C: Detergent residue due to poor rinsing after cleaning	4	7	6	168	Appropriate cleaning procedure has to be followed.	2	7	1	14	(38, 68)
		P: Physical contaminants due to the damaged filtration tool	4	4	3	48	Not significant	-	-	-	-	(79–81, 129)
8	Manual Bottling	B: Microbiological contamination due to the insufficient cleaning of the bottle by manual cleaning	6	8	6	288	Appropriate cleaning procedure has to be followed.	2	8	4	64	(38, 68)
		B: Microbiological contamination caused by improper closing or sealing of bottle	8	8	5	320	Maintenance of equipment (maintenance procedure) must be ensured. Personnel has to be educated.	4	8	2	64	(38, 68)
		B: Contamination from the bottle	6	7	7	294	Vendor must be reliable.	3	7	4	84	(38, 68)

Implementation of FMEA to Ekşi Ayran Production

CP	Processing stage	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections	List of literatures
		B: Contamination stems from incorrect handling of personnel during food processing	6	8	7	336	Food personnel has to be taught the correct handwashing techniques and their importance along with hygiene training. Hands should be washed using quality approved disinfectants and personnel hygiene should be checked continuously.	2	8	3	48	(123–128)
		P: Contamination from the staff due to improper practices during packaging	5	4	6	120	Personnel should be developed through training, which highlights the significance of the utilization of food processor tools like gloves, arm sleeve covers and bonnet.	2	4	5	40	(77, 78, 121, 122)
9	Storage	B: Microbiological reproduction caused by inappropriate storage conditions	5	8	6	240	Properly cleaned, regularly inspected areas in terms of hygiene have to be used for storage.	2	8	4	64	(83–85)
		B: Microbiological reproduction caused by inappropriate storage temperature	6	7	6	252	Calibration of thermometers / probes used for temperature measurements must be carried out on time and regularly.	2	7	2	28	(83–85)

Table B. 2. Implementation of FMEA to Çüküdür Suyu Production

CP	Processing stage	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections	List of literatures
1	Receiving raw ingredients-Water supply	B: *Hepatitis A, Escherichia coli, Giardia lamblia, Vibrio cholera, Shigella spp., Cryptosporidium parvum, Cyclospora cayetanensis, Salmonella spp., Toxoplasma gondii* and *Norwalk*, viruses can carried by water	4	7	8	224	Analysis of microbiological reproduction must be performed periodically. With the help of chemical agents, microbiological treatment of water must be done with chlorine, ozone.	2	7	2	28	(5, 42, 110–112)
		B: Parasites in water	4	7	8	224	Analysis of microbiological reproduction must be performed periodically. With the help of chemical agents, microbiological treatment of water must be done with chlorine, ozone.	2	7	2	28	(5, 110–112)
		C: Chemical substance contamination like bromate, benzene, cyanide in water	4	8	7	224	Chemical analysis has to be performed periodically. Proper filtration system has to be utilized if necessary.	2	8	3	48	(5)
		C: Contamination of water by nitrate or fertilisers containing nitrate	4	7	6	168	Chemical analysis has to be performed periodically. Proper filtration system has to be utilized if necessary.	2	7	3	42	(5, 110)

Implementation of FMEA to Çükündür Suyu Production

CP	Processing stage	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections	List of literatures
		C: Water contaminated with heavy metal residues like lead, arsenic, cadmium	4	8	9	288	Chemical analysis has to be performed periodically. Proper filtration system has to be utilized if necessary.	2	8	3	48	(5, 42, 113)
		C: Uncontrolled water source with high chlorine concentration	6	7	3	126	Utilize drinkable water controlled by local authority. Perform regular laboratory examination.	2	7	3	42	(5, 42, 110–113)
		C: Pesticide contamination of water through soil erosion from the agricultural fields	7	9	3	189	Utilize drinkable water controlled by local authority. Perform regular laboratory examination.	2	9	2	36	(5, 42, 113)
		C: Contamination of water due to inappropriate or damaged metal pipe connections	6	7	3	126	Pipes and connectors must comply with standards.	2	7	3	42	(5, 42, 110)
	Receiving beet	B: Microbiological contamination by fungus *Fusaria*	6	6	5	180	Certified products from reliable vendors have to be used. The contaminated parts have to be removed. Storage conditions have to be held at an optimal degree.	2	6	4	48	(132–134)
		C: Chemical contamination due to the mycotoxin such as Mycophenolic acid and zearalenone (ZEA)	6	6	5	180	Certified products from reliable vendors have to be used. The contaminated parts have to be removed. Storage conditions have to be held at an optimal degree.	2	6	4	48	(97, 132)
		C: Pesticide contamination such as insecticide (organophosphorous) and fungicides (triazoles)	6	9	5	270	Certified products from reliable vendors have to be used. The contaminated parts have to be removed. Storage conditions have	2	9	3	54	(97, 135)

CP	Processing stage	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections	List of literatures
							to be held at an optimal degree. Pesticide analysis has to be done.					
		P: Contamination which stems from physical environment due to the dust and impurities.	5	3	3	45	Not significant	-	-	-	-	(79–81, 129)
	Receiving molasses	B: Microbiological contamination due to the *Aspergillus ochraceus and Penicillium verrucosum*	6	9	5	270	Certified products from reliable vendors have to be used. The contaminated parts have to be removed. Storage conditions have to be held at an optimal degree. Humidity needs to be checked.	2	9	3	54	(136, 137)
		C: Mycotoxin contamination of OTA	6	9	5	270	Certified products from reliable vendors have to be used. The contaminated parts have to be removed. Storage conditions have to be held at an optimal degree. Humidity needs to be checked.	2	9	3	54	(136, 137)
		P: Contamination which stems from physical environment due to the dust and impurities.	5	3	3	45	Not significant	-	-	-	-	(79–81, 129)
	Receiving dried pepper	B: Microbiological (Fungi) contamination stems from *Aspergillus fumigatus, A. Ochraceus, A. niger, A. flavus*	7	9	6	378	After the peppers are harvested, the peppers must be washed thoroughly and free from dirt. Reliable vendor must be prefered. Storage conditions have to be held at an optimal degree. Humidity needs to be checked.	2	9	4	72	(101, 103)

Implementation of FMEA to Çüküdür Suyu Production

CP	Processing stage	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections	List of literatures
		C: Mycotoxins OTA and mainly Aflatoxin B_1	7	9	5	315	Before packaging and storage aflatoxin analysis has to be done to determine the contamination levels of aflatoxins. The allowed maximum legal limits of total aflatoxin for red dried chili pepper is 10 ppb in Turkey.	3	9	3	81	(101, 102)
		C: Pesticide contamination such as insecticide (organophosphorous) and fungicides (triazoles)	6	9	5	270	Certified products from reliable vendors have to be used. The contaminated parts have to be removed. Storage conditions have to be held at an optimal degree. Pesticide analysis has to be done.	2	9	3	54	(97, 101, 135)
		P: Contamination which stems from physical environment due to the dust and impurities.	5	3	3	45	Not significant	-	-	-	-	(79–81, 129)
	Receiving salt	B: Microbial growth due to poor storage conditions before and after receiving	5	7	4	140	Certified products from reliable vendors have to be used. The contaminated parts have to be removed. Storage conditions have to be held at an optimal degree.	2	9	2	36	(42)
		P: Contamination which stems from physical environment due to the dust and impurities.	5	3	3	45	Not significant	-	-	-	-	(79–81, 129)

Implementation of FMEA to Çükündür Suyu Production

CP	Processing stage	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections	List of literatures
	Receiving stale bread	B: Microbiological contamination by bacterias (*Bacillus Cereus, Clostridium perfringens*) and fungus (*Aspergillus flavus, Fusarium graminearum, Fusarium verticilloides*)	6	9	6	324	The flour must be obtained from approved vendors. Quality control and microbiological analysis certificates must be available. The certificates must meet the approved standarts and should report the humidity of flour.	2	9	3	54	(32, 138)
		C: Mycotoxins such as Zearalenone, Fumonisin, Aflatoxin B_1	6	9	5	270	Flour must be obtained from certified vendors. Quality control and chemical analysis certificates must be available.	2	9	3	54	(97, 135)
		P: Contamination which stems from physical environment due to the dust and impurities.	5	3	3	45	Not significant	-	-	-	-	(79–81, 129)
	Receiving barley flour	B: Microbiological contamination due to the toxigenic genera (*Alternaria, Fusarium, Aspergillus, Penicillium*)	6	9	5	270	Barley must be purchased from reliable vendors and include quality certificates which demonstrate moisture content of grains. Defective portion must be rejected.	2	9	3	54	(72, 73)

Implementation of FMEA to Çükündür Suyu Production

CP	Processing stage	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections	List of literatures
		C: Mycotoxins (Deoxynivalenol/nivalenol, Ochratoxin A, Zearalenone) contamination stems from mold growth as a result of improper storage after harvesting, as well as inappropriate environmental conditions during crop growth.	6	9	4	216	Barley must be purchased from reliable vendors and include quality certificates which demonstrate moisture content of grains. Defective portion must be rejected.	2	9	3	54	(72, 74)
		C: Pesticide contamination such as insecticide (organophosphorous) and fungicides (triazoles)	6	9	5	270	Certified products from reliable vendors have to be used. The contaminated parts have to be removed. Storage conditions have to be held at an optimal degree. Pesticide analysis has to be done.	2	9	3	54	(97, 135)
		C: Contamination due to the rodents (mouse urinary aeroallergens)	6	9	5	270	Integrated Pest Management (IPM) program that uses feed and traps as well as accurate monitoring methods must be used.	2	9	4	72	(75, 139)
		P: Contamination caused by physical pollutants such as feces, urine and hair carried by rodents	6	9	4	216	Integrated Pest Management (IPM) program that uses feed and traps as well as accurate monitoring methods must be used.	2	9	4	72	(75, 139)
2	Peeling and cutting (Beets)	B: Microbial growth caused by unhealthy practices without attention to personal hygiene	8	9	3	216	Personnel should be developed through training, which highlights the significance of the utilization of food processor tools like gloves, arm sleeve covers and bonnet.	2	9	3	54	(5, 42, 47, 50, 96)

Implementation of FMEA to Çükündür Suyu Production

CP	Processing stage	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections	List of literatures
		B: Contamination stems from incorrect handling of personnel during food processing	6	8	7	336	Food personnel has to be taught the correct handwashing techniques and their importance along with hygiene training. Hands should be washed using quality approved disinfectants and personnel hygiene should be checked continuously.	2	8	3	48	(123–128)
		B: Cross-contamination as a result of poor manual cleaning and storage of kitchen equipment such as knives and cutting boards	6	8	6	288	Proper cleaning procedure (disinfection, washing, rinsing, and cleaning) must be applied. If raw and cooked foods are processed concurrently, different storage containers and cutting tools must be utilized as equipment.	2	8	4	64	(76, 104–107)
		C: Cleaning agent residues as a result of insufficient rinsing of equipments by personnel	5	5	3	75	Not significant	-	-	-	-	(68)
		P: Contamination from the staff (Hair, nail, jeweleries, etc.) because of inappropriate implementations throughout process	5	4	6	120	Personnel should be developed through training, which highlights the significance of the utilization of food processor tools like gloves, arm sleeve covers and bonnet.	2	4	5	40	(77, 78, 121, 122)
		P: Contamination which stems from physical environment due to the dust and impurities.	5	3	3	45	Not significant	-	-	-	-	(79–81, 129)

Implementation of FMEA to Çükündür Suyu Production

CP	Processing stage	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections	List of literatures
3	Filling into wide-mouth jar	B: Microbial growth caused by unhealthy practices without attention to personal hygiene	8	9	3	216	Personnel should be developed through training, which highlights the significance of the utilization of food processor tools like gloves, arm sleeve covers and bonnet.	2	9	3	54	(5, 42, 47, 50, 96)
		C: Cleaning agent residues as a result of insufficient rinsing of equipments by personnel	5	5	3	75	Not significant	-	-	-	-	(68)
		P: Physical contamination caused by the passage of dust and sand into the food by air and insect particles	4	4	3	48	Not significant	-	-	-	-	(79–81, 129)
		P: Plastic, glass, wood pieces from the worn equipment	3	6	4	72	Not significant	-	-	-	-	(68)
		P: Contamination from the staff (Hair, nail, jewelleries, etc.) because of inappropriate implementations throughout process	5	4	6	120	Personnel should be developed through training, which highlights the significance of the utilization of food processor tools like gloves, arm sleeve covers and bonnet.	2	4	5	40	(77, 78, 121, 122)
		P: Contamination which stems from physical environment due to the dust and impurities.	5	3	3	45	Not significant	-	-	-	-	(79–81, 129)

Implementation of FMEA to Çükündür Suyu Production

CP	Processing stage	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections	List of literatures
4	Kneading dough	B: Microbial growth caused by unhealthy practices without attention to personal hygiene	8	9	3	216	Personnel should be developed through training, which highlights the significance of the utilization of food processor tools like gloves, arm sleeve covers and bonnet.	2	9	3	54	(5, 42, 47, 50, 96)
		B: Microbiological transmission through lack of personal hygiene	7	8	7	392	Food personnel has to be taught the correct handwashing techniques and their importance along with hygiene training. Hands should be washed using quality approved disinfectants and personnel hygiene should be checked continuously.	2	8	3	48	(77, 78, 121, 122)
		C: Cleaning agent residues as a result of insufficient rinsing of equipments by personnel	5	5	3	75	Not significant	-	-	-	-	(68)
		P: Foreign materials from the kneading box due to improper cleaning.	5	4	6	120	Appropriate cleaning methods has to be applied. Food personnel has to be regularly checked in terms of hygiene and sanitary safety ensured.	2	4	5	40	(79–81, 129)
		P: Contamination from the staff (Hair, nail, jewelleries, etc.) because of inappropriate implementations throughout process	5	4	6	120	Personnel should be developed through training, which highlights the significance of the utilization of food processor tools like gloves, arm sleeve covers and bonnet.	2	4	5	40	(77, 78, 121, 122)

Implementation of FMEA to Çükündür Suyu Production

CP	Processing stage	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections	List of literatures
		P: Contamination which stems from physical environment due to the dust and impurities.	5	3	3	45	Not significant	-	-	-	-	(79–81, 129)
5	Wrapping with cloth pouch	B: Microorganisms (*Pseudomonas aeruginosa, Klebsiella aerogenes, Staphylococcus saprophyticus, E. coli*) can pass from a poorly cleaned or contaminated cloth to hands.	5	9	5	225	Staff must be trained. Appropriate cleaning methods has to be applied. Cloth pouch must not be used repeatedly.	2	9	2	36	(108)
		B: Microbial growth caused by unhealthy practices without attention to personal hygiene	8	9	3	216	Personnel should be developed through training, which highlights the significance of the utilization of food processor tools like gloves, arm sleeve covers and bonnet.	2	9	3	54	(5, 42, 47, 50, 96)
		C: Chemical contamination due to the various pesticides utilized in the processing phases of natural fabrics like cotton (storage)	6	8	5	240	Reliable vendor must be prefered. Storage conditions have to be held at an optimal degree.	2	7	3	42	(109)
		P: Foreign materials from the cloth pouch	5	4	3	60	Not significant	-	-	-	-	(108, 109)
		P: Contamination which stems from physical environment due to the dust and impurities.	5	3	3	45	Not significant	-	-	-	-	(79–81, 129)

Implementation of FMEA to Çükündür Suyu Production

CP	Processing stage	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections	List of literatures
		P: Contamination from the staff (Hair, nail, jewelleries, etc.) because of inappropriate implementations throughout process	5	4	6	120	Personnel should be developed through training, which highlights the significance of the utilization of food processor tools like gloves, arm sleeve covers and bonnet.	2	4	5	40	(77, 78, 121, 122)
6	Mixing	B: Microorganisms from the environment (air)	5	5	3	75	Not significant	-	-	-	-	
		C: Cleaning agent residues as a result of insufficient rinsing of equipments by personnel	5	5	3	75	Not significant	-	-	-	-	(68)
		P: Contamination from the staff (Hair, nail, jewelleries, etc.) because of inappropriate implementations throughout process	5	4	6	120	Personnel should be developed through training, which highlights the significance of the utilization of food processor tools like gloves, arm sleeve covers and bonnet.	2	4	5	40	(77, 78, 121, 122)
		P: Contamination which stems from physical environment due to the dust and impurities.	5	3	3	45	Not significant	-	-	-	-	(79–81, 129)
7	Storage in closed-mouth container for 3 weeks	B: Microbiological reproduction caused by inappropriate storage conditions	5	8	6	240	Properly cleaned, regularly inspected areas in terms of hygiene have to be used for storage.	2	8	4	64	(83–85)

Implementation of FMEA to Çükündür Suyu Production

CP	Processing stage	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections	List of literatures
		B: Microbiological reproduction caused by inappropriate storage temperature	6	7	6	252	Calibration of thermometers / probes used for temperature measurements must be carried out on time and regularly.	2	7	2	28	(83–85)

Table B. 3. Implementation of FMEA to Gilaburu Production

CP	Processing stage	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections	List of literatures
1	Obtaining gilaburu	B: Microbiological contamination during the harvest which stems from contact of cranberries each other and also carriers	8	9	3	216	Personnel should be developed through training, which emphasizes the importance of the use of equipment. Damaged lots must be removed.	2	9	3	54	(140)
		B: Microbiological contamination due to insanitary practice during transportation (from boxes, crates, trucks etc.)	8	9	3	216	Personnel should be developed through training, which emphasizes the importance of the use of equipment. Damaged lots must be removed. The quality and reliability of the equipment must be regularly monitored.	2	9	3	54	(5, 42, 47, 50, 96)
		C: Pesticide contamination such as insecticide (organophosphorous) and fungicides (triazoles)	6	9	5	270	Certified products from reliable vendors have to be used. The contaminated parts have to be removed. Storage conditions have to be held at an optimal degree. Pesticide analysis has to be done.	2	9	3	54	(97, 135)
	Water supply	*B: Hepatitis A, Escherichia coli, Giardia lamblia, Vibrio cholera, Shigella spp., Cryptosporidium parvum, Cyclospora cayetanensis, Salmonella spp., Toxoplasma gondii* and *Norwalk,* viruses can carried by water	4	7	8	224	Analysis of microbiological reproduction must be performed periodically. With the help of chemical agents, microbiological treatment of water must be done with chlorine, ozone.	2	7	2	28	(5, 42, 110–112)

Implementation of FMEA to Gilaburu Production

CP	Processing stage	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections	List of literatures
		B: Parasites in water	4	7	8	224	Analysis of microbiological reproduction must be performed periodically. With the help of chemical agents, microbiological treatment of water must be done with chlorine, ozone.	2	7	2	28	(5, 110–112)
		C: Chemical substance contamination like bromate, benzene, cyanide in water	4	8	7	224	Chemical analysis has to be performed periodically. A suitable filtration system must be used if necessary such as reverse osmosis.	2	8	3	48	(5)
		C: Contamination of water by nitrate or fertilisers containing nitrate	4	7	6	168	Chemical analysis has to be performed periodically. A suitable filtration system must be used if necessary such as reverse osmosis.	2	7	3	42	(5, 110)
		C: Water contaminated with heavy metal residues like lead, arsenic, cadmium	4	8	9	288	Chemical analysis has to be performed periodically. A suitable filtration system must be used if necessary such as reverse osmosis.	2	8	3	48	(5, 42, 113)
		C: Uncontrolled water source with high chlorine concentration	6	7	3	126	Utilize drinkable water controlled by local authority. Perform regular laboratory examination.	2	7	3	42	(5, 42, 110–113)
		C: Pesticide contamination of water through soil erosion from the agricultural fields	7	9	3	189	Utilize drinkable water controlled by local authority. Perform regular laboratory examination.	2	9	2	36	(5, 42, 113)
		C: Contamination of water due to inappropriate or damaged metal pipe connections	6	7	3	126	Pipes and connectors must comply with standards.	2	7	3	42	(5, 42, 110)

Implementation of FMEA to Gilaburu Production

CP	Processing stage	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections	List of literatures
2	Washing	*B:* Cross-contamination *Hepatitis A, Escherichia coli, Giardia lamblia, Vibrio cholera, Shigella spp., Cryptosporidium parvum, Cyclospora cayetanensis, Salmonella spp., Toxoplasma gondii* and *Norwalk*, viruses can carried by water.	4	7	8	224	Microbiological analysis has to be performed for verification. Systems such as ozone, chlorine and UV must be implemented for microbial treatment of water.	2	7	2	28	(5, 42, 110–112)
		B: Contamination stems from incorrect handling of personnel during food processing	6	8	7	336	Food personnel has to be taught the correct handwashing techniques and their importance along with hygiene training. Hands should be washed using quality approved disinfectants and personnel hygiene should be checked continuously.	2	8	3	48	(123–128)
		P: Contamination from the staff (Hair, nail, jewelleries, etc.) because of inappropriate implementations throughout process	5	4	6	120	Personnel should be developed through training, which highlights the significance of the utilization of food processor tools like gloves, arm sleeve covers and bonnet.	2	4	5	40	(77, 78, 121, 122)
		P: Contamination which stems from physical environment due to the dust and impurities.	5	3	3	45	Not significant	-	-	-	-	(79–81, 129)
3	Crushing	B: Microbial growth caused by unhealthy practices without attention to personal hygiene	8	9	3	216	Personnel should be developed through training, which highlights the significance of the utilization of food processor tools like gloves, arm sleeve covers and bonnet.	2	9	3	54	(5, 42, 47, 50, 96)

CP	Processing stage	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections	List of literatures
		B: Contamination stems from incorrect handling of personnel during food processing	6	8	7	336	Food personnel has to be taught the correct handwashing techniques and their importance along with hygiene training. Hands should be washed using quality approved disinfectants and personnel hygiene should be checked continuously.	2	8	3	48	(123–128)
		C: Cleaning agent residues as a result of insufficient rinsing of equipments by personnel	5	5	3	75	Not significant	-	-	-	-	(68)
		P: Contamination from the staff (Hair, nail, jeweleries, etc.) because of inappropriate implementations throughout process	5	4	6	120	Personnel should be developed through training, which highlights the significance of the utilization of food processor tools like gloves, arm sleeve covers and bonnet.	2	4	5	40	(77, 78, 121, 122)
4	Filling into plastic drums	B: Microbial growth caused by unhealthy practices without attention to personal hygiene	8	9	3	216	Personnel should be developed through training, which highlights the significance of the utilization of food processor tools like gloves, arm sleeve covers and bonnet.	2	9	3	54	(5, 42, 47, 50, 96)
		C: Cleaning agent residues as a result of insufficient rinsing of equipments by personnel	5	5	3	75	Not significant	-	-	-	-	(68)
		C: Endocrine-Disrupting Chemicals derived from plastic food containers (styrene, bisphenol A, phthalate)	6	9	6	324	Glass containers should be preferred.	2	9	4	72	(82)

Implementation of FMEA to Gilaburu Production

CP	Processing stage	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections	List of literatures
		P: Physical contamination caused by the passage of dust and sand into the food by air and insect particles	4	4	3	48	Not significant	-	-	-	-	(79–81, 129)
		P: Plastic pieces from the worn equipment	3	6	4	72	Not significant	-	-	-	-	(5, 82)
		P: Contamination from the staff (Hair, nail, jewelleries, etc.) because of inappropriate implementations throughout process	5	4	6	120	Personnel should be developed through training, which highlights the significance of the utilization of food processor tools like gloves, arm sleeve covers and bonnet.	2	4	5	40	(77, 78, 121, 122)
5	Storage in dark place at 25 C°	B: Microbiological reproduction caused by inappropriate storage conditions	5	8	6	240	Properly cleaned, regularly inspected areas in terms of hygiene have to be used for storage.	2	8	4	64	(83–85)
		B: Microbiological reproduction caused by inappropriate storage temperature	6	7	6	252	Calibration of thermometers / probes used for temperature measurements must be carried out on time and regularly.	2	7	2	28	(83–85)
6	Pressing by hand	B: Microbial growth caused by unhealthy practices without attention to personal hygiene	8	9	3	216	Personnel should be developed through training, which highlights the significance of the utilization of food processor tools like gloves, arm sleeve covers and bonnet.	2	9	3	54	(5, 42, 47, 50, 96)

Implementation of FMEA to Gilaburu Production

CP	Processing stage	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections	List of literatures
		B: Microbiological transmission through lack of personal hygiene	7	8	7	392	Food personnel has to be taught the correct handwashing techniques and their importance along with hygiene training. Hands should be washed using quality approved disinfectants and personnel hygiene should be checked continuously.	2	8	3	48	(77, 78, 121, 122)
		P: Contamination from the staff (Hair, nail, jewelleries, etc.) because of inappropriate implementations throughout process	5	4	6	120	Personnel should be developed through training, which highlights the significance of the utilization of food processor tools like gloves, arm sleeve covers and bonnet.	2	4	5	40	(77, 78, 121, 122)
		P: Physical contamination caused by the passage of dust and sand into the food by air and insect particles	4	4	3	48	Not significant	-	-	-	-	(79–81, 129)
7	Manual Bottling	B: Microbiological contamination due to the insufficient cleaning of the bottle by manual cleaning	6	8	6	288	Appropriate cleaning methods has to be applied.	2	8	4	64	(129)
		B: Microbiological contamination caused by improper closing or sealing of bottle	8	8	5	320	Maintenance of equipment (maintenance procedure) must be ensured. Personnel education is required.	4	8	2	64	(5)
		B: Contamination from the bottle	6	7	7	294	Vendor must be reliable.	3	7	4	84	(68)

Implementation of FMEA to Gilaburu Production

CP	Processing stage	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections	List of literatures
		B: Contamination stems from incorrect handling of personnel during food processing	6	8	7	336	Food personnel has to be taught the correct handwashing techniques and their importance along with hygiene training. Hands should be washed using quality approved disinfectants and personnel hygiene should be checked continuously.	2	8	3	48	(123–128)
		P: Contamination from the staff due to improper practices during packaging	5	4	6	120	Personnel should be developed through training, which highlights the significance of the utilization of food processor tools like gloves, arm sleeve covers and bonnet.	2	4	5	40	(77, 78, 121, 122)

Table B. 4. Implementation of FMEA to Hardaliye Production

CP	Processing stage	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections	List of literatures
1	Receiving raw ingredients-Water supply	B: *Hepatitis A, Escherichia coli, Giardia lamblia, Vibrio cholera, Shigella spp., Cryptosporidium parvum, Cyclospora cayetanensis, Salmonella spp., Toxoplasma gondii* and *Norwalk*, viruses can carried by water	4	7	8	224	Microbiological analysis has to be performed periodically. Microbiological treatment with the help of chemical agents like chlorine, ozone or UV (ultra violet) based systems must be applied to water.	2	7	2	28	(5, 42, 110–112)
		B: Parasites in water	4	7	8	224	Microbiological analysis has to be performed periodically. Microbiological treatment with the help of chemical agents like chlorine, ozone or UV (ultra violet) based systems must be applied to water.	2	7	2	28	(5, 110–112)
		C: Chemical substance contamination like bromate, benzene, cyanide in water	4	8	7	224	Chemical analysis has to be performed periodically. Proper filtration system has to be utilized if necessary.	2	8	3	48	(5)
		C: Contamination of water by nitrate or fertilisers containing nitrate	4	7	6	168	Chemical analysis has to be performed periodically. Proper filtration system has to be utilized if necessary.	2	7	3	42	(5, 110)

CP	Processing stage	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections	List of literatures
		C: Water contaminated with heavy metal residues like lead, arsenic, cadmium	4	8	9	288	Chemical analysis has to be performed periodically. Proper filtration system has to be utilized if necessary.	2	8	3	48	(5, 42, 113)
		C: Uncontrolled water source with high chlorine concentration	6	7	3	126	Utilize drinkable water controlled by local authority. Perform regular laboratory examination.	2	7	3	42	(5, 42, 110–113)
		C: Pesticide contamination of water through soil erosion from the agricultural fields	7	9	3	189	Utilize drinkable water controlled by local authority. Perform regular laboratory examination.	2	9	2	36	(5, 42, 113)
		C: Contamination of water due to inappropriate or damaged metal pipe connections	6	7	3	126	Pipes and connectors must comply with standards.	2	7	3	42	(5, 42, 110)
	Receiving barley	B: Microbiological contamination due to the toxigenic genera (*Alternaria, Fusarium, Aspergillus, Penicillium*)	6	9	5	270	Barley must be purchased from reliable vendors and include quality certificates which demonstrate moisture content of grains. Defective portion must be rejected.	2	9	3	54	(72, 73)
		C: Mycotoxins (Deoxynivalenol/nivalenol, Ochratoxin A, Zearalenone) contamination stems from mold growth as a result of improper storage after harvesting, as well as inappropriate environmental conditions during crop growth.	6	9	4	216	Barley must be purchased from reliable vendors and include quality certificates which demonstrate moisture content of grains. Defective portion must be rejected.	2	9	3	54	(72, 74)

CP	Processing stage	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections	List of literatures
		C: Pesticide contamination such as insecticide (organophosphorous) and fungicides (triazoles)	6	9	5	270	Certified products from reliable vendors have to be used. The contaminated parts have to be removed. Storage conditions have to be held at an optimal degree. Pesticide analysis has to be done.	2	9	3	54	(97, 135)
		C: Contamination due to the rodents (mouse urinary aeroallergens)	6	9	5	270	Adopt environmentally friendly Integrated Pest Management (IPM) programmes. Monitor rodents and utilize baits and traps.	2	9	4	72	(75, 139)
		P: Contamination caused by physical pollutants such as feces, urine and hair carried by rodents	6	9	4	216	Integrated Pest Management (IPM) program that uses feed and traps as well as accurate monitoring methods must be used.	2	9	4	72	(75, 139)
	Receiving mustard	B: Microbiological contamination stems from *Penicillium verrucosum, P. aurantiogriseum, P. sp. 102/01, P. griseofulvum. Eurotium repens, P. aurantiogriseum, P. sp. 100/01, P. expansum* and *P. chrysogenum*	6	9	5	270	Mustard must be checked regularly as it is prone to fungal growth. Storing and transporting under low temperature and humidity conditions is important to prevent fungal growth.	2	9	3	54	(75, 141)

Implementation of FMEA to Hardaliye Production

CP	Processing stage	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections	List of literatures
		C: Chemical contamination due to mycotoxins such as nephrotoxic glycopeptides, viomellein, xanthomegnin.	6	9	5	270	Mustard must be checked regularly as it is prone to fungal growth. Storing and transporting under low temperature and humidity conditions is important to prevent fungal growth.	2	9	3	54	(75, 141)
		P: Physical contamination caused by the passage of dust and sand into the food by air and insect particles	4	4	3	48	Not significant	-	-	-	-	(79–81, 129)
	Receiving grape	B: Microbiological contamination due to the *Aspergillus carbonarius* and *Aspergillus niger*	7	9	3	189	Grapes must be stored between 0 and -2°C. Certified products from reliable vendors have to be used. The contaminated parts have to be removed. Storage conditions have to be held at an optimal degree. Humidity needs to be checked.	2	9	2	36	(87–89)
		B: Damaged grapes are significant vehicles of dangerous spoilage microorganisms	7	9	3	189	Certified products from reliable vendors have to be used. The contaminated parts have to be removed. Storage conditions have to be held at an optimal degree.	2	9	2	36	(142)

CP	Processing stage	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections	List of literatures
		C: Contamination due to the presence of mycotoxin (Ochratoxin A)	7	9	3	189	Certified products from reliable vendors have to be used. The contaminated parts have to be removed. Storage conditions have to be held at an optimal degree. Humidity needs to be checked. Effective washing procedure must be implemented	2	9	2	36	(87, 88, 143)
		C: Contamination due to fungicide residues (Sulphur dioxide)	7	9	3	189	Certified products from reliable vendors have to be used. The contaminated parts have to be removed. Storage conditions have to be held at an optimal degree. Humidity needs to be checked. Effective washing procedure must be implemented	2	9	2	36	(88, 90)
		P: Physical contamination caused by the passage of dust and sand into the food by air and insect particles	4	4	3	48	Not significant	-	-	-	-	(79–81, 129)
2	Washing grape with stalk	B: Cross-contamination *Hepatitis A, Escherichia coli, Giardia lamblia, Vibrio cholera, Shigella spp., Cryptosporidium parvum, Cyclospora cayetanensis, Salmonella spp., Toxoplasma gondii* and *Norwalk,* viruses can carried by water	4	7	8	224	Microbiological analysis has to be performed for verification. Systems such as ozone, chlorine and UV must be implemented for microbial treatment of water.	2	7	2	28	(5, 42, 110–112)

CP	Processing stage	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections	List of literatures
		B: Contamination stems from incorrect handling of personnel during food processing	6	8	7	336	Food personnel has to be taught the correct handwashing techniques and their importance along with hygiene training. Hands should be washed using quality approved disinfectants and personnel hygiene should be checked continuously.	2	8	3	48	(123–128)
		B: Contamination from the cloth squeezing material.	5	8	6	240	Periodic hygiene control must be done for cloth squeezing material.	2	8	4	64	(108)
		P: Contamination from the staff (Hair, nail, jewelleries, etc.) because of inappropriate implementations throughout process	5	4	6	120	Personnel should be developed through training, which highlights the significance of the utilization of food processor tools like gloves, arm sleeve covers and bonnet.	2	4	5	40	(77, 78, 121, 122)
		P: Contamination which stems from physical environment due to the dust and impurities.	5	3	3	45	Not significant	-	-	-	-	(79–81, 129)
3	Wrapping with cloth pouch	B: Microorganisms (*Pseudomonas aeruginosa, Klebsiella aerogenes, Staphylococcus saprophyticus, E. coli*) can pass from a poorly cleaned or contaminated cloth to hands.	5	9	5	225	Staff must be trained. Appropriate cleaning methods has to be applied. Cloth pouch must not be used repeatedly.	2	9	2	36	(108)

CP	Processing stage	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections	List of literatures
		B: Microbial growth caused by unhealthy practices without attention to personal hygiene	8	9	3	216	Personnel should be developed through training, which highlights the significance of the utilization of food processor tools like gloves, arm sleeve covers and bonnet.	2	9	3	54	(5, 42, 47, 50, 96)
		C: Chemical contamination due to the various pesticides utilized in the processing phases of natural fabrics like cotton (storage)	6	8	5	240	Reliable vendor must be prefered. Storage conditions have to be held at an optimal degree.	2	7	3	42	(109)
		P: Foreign materials from the cloth pouch	5	4	3	60	Not significant	-	-	-	-	(108, 109)
		P: Contamination which stems from physical environment due to the dust and impurities.	5	3	3	45	Not significant	-	-	-	-	(79–81, 129)
		P: Contamination from the staff (Hair, nail, jewelleries, etc.) because of inappropriate implementations throughout process	5	4	6	120	Personnel should be developed through training, which highlights the significance of the utilization of food processor tools like gloves, arm sleeve covers and bonnet.	2	4	5	40	(77, 78, 121, 122)
4	Filling into the clay	C: Lead and cadmium contamination from clay pot	6	7	3	126	Any container, as given in TS 4403-4404-4422 (1985), must pay attention to the acceptable limits for lead and cadmium quantities released from the surface of the container at the end of contact with the 4% acetic acid solution for 24 hours.	2	7	3	42	(144)

CP	Processing stage	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections	List of literatures
		C: Cleaning agent residues from improperly rinsed filling equipment	5	5	3	75	Not significant	-	-	-	-	(68)
		P: Foreign matter in filling funnel	5	4	3	60	Not significant	-	-	-	-	(79–81, 129)
		P: Contamination which stems from physical environment due to the dust and impurities.	5	3	3	45	Not significant	-	-	-	-	(79–81, 129)
5	Closing the mouth of the pot with grape leaves	B: Microbiological contamination due to the *Enterobacteriaceae*, associated with *P. agglomerans, P. ananatis, P. agglomerans, Er. persicina* and *Ew. americana*	7	9	3	189	Grapes must be stored between 0 and -2°C. Certified products from reliable vendors have to be used. The contaminated parts have to be removed. Storage conditions have to be held at an optimal degree. Humidity needs to be checked.	2	9	2	36	(145, 146)
		C: Contamination due to the presence of mycotoxin (Ochratoxin A)	7	9	3	189	Certified products from reliable vendors have to be used. The contaminated parts have to be removed. Storage conditions have to be held at an optimal degree. Effective washing procedure must be implemented.	2	9	2	36	(87, 88, 143)

CP	Processing stage	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections	List of literatures
		C: Contamination due to fungicide residues (Sulphur dioxide)	7	9	3	189	Certified products from reliable vendors have to be used. The contaminated parts have to be removed. Storage conditions have to be held at an optimal degree. Humidity needs to be checked. Effective washing procedure must be implemented	2	9	2	36	(88, 90)
		P: Physical contamination caused by the passage of dust and sand into the food by air and insect particles	4	4	3	48	Not significant	-	-	-	-	(79–81, 129)
6	Embedding clay into the soil	B: Mold growth stems from moisture changes due to inappropriate storage conditions	6	9	3	162	Reliable vendor must be prefered. Reject the contaminated portion. Storage conditions have to be held at an optimal degree. Humidity needs to be checked.	2	9	3	54	(147)
		B: Microbial growth due to temperature fluctuation on the field.	8	9	3	216	Temperature of the field needs to be checked regularly with an appropriate thermometer.	2	9	2	36	(147)
		B: Microbiological reproduction caused by inappropriate storage conditions	5	8	6	240	Properly cleaned, regularly inspected areas in terms of hygiene have to be used for storage.	2	8	4	64	(147)
7	Storage for 3 weeks	B: Microbiological reproduction caused by inappropriate storage conditions	5	8	6	240	Properly cleaned, regularly inspected areas in terms of hygiene have to be used for storage.	2	8	4	64	(83–85)

CP	Processing stage	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections	List of literatures
		B: Microbiological reproduction caused by inappropriate storage temperature	6	7	6	252	Calibration of thermometers / probes used for temperature measurements must be carried out on time and regularly.	2	7	2	28	(83–85)
		B: Mold growth stems from moisture changes due to inappropriate storage conditions	6	9	3	162	Certified products from reliable vendors have to be used. The contaminated parts have to be removed. Storage conditions have to be held at an optimal degree. Humidity needs to be checked.	2	9	3	54	(83–85)
		C: Chemical contamination due to mycotoxins such as Byssoclamic acid, Patulin, Ochratoxin A	6	7	7	294	None	-	-	-	-	(86)
8	Filtration	B: Microbiological contamination as a result of poor manual cleaning and storage of kitchen equipment	5	8	4	160	Appropriate cleaning methods has to be applied.	2	8	2	32	
		B: Microbiological contamination due to the use of inappropriate cleaning material.	6	7	2	84	Not significant	-	-	-	-	(130, 131)
		C: Detergent residue due to poor rinsing after cleaning	4	7	6	168	Appropriate cleaning procedure has to be followed.	2	7	1	14	(38, 68)
		P: Physical contaminants due to the damaged filtration tool	4	4	3	48	Not significant	-	-	-	-	(79–81, 129)
9	Bottling	B: Microbiological contamination due to the insufficient cleaning of the bottle by manual cleaning	6	8	6	288	Appropriate cleaning methods has to be applied.	2	8	4	64	(38, 68)

CP	Processing stage	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections	List of literatures
		B: Microbiological contamination caused by improper closing or sealing of bottle	8	8	5	320	Maintenance of equipment (maintenance procedure) must be ensured. Personnel education is required.	4	8	2	64	(38, 68)
		B: Contamination from the bottle	6	7	7	294	Vendor must be reliable.	3	7	4	84	(38, 68)
		B: Contamination stems from incorrect handling of personnel during food processing	6	8	7	336	Food personnel has to be taught the correct handwashing techniques and their importance along with hygiene training. Hands should be washed using quality approved disinfectants and personnel hygiene should be checked continuously.	2	8	3	48	(123–128)
		P: Contamination from the staff due to improper practices during packaging	5	4	6	120	Personnel should be developed through training, which highlights the significance of the utilization of food processor tools like gloves, arm sleeve covers and bonnet.	2	4	5	40	(77, 78, 121, 122)

Table B. 5. Implementation of FMEA to Hayva Şerbeti Production

CP	Processing stage	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections	List of literatures
1	Receiving raw ingredients - Water supply	B: *Hepatitis A, Escherichia coli, Giardia lamblia, Vibrio cholera, Shigella spp., Cryptosporidium parvum, Cyclospora cayetanensis, Salmonella spp., Toxoplasma gondii* and *Norwalk*, viruses can carried by water	4	7	8	224	Analysis of microbiological reproduction must be performed periodically. With the help of chemical agents, microbiological treatment of water must be done with chlorine, ozone.	2	7	2	28	(5, 42, 110–112)
		B: Parasites in water	4	7	8	224	Analysis of microbiological reproduction must be performed periodically. With the help of chemical agents, microbiological treatment of water must be done with chlorine, ozone.	2	7	2	28	(5, 110–112)
		C: Chemical substance contamination like bromate, benzene, cyanide in water	4	8	7	224	Chemical analysis has to be performed periodically. Proper filtration system has to be utilized if necessary.	2	8	3	48	(5)
		C: Contamination of water by nitrate or fertilisers containing nitrate	4	7	6	168	Chemical analysis has to be performed periodically. Proper filtration system has to be utilized if necessary.	2	7	3	42	(5, 110)

CP	Processing stage	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections	List of literatures
		C: Water contaminated with heavy metal residues like lead, arsenic, cadmium	4	8	9	288	Chemical analysis has to be performed periodically. Proper filtration system has to be utilized if necessary.	2	8	3	48	(5, 42, 113)
		C: Uncontrolled water source with high chlorine concentration	6	7	3	126	Utilize drinkable water controlled by local authority. Perform regular laboratory examination.	2	7	3	42	(5, 42, 110–113)
		C: Pesticide contamination of water through soil erosion from the agricultural fields	7	9	3	189	Utilize drinkable water controlled by local authority. Perform regular laboratory examination.	2	9	2	36	(5, 42, 113)
		C: Contamination of water due to inappropriate or damaged metal pipe connections	6	7	3	126	Pipes and connectors must comply with standards.	2	7	3	42	(5, 42, 110)

CP	Processing stage	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections	List of literatures
	Receiving quince	B: Microbiological contamination due to the mold (*Penicillium Expansum*)	6	9	4	216	Certified products from reliable vendors have to be used. The contaminated parts have to be removed. Storage conditions have to be held at an optimal degree. Humidity needs to be checked. Effective washing procedure must be implemented. Low doses of UV-C (below 280 nm), chitosans, propolis, glucosinolates must be used to induce resistance against pathogens in harvested fruits	2	9	3	54	(148, 149)
		C: Mycotoxin contamination (Patulin)	6	9	5	270	Certified products from reliable vendors have to be used. The contaminated parts have to be removed. Storage conditions have to be held at an optimal degree.Humidity needs to be checked. Effective washing procedure must be implemented. Low doses of UV-C (below 280 nm), chitosans, propolis, glucosinolates must be used to induce resistance against pathogens in harvested fruits	2	9	4	72	(148, 149)

CP	Processing stage	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections	List of literatures
		C: Pesticide contamination such as insecticide (organophosphorous) and fungicides (triazoles)	6	9	5	270	Certified products from reliable vendors have to be used. The contaminated parts have to be removed. Storage conditions have to be held at an optimal degree. Pesticide analysis has to be done.	2	9	3	54	(97, 135)
		P: Contamination of raw materials by foreign objects.	4	2	2	16	Not significant	-	-	-	-	(79–81, 129)
	Receiving saffron	B: Microbiological contamination by bacterias (*Bacillus simplex, Dietzia maris*) due to the improper Saffron treatment	6	9	5	270	Appropriate drying methods (with increased intensity treatment) must be applied to the saffron	2	9	4	72	(150–153)
		B: Microbiological contamination by fungi (mostly *Aspergillus flavus, A. parasiticu*s, and *A. Niger*)	6	9	5	270	Reliable vendor must be prefered. Storage conditions must be optimized.	2	9	4	72	(154)
		C: Presence of mycotoxin in saffron (AFB_1)	7	9	5	315	Reliable vendor must be prefered. Storage conditions must be optimized.	2	9	4	72	(154–156)
		P: Contamination which stems from physical environment due to the dust and impurities.	5	3	3	45	Not significant	-	-	-	-	(79–81, 129)

CP	Processing stage	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections	List of literatures
	Receiving honey	B: Microbiological contamination in honey due to the yeasts and spore-forming bacteria (*Bacillus genus, Clostridium botulinum*)	6	10	5	300	Certified products from reliable vendors have to be used. The contaminated parts have to be removed. Storage conditions have to be held at an optimal degree. Health authorities should establish regulations that guarantee and control the production, processing and analysis of honey. The safety of honeys must be verified with correct analysis and labeled.	2	9	4	72	(91, 92, 157)
		C: Antibiotics, pesticides, herbicides and metal contamination such as copper (Cu), cobalt (Co) and nickel (Ni)	6	9	5	270	Certified products from reliable vendors have to be used. The contaminated parts have to be removed. Storage conditions have to be held at an optimal degree. Health authorities should establish regulations that guarantee and control the production, processing and analysis of honey. The safety of honeys must be verified with correct analysis and labeled.	2	9	3	54	(91, 92)

Implementation of FMEA to Hayva Şerbeti Production

CP	Processing stage	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections	List of literatures
		C: Allergen proteins derived from the proteins secreted by the bees responsible for honey allergy (honeybee heads and pollen proteins)	6	9	4	216	Certified products from reliable vendors have to be used. The contaminated parts have to be removed. Storage conditions have to be held at an optimal degree. Health authorities should establish regulations that guarantee and control the production, processing and analysis of honey. The safety of honeys must be verified with correct analysis and labeled.	2	9	3	54	(91, 93)
		C: Honey contamination due to the phytotoxins like pyrrolizidine alkaloids, GTXs, hyoscyamine, hyoscine, saponin, strychnine	6	9	5	270	Certified products from reliable vendors have to be used. The contaminated parts have to be removed. Storage conditions have to be held at an optimal degree. Health authorities should establish regulations that guarantee and control the production, processing and analysis of honey. The safety of honeys must be verified with correct analysis and labeled.	2	9	3	54	(91)

CP	Processing stage	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections	List of literatures
		C: Chemical formation of 5-hydroxymethylfurfural (HMF) during the heating or preservation processes	6	9	4	216	Process control must be done regularly. Degree of heat exposed to the honey have to be under control.	2	9	2	36	(91)
		P: Contamination which stems from physical environment due to the dust and impurities.	5	3	3	45	Not significant	-	-	-	-	(79–81, 129)
	Receiving vinegar	B: Microbiological contamination due to the *Bacillus sp.* and *Lactobacillus sp.* (metabolites like organic acids) in vinegar	6	9	3	162	Climate change must be under control. Certified products from reliable vendors have to be used. The contaminated parts have to be removed. Storage conditions have to be held at an optimal degree.	2	9	3	54	(158)
		C: Contamination of Ochratoxin A (OTA)	5	9	4	180	Climate change must be under control. Certified products from reliable vendors have to be used. The contaminated parts have to be removed. Storage conditions have to be held at an optimal degree.	2	9	3	54	(87, 143, 159)
		P: Contamination which stems from physical environment due to the dust and impurities.	5	3	3	45	Not significant	-	-	-	-	(79–81, 129)

CP	Processing stage	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections	List of literatures
2	Crushing quince with peel and kernel	B: Microbial growth caused by unhealthy practices without attention to personal hygiene	8	9	3	216	Personnel should be developed through training, which highlights the significance of the utilization of food processor tools like gloves, arm sleeve covers and bonnet.	2	9	3	54	(5, 42, 47, 50, 96)
		B: Contamination stems from incorrect handling of personnel during food processing	6	8	7	336	Food personnel has to be taught the correct handwashing techniques and their importance along with hygiene training. Hands should be washed using quality approved disinfectants and personnel hygiene should be checked continuously.	2	8	3	48	(123–128)
		B: Cross contamination stems from poor cleaning or improper storage of equipment and utensils such as cutting boards, knives	6	8	6	288	Proper cleaning procedure (disinfection, washing, rinsing, and cleaning) must be applied. To verificate, microbiological analysis has to be performed periodically. If raw and cooked foods are processed concurrently, different storage containers and cutting tools must be utilized as equipment.	2	8	4	64	(76, 104–107)
		C: Cleaning agent residues as a result of insufficient rinsing of equipments by personnel	5	5	3	75	Not significant	-	-	-	-	(68)

CP	Processing stage	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections	List of literatures
		P: Contamination from the staff (Hair, nail, jeweleries, etc.) because of inappropriate implementations throughout process	5	4	6	120	Personnel should be developed through training, which highlights the significance of the utilization of food processor tools like gloves, arm sleeve covers and bonnet.	2	4	5	40	(77, 78, 121, 122)
3	Boiling in a copper pot	B: Cross contamination-from improper pot cleaning (manual cleaning)	7	9	3	189	Personnel education is required. Proper washing, cleaning, rinsing and disinfection equipment must be implemented.	2	9	2	36	(76, 104–107)
		B: Disease causing microorganisms due to improper time and temperature treatment	5	5	3	75	Not significant	-	-	-	-	(5, 42)
		C: Cleaning agent residues as a result of insufficient rinsing of equipments by personnel	5	5	3	75	Not significant	-	-	-	-	(68)
		C: Addition of copper from the pot	8	8	3	192	Pots and utensils made by stainless steel must be used	1	8	1	8	(144)
		P: Contamination which stems from physical environment due to the dust and impurities.	5	3	3	45	Not significant	-	-	-	-	(79–81, 129)

CP	Processing stage	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections	List of literatures
4	Mixing with wooden spoon (Saffron)	B: Microbial growth caused by unhealthy practices without attention to personal hygiene	8	9	3	216	Personnel should be developed through training, which highlights the significance of the utilization of food processor tools like gloves, arm sleeve covers and bonnet.	2	9	3	54	(5, 42, 47, 50, 96)
		C: Cleaning agent residues as a result of insufficient rinsing of equipments by personnel	5	5	3	75	Not significant	-	-	-	-	(68)
		P: Contamination from the staff (Hair, nail, jewelleries, etc.) because of inappropriate implementations throughout process	5	4	6	120	Personnel should be developed through training, which highlights the significance of the utilization of food processor tools like gloves, arm sleeve covers and bonnet.	2	4	5	40	(77, 78, 121, 122)
		P: Wood pieces from the worn mixing equipment	3	6	4	72	Not significant	-	-	-	-	
		P: Foreign materials from the mixing equipment (wooden spoon) due to improper cleaning.	5	4	6	120	Appropriate cleaning methods has to be applied. Food personnel has to be regularly checked in terms of hygiene and sanitary safety ensured.	2	4	5	40	(79–81, 129)
5	Mixing (Honey, Vinegar)	B: Microorganisms from the environment (air)	5	5	3	75	Not significant	-	-	-	-	
		C: Cleaning agent residues as a result of insufficient rinsing of equipments by personnel	5	5	3	75	Not significant	-	-	-	-	(68)

CP	Processing stage	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections	List of literatures
		P: Contamination from the staff (Hair, nail, jewelleries, etc.) because of inappropriate implementations throughout process	5	4	6	120	Personnel should be developed through training, which highlights the significance of the utilization of food processor tools like gloves, arm sleeve covers and bonnet.	2	4	5	40	(77, 78, 121, 122)
		P: Contamination which stems from physical environment due to the dust and impurities.	5	3	3	45	Not significant	-	-	-	-	(79–81, 129)
6	Pouring into the closed-mouth jar	B: Microbial growth caused by unhealthy practices without attention to personal hygiene	8	9	3	216	Personnel should be developed through training, which highlights the significance of the utilization of food processor tools like gloves, arm sleeve covers and bonnet.	2	9	3	54	(5, 42, 47, 50, 96)
		B: Microbiological contamination caused by improper closing or sealing of jar	8	8	5	320	Maintenance of equipment must be ensured. Personnel education is required.	4	8	2	64	(5)
		P: Contamination from the staff (Hair, nail, jewelleries, etc.) because of inappropriate implementations throughout process	5	4	6	120	Personnel should be developed through training, which highlights the significance of the utilization of food processor tools like gloves, arm sleeve covers and bonnet.	2	4	5	40	(77, 78, 121, 122)

Implementation of FMEA to Hayva Şerbeti Production

CP	Processing stage	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections	List of literatures
		P: Contamination which stems from physical environment due to the dust and impurities.	5	3	3	45	Not significant	-	-	-	-	(79–81, 129)
7	Storage for a week	B: Microbiological reproduction caused by inappropriate storage conditions	5	8	6	240	Properly cleaned, regularly inspected areas in terms of hygiene have to be used for storage.	2	8	4	64	(83–85)
		B: Microbiological reproduction caused by inappropriate storage temperature	6	7	6	252	Calibration of thermometers / probes used for temperature measurements must be carried out on time and regularly.	2	7	2	28	(83–85)

Table B. 6. Implementation of FMEA to Kefir Production

CP	Processing stage	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections	List of literatures
1	Raw milk	B: Microbiological contamination in raw milk stems from incorrect handling of personnel during food processing	9	7	5	315	Vendor must be reliable. After receiving immediate cooling below 5 °C is required. Precautions must be taken to prevent breakage of the cold chain from farm to receiving. The pH controls must be done for each lot	4	7	2	56	(5, 123–128)
		B: High number of pathogen (*Mycobacterium tuberculosis, E.coli O157:H7, Shigella dysenteria, Salmonella spp.*, etc.) in milk caused by incorrect handling during the process and storage	8	10	9	720	Vendor must be reliable. After receiving immediate cooling below 5 °C is required. Precautions must be taken to prevent breakage of the cold chain from farm to receiving. The pH controls must be done for each lot. Pathogen analysis has to be done periodically	3	10	3	90	(5, 123–128)
		B: Contamination of raw milk with enterotoxin producing *S. Aureus* due to the mastitis disease of bovine	5	8	5	200	Veterinary controls in cattle farms must be done periodically. Regular somatic cell count must be done regularly	2	8	2	32	(5, 94, 95)

CP	Processing stage	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections	List of literatures
		B: Microbiological contamination due to the parasites such as *Cryptosporidium spp.*, *Protozoa* in milk from unhealthy animal sources	3	8	8	192	Vendor must be reliable. Veterinary controls in cattle farms must be done periodically. Analysis for parasites must be perform regularly.	2	8	5	80	(5, 94)
		C: Veterinary drug residues in milk samples caused by improper veterinary practices	7	8	7	392	Vendor must be reliable. Antibiotics analysis must regularly be performed for each lot with the help of antibiotic kits	2	8	2	32	(5, 94)
		C: Environmental contaminants (primarily dioxin and dioxin-like compounds)	7	8	7	392	Vendor must be reliable. Analysis for environmental contaminants must regularly be performed for each lot	2	8	2	32	(5, 94)
		C: High level of aflatoxin M_1 in milk which stems from improper agricultural practices and contaminated feed using in cattle farms	5	8	9	360	Vendor has to be reliable. Total aflatoxin analysis must regularly be performed for each lot with the help of aflatoxin kits	2	8	2	32	(5, 94)
		C: Pesticide contamination caused by organophosphorus and carbamates residues in milk and feedstuff supplied to dairy cattle	3	8	8	192	Vendor has to be reliable. Pesticide analysis has to be performed periodically.	2	8	5	80	(5, 94, 160)

CP	Processing stage	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections	List of literatures
		P: Metal, glass, plastic etc. contamination of raw milk due to inappropriate interventions by personnel and agricultural practices	5	6	2	60	Not significant	-	-	-	-	(79–81, 129)
2	Boiling (90 °C for 2 mins)	B: Cross contamination-from improper pot cleaning (manual cleaning)	7	9	3	189	Personnel education is required. Proper washing, cleaning, rinsing and disinfection equipment must be implement.	2	9	2	36	(76, 104–107)
		B: Disease causing microorganisms due to improper time and temperature treatment	5	5	3	75	Not significant	-	-	-	-	(49, 51)
		C: Cleaning agent residues as a result of insufficient rinsing of equipments by personnel	5	5	3	75	Not significant	-	-	-	-	(68)
		C: Addition of copper from the pot	8	8	3	192	Pots and utensils made by stainless steel must be used	1	8	1	8	(144)
		P: Contamination which stems from physical environment due to the dust and impurities.	5	3	3	45	Not significant	-	-	-	-	(79–81, 129)
3	Cooling to 35-40 °C	B: Microbiological contamination from the environment especially air	5	5	3	75	Not significant	-	-	-	-	(49, 51)
		B: Microbial growth due to the extended cooling time (uncontrolled time-temperature relation)	7	7	2	98	Not significant	-	-	-	-	(49, 51)

CP	Processing stage	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections	List of literatures
		P: Contamination which stems from physical environment due to the dust and impurities.	5	3	3	45	Not significant	-	-	-	-	(79–81, 129)
4	Addition of kefir grains	B: Pathogens from the contaminated kefir culture	5	9	7	315	Vendor must be reliable. Staff must be trained about the proper handling of kefir cultures	2	9	4	72	
		B: Microbial growth caused by unhealthy practices without attention to personal hygiene	8	9	3	216	Personnel should be developed through training, which highlights the significance of the utilization of food processor tools like gloves, arm sleeve covers and bonnet.	2	9	3	54	(5, 42, 47, 50, 96)
		P: Foreign materials from the packages used for kefir culture packaging	4	5	3	60	Not significant	-	-	-	-	(79–81, 129)
5	Wrapping mouth with cloth pouch (overnight)	B: Microorganisms from the unclean wrapping material	5	9	4	180	Staff must be trained. Appropriate cleaning methods has to be applied. Wrapping material must not be used repeatedly.	2	9	2	36	(108)
		B: Microbial growth caused by unhealthy practices without attention to personal hygiene	8	9	3	216	Personnel should be developed through training, which highlights the significance of the utilization of food processor tools like gloves, arm sleeve covers and bonnet.	2	9	3	54	(5, 42, 47, 50, 96)
		P: Foreign materials from the wrapping material	5	4	3	60	Not significant	-	-	-	-	(108, 109)

CP	Processing stage	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections	List of literatures
		P: Contamination from the staff (Hair, nail, jewelleries, etc.) because of inappropriate implementations throughout process	5	4	6	120	Personnel should be developed through training, which highlights the significance of the utilization of food processor tools like gloves, arm sleeve covers and bonnet.	2	4	5	40	(77, 78, 121, 122)
6	Storage in refrigerator (4-5 hours)	B: Microbiological contamination stems from inappropriate storage conditions and excessive storage time	5	10	6	300	Food personnel has to be trained in food safety. Process control should be carried to computer as much as possible. Maintenance and control of the thermometer and probe have to be performed regularly.	2	10	2	40	(49, 51)
		B: Cross contamination caused by improper storage conditions	6	9	5	270	Appropriate storage conditions must be provided. Foods should be properly placed in the refrigerator.	2	9	3	54	(76, 104–107)
		P: Contamination which stems from physical environment due to the dust and impurities.	5	3	3	45	Not significant	-	-	-	-	(79–81, 129)
7	Removal of kefir grains with sterile sieve	P: Contamination from the staff due to improper practices during packaging	5	4	6	120	Personnel should be developed through training, which highlights the significance of the utilization of food processor tools like gloves, arm sleeve covers and bonnet.	2	4	5	40	(77, 78, 121, 122)

CP	Processing stage	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections	List of literatures
8	Manual Bottling	B: Microbiological contamination due to the insufficient cleaning of the bottle by manual cleaning	6	8	6	288	Appropriate cleaning methods has to be applied.	2	8	4	64	(38, 68)
		B: Microbiological contamination caused by improper closing or sealing of bottle	8	8	5	320	Maintenance of equipment (maintenance procedure) must be ensured. Personnel education is required.	4	8	2	64	(38, 68)
		B: Contamination from the bottle	6	7	7	294	Vendor must be reliable.	3	7	4	84	(38, 68)
		B: Contamination stems from incorrect handling of personnel during food processing	6	8	7	336	Food personnel has to be taught the correct handwashing techniques and their importance along with hygiene training. Hands should be washed using quality approved disinfectants and personnel hygiene should be checked continuously.	2	8	3	48	(123–128)
		P: Contamination from the staff due to improper practices during packaging	5	4	6	120	Personnel should be developed through training, which highlights the significance of the utilization of food processor tools like gloves, arm sleeve covers and bonnet.	2	4	5	40	(77, 78, 121, 122)

Table B. 7. Implementation of FMEA to Mişmiş Şerbeti Production

CP	Processing stage	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections	List of literatures
1	Receiving raw ingredients-Water supply	B: *Hepatitis A, Escherichia coli, Giardia lamblia, Vibrio cholera, Shigella spp., Cryptosporidium parvum, Cyclospora cayetanensis, Salmonella spp., Toxoplasma gondii* and *Norwalk*, viruses can carried by water	4	7	8	224	Analysis of microbiological reproduction must be performed periodically. With the help of chemical agents, microbiological treatment of water must be done with chlorine, ozone.	2	7	2	28	(5, 42, 110–112)
		B: Parasites in water	4	7	8	224	Analysis of microbiological reproduction must be performed periodically. With the help of chemical agents, microbiological treatment of water must be done with chlorine, ozone.	2	7	2	28	(5, 110–112)
		C: Chemical substance contamination like bromate, benzene, cyanide in water	4	8	7	224	Chemical analysis has to be performed periodically. Proper filtration system has to be utilized if necessary.	2	8	3	48	(5)
		C: Contamination of water by nitrate or fertilisers containing nitrate	4	7	6	168	Chemical analysis has to be performed periodically. Proper filtration system has to be utilized if necessary.	2	7	3	42	(5, 110)

CP	Processing stage	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections	List of literatures
		C: Water contaminated with heavy metal residues like lead, arsenic, cadmium	4	8	9	288	Chemical analysis has to be performed periodically. Proper filtration system has to be utilized if necessary.	2	8	3	48	(5, 42, 113)
		C: Uncontrolled water source with high chlorine concentration	6	7	3	126	Utilize drinkable water controlled by local authority. Perform regular laboratory examination.	2	7	3	42	(5, 42, 110–113)
		C: Pesticide contamination of water through soil erosion from the agricultural fields	7	9	3	189	Utilize drinkable water controlled by local authority. Perform regular laboratory examination.	2	9	2	36	(5, 42, 113)
		C: Contamination of water due to inappropriate or damaged metal pipe connections	6	7	3	126	Pipes and connectors must comply with standards.	2	7	3	42	(5, 42, 110)
	Receiving apricot	B: Microbiological contamination due to the mold (*Penicillium expansum*)	6	9	4	216	Certified products from reliable vendors have to be used. The contaminated parts have to be removed. Storage conditions have to be held at an optimal degree. Humidity needs to be checked. Effective washing procedure must be implemented. Low doses of UV-C (below 280 nm), chitosans, propolis, glucosinolates must be used to induce resistance against pathogens in harvested fruits	2	9	3	54	(148, 149)

Implementation of FMEA to Mişmiş Şerbeti Production

CP	Processing stage	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections	List of literatures
		B: Microbiological contamination due to the postharvest appricot pathogens (*A. alternata, R. nigricans and T. Roseum)*	6	9	3	162	Climate change must be under control. Certified products from reliable vendors have to be used. The contaminated parts have to be removed. Storage conditions have to be held at an optimal degree.	2	9	3	54	(143, 161)
		C: Mycotoxin contamination (Patulin, Ochratoxin A, Aflatoxin)	6	9	5	270	Certified products from reliable vendors have to be used. The contaminated parts have to be removed. Storage conditions have to be held at an optimal degree. Effective washing procedure must be implemented. Low doses of UV-C (below 280 nm), chitosans, propolis, glucosinolates must be used to induce resistance against pathogens in harvested fruits	2	9	4	72	(143, 148, 161)
		C: Pesticide contamination (Acetamiprid, chlorpyriphos and carbendazim)	6	9	5	270	Certified products from reliable vendors have to be used. The contaminated parts have to be removed. Storage conditions have to be held at an optimal degree. Pesticide analysis has to be done.	2	9	3	54	(97)
		P: Contamination which stems from physical environment due to the dust and impurities.	5	3	3	45	Not significant	-	-	-	-	(79–81, 129)

CP	Processing stage	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections	List of literatures
	Receiving sugar	B: Microbial growth due to poor storage conditions before and after receiving	5	7	4	140	Certified products from reliable vendors have to be used. The contaminated parts have to be removed. Storage conditions have to be held at an optimal degree.	2	9	2	36	(42)
		P: Contamination which stems from physical environment due to the dust and impurities.	5	3	3	45	Not significant	-	-	-	-	(79–81, 129)
2	Removing the apricot kernel	B: Microbial growth caused by unhealthy practices without attention to personal hygiene	8	9	3	216	Personnel should be developed through training, which highlights the significance of the utilization of food processor tools like gloves, arm sleeve covers and bonnet.	2	9	3	54	(5, 42, 47, 50, 96)
		B: Cross-contamination as a result of poor manual cleaning and storage of kitchen equipment such as knives and cutting boards	6	8	6	288	Proper cleaning procedure (disinfection, washing, rinsing, and cleaning) must be applied. To verificate, microbiological analysis has to be performed periodically.	2	8	4	64	(76, 104–107)
		P: Contamination from the staff (Hair, nail, jewelleries, etc.) because of inappropriate implementations throughout process	5	4	6	120	Personnel should be developed through training, which highlights the significance of the utilization of food processor tools like gloves, arm sleeve covers and bonnet.	2	4	5	40	(77, 78, 121, 122)

Implementation of FMEA to Mişmiş Şerbeti Production

CP	Processing stage	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections	List of literatures
3	Arranging on a tray	B: Microbial growth caused by unhealthy practices without attention to personal hygiene	8	9	3	216	Personnel should be developed through training, which highlights the significance of the utilization of food processor tools like gloves, arm sleeve covers and bonnet.	2	9	3	54	(5, 42, 47, 50, 96)
		C: Cleaning agent residues as a result of insufficient rinsing of equipments by personnel	5	5	3	75	Not significant	-	-	-	-	(68)
		P: Contamination which stems from physical environment due to the dust and impurities (e.g insect fragments)	5	5	3	75	Not significant	-	-	-	-	(79–81, 129)
		P: Plastic, glass and metal particles transmitted from the tray	4	6	4	96	Not significant	-	-	-	-	(144)
4	Interspersing sugar	B: Microbial growth caused by unhealthy practices without attention to personal hygiene	8	9	3	216	Personnel should be developed through training, which highlights the significance of the utilization of food processor tools like gloves, arm sleeve covers and bonnet.	2	9	3	54	(5, 42, 47, 50, 96)
		B: Microbial growth due to poor storage conditions before and after receiving	5	7	4	140	Certified products from reliable vendors have to be used. The contaminated parts have to be removed. Storage conditions have to be held at an optimal degree.	2	9	2	36	(51, 162)

CP	Processing stage	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections	List of literatures
		B: Contamination stems from incorrect handling of personnel during food processing	6	8	7	336	Food personnel has to be taught the correct handwashing techniques and their importance along with hygiene training. Hands should be washed using quality approved disinfectants and personnel hygiene should be checked continuously.	2	8	3	48	(123–128)
		P: Contamination of raw materials by foreign objects.	5	4	3	60	Not significant	-	-	-	-	(79–81, 129)
5	Storage in sun for 2 days	B: Microbiological contamination stems from inappropriate storage conditions and excessive storage time	5	10	6	300	Food personnel has to be trained in food safety. Process control should be carried to computer as much as possible. Maintenance and control of the thermometer and probe have to be performed regularly.	2	10	2	40	(83–85)
		C: The toxins and allergens found in some tissues or body fluids of insects may pass as a result of insect contact with food.	4	6	4	96	Not significant	-	-	-	-	(91, 93)
		P: Physical contamination caused by the passage of dust and sand into the food by air and insect particles	4	4	3	48	Not significant	-	-	-	-	(79–81, 129)
6	Boiling	B: Cross contamination-from improper pot cleaning (manual cleaning)	7	9	3	189	Personnel education is required. Proper washing, cleaning, rinsing and disinfection equipment must be implement.	2	9	2	36	(76, 104–107)

CP	Processing stage	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections	List of literatures
		B: Disease causing microorganisms due to improper time and temperature treatment	5	5	3	75	Not significant	-	-	-	-	
		C: Cleaning agent residues as a result of insufficient rinsing of equipments by personnel	5	5	3	75	Not significant	-	-	-	-	(68)
		C: Addition of copper from the pot	8	8	3	192	Pots and utensils made by stainless steel must be used	1	8	1	8	(144)
		P: Contamination which stems from physical environment due to the dust and impurities.	5	3	3	45	Not significant	-	-	-	-	(79–81, 129)
7	Storage for a day	B: Microbiological contamination stems from inappropriate storage conditions and excessive storage time	5	10	6	300	Food personnel has to be trained in food safety. Process control should be carried to computer as much as possible. Maintenance and control of the thermometer and probe have to be performed regularly.	2	10	2	40	(83–85)
		C: The toxins and allergens found in some tissues or body fluids of insects may pass as a result of insect contact with food.	4	6	4	96	Not significant	-	-	-	-	(91, 93)
		P: Physical contamination caused by the passage of dust and sand into the food by air and insect particles	4	4	3	48	Not significant	-	-	-	-	(79–81, 129)

CP	Processing stage	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections	List of literatures
8	Kneading	B: Microbial growth caused by unhealthy practices without attention to personal hygiene	8	9	3	216	Personnel should be developed through training, which highlights the significance of the utilization of food processor tools like gloves, arm sleeve covers and bonnet.	2	9	3	54	(5, 42, 47, 50, 96)
		B: Microbiological transmission through lack of personal hygiene	7	8	7	392	Food personnel has to be taught the correct handwashing techniques and their importance along with hygiene training. Hands should be washed using quality approved disinfectants and personnel hygiene should be checked continuously.	2	8	3	48	(77, 78, 121, 122)
		C: Cleaning agent residues as a result of insufficient rinsing of equipments by personnel	5	5	3	75	Not significant	-	-	-	-	(68)
		P: Foreign materials from the kneading box due to improper cleaning.	5	4	6	120	Appropriate cleaning methods has to be applied. Food personnel has to be regularly checked in terms of hygiene and sanitary safety ensured.	2	4	5	40	(79–81, 129)
		P: Contamination from the staff (Hair, nail, jewelleries, etc.) because of inappropriate implementations throughout process	5	4	6	120	Personnel should be developed through training, which highlights the significance of the utilization of food processor tools like gloves, arm sleeve covers and bonnet.	2	4	5	40	(77, 78, 121, 122)

CP	Processing stage	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections	List of literatures
		P: Contamination which stems from physical environment due to the dust and impurities.	5	3	3	45	Not significant	-	-	-	-	(79–81, 129)
9	Filtrating through cheese cloth	B: Microorganisms (*Pseudomonas aeruginosa, Klebsiella aerogenes, Staphylococcus saprophyticus, E. coli*) can pass from a poorly cleaned or contaminated cloth to hands.	5	9	5	225	Staff must be trained. Appropriate cleaning methods has to be applied. Cloth pouch must not be used repeatedly.	2	9	2	36	(108, 109)
		B: Microbiological contamination due to the use of inappropriate cleaning material.	6	7	2	84	Not significant	-	-	-	-	(130, 131)
		C: Detergent residue due to poor rinsing after cleaning	4	7	6	168	Appropriate cleaning procedure has to be followed.	2	7	1	14	(38, 68)
		P: Physical contaminants due to the damaged filtration tool (cheese cloth)	4	4	3	48	Not significant	-	-	-	-	(79–81, 129)
10	Manual Bottling	B: Microbiological contamination due to the insufficient cleaning of the bottle by manual cleaning	6	8	6	288	Appropriate cleaning methods has to be applied.	2	8	4	64	(38, 68)
		B: Microbiological contamination caused by improper closing or sealing of bottle	8	8	5	320	Maintenance of equipment (maintenance procedure) must be ensured. Personnel education is required.	4	8	2	64	(38, 68)
		B: Contamination from the bottle	6	7	7	294	Vendor must be reliable.	3	7	4	84	(38, 68)

CP	Processing stage	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections	List of literatures
		B: Contamination stems from incorrect handling of personnel during food processing	6	8	7	336	Food personnel has to be taught the correct handwashing techniques and their importance along with hygiene training. Hands should be washed using quality approved disinfectants and personnel hygiene should be checked continuously.	2	8	3	48	(123–128)
		P: Contamination from the staff due to improper practices during packaging	5	4	6	120	Personnel should be developed through training, which highlights the significance of the utilization of food processor tools like gloves, arm sleeve covers and bonnet.	2	4	5	40	(77, 78, 121, 122)
11	Storage in sun for 5 days	B: Microbiological contamination stems from inappropriate storage conditions and excessive storage time	5	10	6	300	Food personnel has to be trained in food safety. Process control should be carried to computer as much as possible. Maintenance and control of the thermometer and probe have to be performed regularly.	2	10	2	40	(83–85)
		C: The toxins and allergens found in some tissues or body fluids of insects may pass as a result of insect contact with food.	4	6	4	96	Not significant	-	-	-	-	(91, 93)
		P: Physical contamination caused by the passage of dust and sand into the food by air and insect particles	4	4	3	48	Not significant	-	-	-	-	(79–81, 129)

Table B. 8. Implementation of FMEA to Şalgam Suyu Production

CP	Processing stage	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections	List of literatures
1	Receiving raw ingredients-Water supply	*B: Hepatitis A, Escherichia coli, Giardia lamblia, Vibrio cholera, Shigella spp., Cryptosporidium parvum, Cyclospora cayetanensis, Salmonella spp., Toxoplasma gondii* and *Norwalk*, viruses can carried by water	4	7	8	224	Analysis of microbiological reproduction must be performed periodically. With the help of chemical agents, microbiological treatment of water must be done with chlorine, ozone.	2	7	2	28	(5, 42, 110–112)
		B: Parasites in water	4	7	8	224	Analysis of microbiological reproduction must be performed periodically. With the help of chemical agents, microbiological treatment of water must be done with chlorine, ozone.	2	7	2	28	(5, 110–112)
		C: Chemical substance contamination like bromate, benzene, cyanide in water	4	8	7	224	Chemical analysis has to be performed periodically. Proper filtration system has to be utilized if necessary.	2	8	3	48	(5)
		C: Contamination of water by nitrate or fertilisers containing nitrate	4	7	6	168	Chemical analysis has to be performed periodically. Proper filtration system has to be utilized if necessary.	2	7	3	42	(5, 110)
		C: Water contaminated with heavy metal residues like lead, arsenic, cadmium	4	8	9	288	Chemical analysis has to be performed periodically. Proper filtration system has to be utilized if necessary.	2	8	3	48	(5, 42, 113)

CP	Processing stage	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections	List of literatures
		C: Uncontrolled water source with high chlorine concentration	6	7	3	126	Utilize drinkable water controlled by local authority. Perform regular laboratory examination.	2	7	3	42	(5, 42, 110–113)
		C: Pesticide contamination of water through soil erosion from the agricultural fields	7	9	3	189	Utilize drinkable water controlled by local authority. Perform regular laboratory examination.	2	9	2	36	(5, 42, 113)
		C: Contamination of water due to inappropriate or damaged metal pipe connections	6	7	3	126	Pipes and connectors must comply with standards.	2	7	3	42	(5, 42, 110)
	Receiving turnip	B: Microbiological contamination stems from *Salmonella spp., E. coliO157:H7* and *L. monocytogenes* from irrigation water and manure.	8	9	3	216	Government policies should be developed to control food processors and sellers. These practitioners should be trained in consumer health and product hygiene.	2	9	3	54	(98)
		C: Contamination due to growing the vegetables using contaminated soil	7	9	3	189	The soil protection requirements for the application of liquid manure, sewage sludge and fertilizers must be updated. Advising on needs based use of fertilizers and pesticides. Financial incentives has to be created to minimize them. Critical loads must be determined by government	2	9	2	36	(100, 163)
		C: Pesticide contamination (mostly Acetamiprid, chlorpyriphos and carbendazim)	6	9	5	270	Certified products from reliable vendors have to be used. The contaminated parts have to be removed. Storage conditions have	2	9	3	54	(97, 135)

CP	Processing stage	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections	List of literatures
							to be held at an optimal degree. Pesticide analysis has to be done.					
		C: Chemical contamination due to the environmental pollution (Cu, Mo and Se)	6	9	5	270	Government policies should be developed to control food processors and sellers. These practitioners should be trained in consumer health and product hygiene.	2	9	3	54	(164, 165)
		P: Contamination which stems from physical environment due to the dust and impurities.	5	3	3	45	Not significant	-	-	-	-	(79–81, 129)
	Receiving carrot	B: Microbiological contamination stems from *Salmonella spp., E. coliO157:H7* and *L. monocytogenes* from irrigation water and manure.	8	9	4	288	Government policies should be developed to control food processors and sellers. These practitioners should be trained in consumer health and product hygiene.	2	9	3	54	(98)
		B: Zoonotic parasite geohelminth eggs contamination *Toxocara spp.*	6	9	5	270	Government policies should be developed to control food processors and sellers. These practitioners should be trained in consumer health and product hygiene.	2	9	3	54	(99)

Implementation of FMEA to Şalgam Suyu Production

CP	Processing stage	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections	List of literatures
		C: Contamination due to growing the vegetables using contaminated soil	7	9	4	252	The soil protection requirements for the application of liquid manure, sewage sludge and fertilizers must be updated. Advising on needs based use of fertilizers and pesticides. Financial incentives has to be created to minimize them. Critical loads must be determined by government	2	9	3	54	(100, 163)
		C: Pesticide contamination (Acetamiprid, chlorpyriphos and carbendazim)	6	9	5	270	Certified products from reliable vendors have to be used. The contaminated parts have to be removed. Storage conditions have to be held at an optimal degree. Pesticide analysis has to be done.	2	9	3	54	(97, 135)
		C: Chemical contamination due to the environmental pollution (Cu, Mo and Se)	6	9	5	270	Government policies should be developed to control food processors and sellers. These practitioners should be trained in consumer health and product hygiene.	2	9	3	54	(164, 165)
		P: Contamination which stems from physical environment due to the dust and impurities.	5	3	3	45	Not significant	-	-	-	-	(79–81, 129)
	Receiving salt	B: Microbial growth due to poor storage conditions before and after receiving	5	7	4	140	Certified products from reliable vendors have to be used. The contaminated parts have to be	2	9	2	36	(42)

CP	Processing stage	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections	List of literatures
							removed. Storage conditions have to be held at an optimal degree.					
		P: Contamination which stems from physical environment due to the dust and impurities.	5	3	3	45	Not significant	-	-	-	-	(79–81, 129)
	Receiving dried pepper	B: Microbiological (Fungi) contamination stems from *Aspergillus fumigatus, A. Ochraceus, A. niger, A. flavus*	7	9	6	378	After the peppers are harvested, the peppers must be washed thoroughly and free from dirt. Reliable vendor must be prefered. Storage conditions have to be held at an optimal degree. Humidity needs to be checked.	2	9	4	72	(101)
		C: Mycotoxins OTA and mainly Aflatoxin B_1	7	9	5	315	Before packaging and storage aflatoxin analysis has to be done to determine the contamination levels of aflatoxins. The allowed maximum legal limits of total aflatoxin for red dried chili pepper is 10 ppb in Turkey.	3	9	3	81	(101–103)
		C: Pesticide contamination such as insecticide (organophosphorous) and fungicides (triazoles)	6	9	5	270	Certified products from reliable vendors have to be used. The contaminated parts have to be removed. Storage conditions have to be held at an optimal degree. Pesticide analysis has to be done.	2	9	3	54	(97, 135)
		P: Contamination which stems from physical environment due to the dust and impurities.	5	3	3	45	Not significant	-	-	-	-	(79–81, 129)

Implementation of FMEA to Şalgam Suyu Production

CP	Processing stage	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections	List of literatures
	Receiving bulgur flour	B: Microbiological contamination by bacterias (*Bacillus Cereus, Clostridium perfringens*) and fungus (*Aspergillus flavus, Fusarium graminearum, Fusarium verticilloides*)	6	9	6	324	The flour must be obtained from approved vendors. Quality control and microbiological analysis certificates must be available. The certificates must meet the approved standarts and should report the humidity of flour.	2	9	3	54	(138)
		C: Mycotoxins such as Zearalenone, Fumonisin, Aflatoxin B_1	5	9	6	270	Flour must be obtained from certified vendors. Quality control and chemical analysis certificates must be available.	2	9	3	54	(138)
		C: Pesticide contamination such as insecticide (organophosphorous) and fungicides (triazoles)	6	9	5	270	Certified products from reliable vendors have to be used. The contaminated parts have to be removed. Storage conditions have to be held at an optimal degree. Pesticide analysis has to be done.	2	9	3	54	(97, 135)
		P: Contamination which stems from physical environment due to the dust and impurities.	5	3	3	45	Not significant	-	-	-	-	(79–81, 129)
2	Kneading dough	B: Microbial growth caused by unhealthy practices without attention to personal hygiene	8	9	3	216	Personnel should be developed through training, which highlights the significance of the utilization of food processor tools like gloves, arm sleeve covers and bonnet.	2	9	3	54	(5, 42, 47, 50, 96)

CP	Processing stage	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections	List of literatures
		B: Microbiological transmission through lack of personal hygiene	7	8	7	392	Food personnel has to be taught the correct handwashing techniques and their importance along with hygiene training. Hands should be washed using quality approved disinfectants and personnel hygiene should be checked continuously.	2	8	3	48	(77, 78, 121, 122)
		C: Cleaning agent residues as a result of insufficient rinsing of equipments by personnel	5	5	3	75	Not significant	-	-	-	-	(68)
		P: Foreign materials from the kneading box due to improper cleaning.	5	4	6	120	Appropriate cleaning methods has to be applied. Food personnel has to be regularly checked in terms of hygiene and sanitary safety ensured.	2	4	5	40	(79–81, 129)
		P: Contamination from the staff (Hair, nail, jewelleries, etc.) because of inappropriate implementations throughout process	5	4	6	120	Personnel should be developed through training, which highlights the significance of the utilization of food processor tools like gloves, arm sleeve covers and bonnet.	2	4	5	40	(77, 78, 121, 122)
		P: Contamination which stems from physical environment due to the dust and impurities.	5	3	3	45	Not significant	-	-	-	-	(79–81, 129)
3	Wrapping with cloth pouch	B: Microorganisms (*Pseudomonas aeruginosa, Klebsiella aerogenes, Staphylococcus saprophyticus, E. coli*) can pass from a poorly	5	9	5	225	Staff must be trained. Appropriate cleaning methods has to be applied. Cloth pouch must not be used repeatedly.	2	9	2	36	(108)

CP	Processing stage	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections	List of literatures
		cleaned or contaminated cloth to hands.										
		B: Microbial growth caused by unhealthy practices without attention to personal hygiene	8	9	3	216	Personnel should be developed through training, which highlights the significance of the utilization of food processor tools like gloves, arm sleeve covers and bonnet.	2	9	3	54	(5, 42, 47, 50, 96)
		C: Chemical contamination due to the various pesticides utilized in the processing phases of natural fabrics like cotton (storage)	6	8	5	240	Reliable vendor must be prefered. Storage conditions have to be held at an optimal degree.	2	7	3	42	(109)
		P: Foreign materials from the cloth pouch	5	4	3	60	Not significant	-	-	-	-	(108, 109)
		P: Contamination which stems from physical environment due to the dust and impurities.	5	3	3	45	Not significant	-	-	-	-	(79–81, 129)
		P: Contamination from the staff (Hair, nail, jewelleries, etc.) because of inappropriate implementations throughout process.	5	4	6	120	Personnel should be developed through training, which highlights the significance of the utilization of food processor tools like gloves, arm sleeve covers and bonnet.	2	4	5	40	(77, 78, 121, 122)
4	Storage for 3 days	B: Microbiological reproduction caused by inappropriate storage conditions	5	8	6	240	Properly cleaned, regularly inspected areas in terms of hygiene have to be used for storage.	2	8	4	64	(83–85)
		B: Microbiological reproduction caused by inappropriate storage temperature	6	7	6	252	Calibration of thermometers / probes used for temperature measurements must be carried out on time and regularly.	2	7	2	28	(83–85)

CP	Processing stage	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections	List of literatures
5	Peeling and cutting (Turnip)	B: Microbial growth caused by unhealthy practices without attention to personal hygiene	8	9	3	216	Personnel should be developed through training, which highlights the significance of the utilization of food processor tools like gloves, arm sleeve covers and bonnet.	2	9	3	54	(5, 42, 47, 50, 96)
		B: Contamination stems from incorrect handling of personnel during food processing	6	8	7	336	Food personnel has to be taught the correct handwashing techniques and their importance along with hygiene training. Hands should be washed using quality approved disinfectants and personnel hygiene should be checked continuously.	2	8	3	48	(123–128)
		B: Cross-contamination as a result of poor manual cleaning and storage of kitchen equipment such as knives and cutting boards	6	8	6	288	Proper cleaning procedure (disinfection, washing, rinsing, and cleaning) must be applied. To verificate, microbiological analysis has to be performed periodically. If raw and cooked foods are processed concurrently, different storage containers and cutting tools must be utilized as equipment.	2	8	4	64	(76, 104–107)
		C: Cleaning agent residues as a result of insufficient rinsing of equipments by personnel	5	5	3	75	Not significant	-	-	-	-	(68)
		P: Contamination from the staff (Hair, nail, jeweleries, etc.) because of inappropriate	5	4	6	120	Personnel should be developed through training, which highlights the significance of the utilization of	2	4	5	40	(77, 78, 121, 122)

CP	Processing stage	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections	List of literatures
		implementations throughout process.					food processor tools like gloves, arm sleeve covers and bonnet.					
		P: Contamination which stems from physical environment due to the dust and impurities.	5	3	3	45	Not significant	-	-	-	-	(79–81, 129)
6	Mixing	B: Microorganisms from the environment (air)	5	5	3	75	Not significant	-	-	-	-	
		C: Cleaning agent residues as a result of insufficient rinsing of equipments by personnel	5	5	3	75	Not significant	-	-	-	-	(68)
		P: Contamination from the staff (Hair, nail, jewelleries, etc.) because of inappropriate implementations throughout process.	5	4	6	120	Personnel should be developed through training, which highlights the significance of the utilization of food processor tools like gloves, arm sleeve covers and bonnet.	2	4	5	40	(77, 78, 121, 122)
		P: Contamination which stems from physical environment due to the dust and impurities.	5	3	3	45	Not significant	-	-	-	-	(79–81, 129)
7	Storage for 3 days	B: Microbiological reproduction caused by inappropriate storage conditions	5	8	6	240	Properly cleaned, regularly inspected areas in terms of hygiene have to be used for storage.	2	8	4	64	(83–85)
		B: Microbiological reproduction caused by inappropriate storage temperature	6	7	6	252	Calibration of thermometers / probes used for temperature measurements must be carried out on time and regularly.	2	7	2	28	(83–85)

CP	Processing stage	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections	List of literatures
8	Peeling and cutting (Carrot)	B: Microbial growth caused by unhealthy practices without attention to personal hygiene	8	9	3	216	Personnel should be developed through training, which highlights the significance of the utilization of food processor tools like gloves, arm sleeve covers and bonnet.	2	9	3	54	(5, 42, 47, 50, 96)
		B: Contamination stems from incorrect handling of personnel during food processing	6	8	7	336	Personnel education on personnel hygiene and is required. Disinfectants must be supplied from the approved sources. Personal hygiene must be regularly controlled in a strict manner.	2	8	3	48	(123–128)
		B: Cross-contamination as a result of poor manual cleaning and storage of kitchen equipment such as knives and cutting boards	6	8	6	288	Proper cleaning procedure (disinfection, washing, rinsing, and cleaning) must be applied. To verificate, microbiological analysis has to be performed periodically. If raw and cooked foods are processed concurrently, different storage containers and cutting tools must be utilized as equipment.	2	8	4	64	(76, 104–107)
		C: Cleaning agent residues as a result of insufficient rinsing of equipments by personnel	5	5	3	75	Not significant	-	-	-	-	(68)
		P: Contamination from the staff (Hair, nail, jeweleries, etc.) because of inappropriate implementations throughout process.	5	4	6	120	Personnel should be developed through training, which highlights the significance of the utilization of food processor tools like gloves, arm sleeve covers and bonnet.	2	4	5	40	(77, 78, 121, 122)

Implementation of FMEA to Şalgam Suyu Production

CP	Processing stage	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections	List of literatures
		P: Contamination which stems from physical environment due to the dust and impurities.	5	3	3	45	Not significant	-	-	-	-	(79–81, 129)
9	Storage for a month	B: Microbiological reproduction caused by inappropriate storage conditions	5	8	6	240	Properly cleaned, regularly inspected areas in terms of hygiene have to be used for storage.	2	8	4	64	(83–85)
		B: Microbiological reproduction caused by inappropriate storage temperature	6	7	6	252	Calibration of thermometers / probes used for temperature measurements must be carried out on time and regularly.	2	7	2	28	(83–85)

Table B. 9. Implementation of FMEA to Töngel Şerbeti Production

CP	Processing stage	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections	List of literatures
1	Receiving raw ingredients - Water supply	B: *Hepatitis A, Escherichia coli, Giardia lamblia, Vibrio cholera, Shigella spp., Cryptosporidium parvum, Cyclospora cayetanensis, Salmonella spp., Toxoplasma gondii* and *Norwalk,* viruses can carried by water	4	7	8	224	Analysis of microbiological reproduction must be performed periodically. With the help of chemical agents, microbiological treatment of water must be done with chlorine, ozone.	2	7	2	28	(5, 42, 110–112)
		B: Parasites in water	4	7	8	224	Analysis of microbiological reproduction must be performed periodically. With the help of chemical agents, microbiological treatment of water must be done with chlorine, ozone.	2	7	2	28	(5, 110–112)
		C: Chemical substance contamination like bromate, benzene, cyanide in water	4	8	7	224	Chemical analysis has to be performed periodically. Proper filtration system has to be utilized if necessary.	2	8	3	48	(5)
		C: Contamination of water by nitrate or fertilisers containing nitrate	4	7	6	168	Chemical analysis has to be performed periodically. Proper filtration system has to be utilized if necessary.	2	7	3	42	(5, 110)
		C: Water contaminated with heavy metal residues like lead, arsenic, cadmium	4	8	9	288	Chemical analysis has to be performed periodically. Proper filtration system has to be utilized if necessary.	2	8	3	48	(5, 42, 113)

Implementation of FMEA to Töngel Şerbeti Production

CP	Processing stage	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections	List of literatures
		C: Uncontrolled water source with high chlorine concentration	6	7	3	126	Utilize drinkable water controlled by local authority. Perform regular laboratory examination.	2	7	3	42	(5, 42, 110–113)
		C: Pesticide contamination of water through soil erosion from the agricultural fields	7	9	3	189	Utilize drinkable water controlled by local authority. Perform regular laboratory examination.	2	9	2	36	(5, 42, 113)
		C: Contamination of water due to inappropriate or damaged metal pipe connections	6	7	3	126	Pipes and connectors must comply with standards.	2	7	3	42	(5, 42, 110)
	Receiving honey	B: Microbiological contamination in honey due to the yeasts and spore-forming bacteria (*Bacillus genus, Clostridium botulinum*)	6	10	5	300	Certified products from reliable vendors have to be used. The contaminated parts have to be removed. Storage conditions have to be held at an optimal degree. Health authorities should establish regulations that guarantee and control the production, processing and analysis of honey. The safety of honeys must be verified with correct analysis and labeled.	2	9	4	72	(91, 92, 157)

Implementation of FMEA to Töngel Şerbeti Production

CP	Processing stage	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections	List of literatures
		C: Antibiotics, pesticides, herbicides and metal contamination such as copper (Cu), cobalt (Co) and nickel (Ni)	6	9	5	270	Certified products from reliable vendors have to be used. The contaminated parts have to be removed. Storage conditions have to be held at an optimal degree. Health authorities should establish regulations that guarantee and control the production, processing and analysis of honey. The safety of honeys must be verified with correct analysis and labeled.	2	9	3	54	(91, 92)
		C: Allergen proteins derived from the proteins secreted by the bees responsible for honey allergy (honeybee heads and pollen proteins)	6	9	5	270	Certified products from reliable vendors have to be used. The contaminated parts have to be removed. Storage conditions have to be held at an optimal degree. Health authorities should establish regulations that guarantee and control the production, processing and analysis of honey. The safety of honeys must be verified with correct analysis and labeled.	2	9	3	54	(91, 93)

Implementation of FMEA to Töngel Şerbeti Production

CP	Processing stage	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections	List of literatures
		C: Honey contamination due to the phytotoxins like pyrrolizidine alkaloids, GTXs, hyoscyamine, hyoscine, saponin, strychnine	6	9	5	270	Certified products from reliable vendors have to be used. The contaminated parts have to be removed. Storage conditions have to be held at an optimal degree. Health authorities should establish regulations that guarantee and control the production, processing and analysis of honey. The safety of honeys must be verified with correct analysis and labeled.	2	9	3	54	(91)
		C: Chemical formation of 5-hydroxymethylfurfural (HMF) during the heating or preservation processes	6	9	4	216	Process control must be done regularly. Degree of heat exposed to the honey have to be under control.	2	9	2	36	(91)
		P: Contamination which stems from physical environment due to the dust and impurities.	5	3	3	45	Not significant	-	-	-	-	(79–81, 129)
	Receiving barley	B: Microbiological contamination due to the toxigenic genera (*Alternaria, Fusarium, Aspergillus, Penicillium*)	6	9	5	270	Barley must be purchased from reliable vendors and include quality certificates which demonstrate moisture content of grains. Defective portion must be rejected.	2	9	3	54	(72, 73)

Implementation of FMEA to Töngel Şerbeti Production

CP	Processing stage	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections	List of literatures
		C: Mycotoxins (Deoxynivalenol/nivalenol, Ochratoxin A, Zearalenone) contamination stems from mold growth as a result of improper storage after harvesting, as well as inappropriate environmental conditions during crop growth.	6	9	3	162	Barley must be purchased from reliable vendors and include quality certificates which demonstrate moisture content of grains. Defective portion must be rejected.	2	9	3	54	(72, 74)
		C: Contamination due to the rodents (mouse urinary aeroallergens)	6	9	4	216	Integrated Pest Management (IPM) program that uses feed and traps as well as accurate monitoring methods must be used.	2	9	3	54	(97, 135)
		C: Pesticide contamination such as insecticide (organophosphorous) and fungicides (triazoles)	6	9	5	270	Certified products from reliable vendors have to be used. The contaminated parts have to be removed. Storage conditions have to be held at an optimal degree. Pesticide analysis has to be done.	2	9	3	54	(75, 139)
		P: Contamination caused by physical pollutants such as feces, urine and hair carried by rodents	6	9	4	216	Integrated Pest Management (IPM) program that uses feed and traps as well as accurate monitoring methods must be used.	2	9	3	54	(75, 139)
	Receiving medlar	B: Microbiological contamination due to the mold (*Penicillium Expansum*)	6	9	4	216	Certified products from reliable vendors have to be used. The contaminated parts have to be removed. Storage conditions have to be held at an optimal degree. Humidity needs to be checked.	2	9	3	54	(148, 149)

Implementation of FMEA to Töngel Şerbeti Production

CP	Processing stage	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections	List of literatures
							Effective washing procedure must be implemented. Low doses of UV-C (below 280 nm), chitosans, propolis, glucosinolates must be used to induce resistance against pathogens in harvested fruits					
		C: Mycotoxin contamination (Patulin)	6	9	5	270	Certified products from reliable vendors have to be used. The contaminated parts have to be removed. Storage conditions have to be held at an optimal degree. Humidity needs to be checked. Effective washing procedure must be implemented. Low doses of UV-C (below 280 nm), chitosans, propolis, glucosinolates must be used to induce resistance against pathogens in harvested fruits	2	9	4	72	(148, 149)
		C: Pesticide residues such as Methamidophos, acephate, omethoate, fenitrothion	6	9	5	270	Certified products from reliable vendors have to be used. The contaminated parts have to be removed. Storage conditions have to be held at an optimal degree. Pesticide analysis has to be done.	2	9	3	54	(97, 135)
		P: Contamination of raw materials by foreign objects.	4	2	2	16	Not significant	-	-	-	-	(79–81, 129)

Implementation of FMEA to Töngel Şerbeti Production

CP	Processing stage	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections	List of literatures
	Receiving hazelnut	B: Mold growth stems from moisture changes due to inappropriate storage conditions	6	9	3	162	Certified products from reliable vendors have to be used. The contaminated parts have to be removed. Storage conditions have to be held at an optimal degree.	2	9	3	54	(42)
		C: Aflatoxin production caused by inappropriate drying process and storage conditions	7	9	3	189	Certified products from reliable vendors have to be used. The contaminated parts have to be removed. Storage conditions have to be held at an optimal degree.					(42)
		C: Allergens	3	9	2	54	Not significant	-	-	-	-	(42)
		P: Nut shell pieces	4	3	2	24	Not significant	-	-	-	-	(42)
2	Washing	B: Cross-contamination *Hepatitis A, Escherichia coli, Giardia lamblia, Vibrio cholera, Shigella spp., Cryptosporidium parvum, Cyclospora cayetanensis, Salmonella spp., Toxoplasma gondii* and *Norwalk,* viruses can carried by water	4	7	8	224	Microbiological analysis has to be performed for verification. Systems such as ozone, chlorine and UV must be implemented for microbial treatment of water.	2	7	2	28	(5, 42, 110–112)
		B: Contamination stems from incorrect handling of personnel during food processing	6	8	7	336	Food personnel has to be taught the correct handwashing techniques and their importance along with hygiene training. Hands should be washed using quality approved disinfectants and personnel hygiene should be checked continuously.	2	8	3	48	(123–128)

CP	Processing stage	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections	List of literatures
		P: Contamination from the staff (Hair, nail, jewelleries, etc.) because of inappropriate implementations throughout process	5	4	6	120	Personnel should be developed through training, which highlights the significance of the utilization of food processor tools like gloves, arm sleeve covers and bonnet.	2	4	5	40	(77, 78, 121, 122)
		P: Contamination which stems from physical environment due to the dust and impurities.	5	3	3	45	Not significant	-	-	-	-	(79–81, 129)
3	Place into the closed wooden bucket	B: Microbial growth caused by unhealthy practices without attention to personal hygiene	8	9	3	216	Personnel should be developed through training, which highlights the significance of the utilization of food processor tools like gloves, arm sleeve covers and bonnet.	2	9	3	54	(5, 42, 47, 50, 96)
		C: Cleaning agent residues as a result of insufficient rinsing of equipments by personnel	5	5	3	75	Not significant	-	-	-	-	(68)
		P: Physical contamination caused by the passage of dust and sand into the food by air and insect particles	4	4	3	48	Not significant	-	-	-	-	(79–81, 129)
		P: Wood pieces from the worn equipment (wooden bucket)	3	6	4	72	Not significant	-	-	-	-	
		P: Contamination from the staff (Hair, nail, jewelleries, etc.) because of inappropriate implementations throughout process	5	4	6	120	Personnel should be developed through training, which highlights the significance of the utilization of food processor tools like gloves, arm sleeve covers and bonnet.	2	4	5	40	(77, 78, 121, 122)

Implementation of FMEA to Töngel Şerbeti Production

CP	Processing stage	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections	List of literatures
4	Storage for 2 days	B: Microbiological reproduction caused by inappropriate storage conditions	5	8	6	240	Adequate facilities for hygienic storage must be provided. Appropriate cleaning methods has to be applied. Periodic controls.	2	8	4	64	(83–85)
		B: Microbiological reproduction caused by inappropriate storage temperature	6	7	6	252	Calibration of thermometers / probes used for temperature measurements must be carried out on time and regularly.	2	7	2	28	(83–85)
		P: Physical contamination caused by the passage of dust and sand into the food by air and insect particles	4	4	3	48	Not significant	-	-	-	-	(79–81, 129)
5	Kneading	B: Microbial growth caused by unhealthy practices without attention to personal hygiene	8	9	3	216	Personnel should be developed through training, which highlights the significance of the utilization of food processor tools like gloves, arm sleeve covers and bonnet.	2	9	3	54	(5, 42, 47, 50, 96)
		B: Microbiological transmission through lack of personal hygiene	7	8	7	392	Food personnel has to be taught the correct handwashing techniques and their importance along with hygiene training. Hands should be washed using quality approved disinfectants and personnel hygiene should be checked continuously.	2	8	3	48	(77, 78, 121, 122)
		C: Cleaning agent residues as a result of insufficient rinsing of equipments by personnel	5	5	3	75	Not significant	-	-	-	-	(68)

Implementation of FMEA to Töngel Şerbeti Production

CP	Processing stage	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections	List of literatures
		P: Foreign materials from the kneading box due to improper cleaning.	5	4	6	120	Appropriate cleaning methods has to be applied. Food personnel has to be regularly checked in terms of hygiene and sanitary safety ensured.	2	4	5	40	(79–81, 129)
		P: Contamination from the staff (Hair, nail, jewelleries, etc.) because of inappropriate implementations throughout process	5	4	6	120	Personnel should be developed through training, which highlights the significance of the utilization of food processor tools like gloves, arm sleeve covers and bonnet.	2	4	5	40	(77, 78, 121, 122)
		P: Contamination which stems from physical environment due to the dust and impurities.	5	3	3	45	Not significant	-	-	-	-	(79–81, 129)
6	Storage in an open container for a day	B: Cross-contamination from improper container cleaning	7	9	3	189	Proper cleaning procedure (disinfection, washing, rinsing, and cleaning) must be applied. To verificate, microbiological analysis has to be performed periodically. If raw and cooked foods are processed concurrently, different storage containers and cutting tools must be utilized as equipment.	2	9	2	36	(76, 104–107)
		C: Cleaning agent residues as a result of insufficient rinsing of equipments by personnel	5	5	3	75	Not significant	-	-	-	-	(68)

Implementation of FMEA to Töngel Şerbeti Production

CP	Processing stage	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections	List of literatures
		P: Physical contamination caused by the passage of dust and sand into the food by air and insect particles	4	4	3	48	Not significant	-	-	-	-	(79–81, 129)
7	Stirring	B: Cross-contamination as a result of poor manual cleaning and storage of kitchen equipment used for stirring	6	8	6	288	Proper cleaning procedure (disinfection, washing, rinsing, and cleaning) must be applied. To verificate, microbiological analysis has to be performed periodically. If raw and cooked foods are processed concurrently, different storage containers and cutting tools must be utilized as equipment.	2	8	4	64	(76, 104–107)
		B: Microbial growth caused by unhealthy practices without attention to personal hygiene	8	9	3	216	Personnel should be developed through training, which highlights the significance of the utilization of food processor tools like gloves, arm sleeve covers and bonnet.	2	9	3	54	(5, 42, 47, 50, 96)
		C: Cleaning agent residues as a result of insufficient rinsing of equipments by personnel	5	5	3	75	Not significant	-	-	-	-	(68)
		P: Physical contaminants due to the damaged stirring tool	4	4	3	48	Not significant	-	-	-	-	(79–81, 129)
		P: Physical contamination caused by the passage of dust and sand into the food by air and insect particles	4	4	3	48	Not significant	-	-	-	-	(79–81, 129)

Implementation of FMEA to Töngel Şerbeti Production

CP	Processing stage	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections	List of literatures
8	Filtration through a cheese cloth	B: Microbiological contamination as a result of poor manual cleaning and storage of equipment (cheese cloth)	5	8	4	160	Appropriate cleaning methods has to be applied.	2	8	2	32	(108, 109)
		B: Microbiological contamination due to the use of inappropriate cleaning material.	6	7	2	84	Not significant	-	-	-	-	(130, 131)
		C: Detergent residue due to poor rinsing after cleaning	4	7	6	168	Appropriate cleaning procedure has to be followed.	2	7	1	14	(38, 68)
		P: Physical contaminants due to the damaged filtration tool (cheese cloth)	4	4	3	48	Not significant	-	-	-	-	(79–81, 129)
9	Storage in a closed wooden külek	B: Microbiological reproduction caused by inappropriate storage conditions	5	8	6	240	Properly cleaned, regularly inspected areas in terms of hygiene have to be used for storage.	2	8	4	64	(83–85)
		B: Microbiological reproduction caused by inappropriate storage temperature	6	7	6	252	Calibration of thermometers / probes used for temperature measurements must be carried out on time and regularly.	2	7	2	28	(83–85)

Table B. 10. Implementation of FMEA to Tükenmez Production

CP	Processing stage	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections	List of literatures
1	Receiving raw ingredients - Water supply	B: *Hepatitis A, Escherichia coli, Giardia lamblia, Vibrio cholera, Shigella spp., Cryptosporidium parvum, Cyclospora cayetanensis, Salmonella spp., Toxoplasma gondii* and *Norwalk*, viruses can carried by water	4	7	8	224	Analysis of microbiological reproduction must be performed periodically. With the help of chemical agents, microbiological treatment of water must be done with chlorine, ozone.	2	7	2	28	(5, 42, 110–112)
		B: Parasites in water	4	7	8	224	Analysis of microbiological reproduction must be performed periodically. With the help of chemical agents, microbiological treatment of water must be done with chlorine, ozone.	2	7	2	28	(5, 110–112)
		C: Chemical substance contamination like bromate, benzene, cyanide in water	4	8	7	224	Chemical analysis have to be performed periodically. Proper filtration system has to be utilized if necessary.	2	8	3	48	(5)
		C: Contamination of water by nitrate or fertilisers containing nitrate	4	7	6	168	Chemical analysis have to be performed periodically. Proper filtration system has to be utilized if necessary.	2	7	3	42	(5, 110)
		C: Water contaminated with heavy metal residues like lead, arsenic, cadmium	4	8	9	288	Chemical analysis have to be performed periodically. Proper filtration system has to be utilized if necessary.	2	8	3	48	(5, 42, 113)

Implementation of FMEA to Tükenmez Production

CP	Processing stage	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections	List of literatures
		C: Uncontrolled water source with high chlorine concentration	6	7	3	126	Utilize drinkable water controlled by local authority. Perform regular laboratory examination.	2	7	3	42	(5, 42, 110–113)
		C: Pesticide contamination of water through soil erosion from the agricultural fields	7	9	3	189	Utilize drinkable water controlled by local authority. Perform regular laboratory examination.	2	9	2	36	(5, 42, 113)
		C: Contamination of water due to inappropriate or damaged metal pipe connections	6	7	3	126	Pipes and connectors must comply with standards.	2	7	3	42	(5, 42, 110)
	Receiving medlar	B: Microbiological contamination due to the mold (*Penicillium Expansum*)	6	9	4	216	Certified products from reliable vendors have to be used. The contaminated parts have to be removed. Storage conditions have to be held at an optimal degree. Humidity needs to be checked. Effective washing procedure must be implemented. Low doses of UV-C (below 280 nm), chitosans, propolis, glucosinolates must be used to induce resistance against pathogens in harvested fruits	2	9	3	54	(148, 149)

Implementation of FMEA to Tükenmez Production

CP	Processing stage	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections	List of literatures
		C: Mycotoxin contamination (Patulin)	6	9	5	270	Certified products from reliable vendors have to be used. The contaminated parts have to be removed. Storage conditions have to be held at an optimal degree. Effective washing procedure must be implemented. Low doses of UV-C (below 280 nm), chitosans, propolis, glucosinolates must be used to induce resistance against pathogens in harvested fruits	2	9	4	72	(148, 149)
		C: Pesticide residues such as Methamidophos, acephate, omethoate, fenitrothion	6	9	5	270	U Certified products from reliable vendors have to be used. The contaminated parts have to be removed. Storage conditions have to be held at an optimal degree. Vendor has to be reliable. Pesticide analysis have to be done.	2	9	3	54	(97, 135)
		P: Contamination of raw materials by foreign objects.	4	2	2	16	Not significant	-	-	-	-	(79–81, 129)

Implementation of FMEA to Tükenmez Production

CP	Processing stage	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections	List of literatures
	Receiving quince	B: Microbiological contamination due to the mold (*Penicillium Expansum*)	6	9	4	216	Certified products from reliable vendors have to be used. The contaminated parts have to be removed. Storage conditions have to be held at an optimal degree. Humidity needs to be checked. Effective washing procedure must be implemented. Low doses of UV-C (below 280 nm), chitosans, propolis, glucosinolates must be used to induce resistance against pathogens in harvested fruits	2	9	3	54	(148, 149)
		C: Mycotoxin contamination (Patulin)	6	9	5	270	Certified products from reliable vendors have to be used. The contaminated parts have to be removed. Storage conditions have to be held at an optimal degree. Humidity needs to be checked. Effective washing procedure must be implemented. Low doses of UV-C (below 280 nm), chitosans, propolis, glucosinolates must be used to induce resistance against pathogens in harvested fruits	2	9	4	72	(148, 149)
		C: Pesticide contamination such as insecticide (organophosphorous) and fungicides (triazoles)	6	9	5	270	Certified products from reliable vendors have to be used. The contaminated parts have to be removed. Storage conditions have to	2	9	3	54	(97, 135)

CP	Processing stage	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections	List of literatures
							be held at an optimal degree. Pesticide analysis has to be done.					
		P: Contamination of raw materials by foreign objects.	4	2	2	16	Not significant	-	-	-	-	(79–81, 129)
	Receiving apple	B: Microbiological contamination due to the toxigenic genera such as *Alternaria Alternata*	6	9	4	216	Reliable vendor must be preferred. Water activity and pH regularly be checked. Guidelines should be prepared to prevent food poisoning. Pathogen reproduction and food deterioration should be inhibited with the help of natural antimicrobials. Defective portion must be rejected.	2	9	3	54	(71, 89, 143, 166)
		C: Mycotoxin contamination such as Alternariol, Alternariol methyl ether, Patulin, Aflatoxins B1, B2, G1, G2	6	9	5	270	Reliable vendor must be preferred. Water activity and pH regularly be checked. Guidelines should be prepared to prevent food poisoning. Pathogen reproduction and food deterioration should be inhibited with the help of natural antimicrobials. Defective portion must be rejected.	2	9	4	72	(71, 143)
		C: Pesticide contamination such as insecticide (organophosphorous) and fungicides (triazoles)	6	9	5	270	Certified products from reliable vendors have to be used. The contaminated parts have to be removed. Storage conditions have to be held at an optimal degree. Pesticide analysis has to be done.	2	9	3	54	(97, 135)

Implementation of FMEA to Tükenmez Production

CP	Processing stage	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections	List of literatures
		P: Contamination of raw materials by foreign objects.	4	2	2	16	Not significant	-	-	-	-	(79–81, 129)
	Receiving pear	B: Microbiological contamination from pear due to the *Listeria monocytogenes, Alternaria alternata, Fusarium sambucinum*	7	9	3	189	Certified products from reliable vendors have to be used. The contaminated parts have to be removed. Storage conditions have to be held at an optimal degree. Effective washing procedure must be implemented. Low doses of UV-C (below 280 nm), chitosans, propolis, glucosinolates must be used to induce resistance against pathogens in harvested fruits	2	9	2	36	(71, 89, 140, 143)
		C: Mycotoxin contamination (Patulin)	6	9	5	270	Certified products from reliable vendors have to be used. The contaminated parts have to be removed. Storage conditions have to be held at an optimal degree. Humidity needs to be checked. Effective washing procedure must be implemented. Low doses of UV-C (below 280 nm), chitosans, propolis, glucosinolates must be used to induce resistance against pathogens in harvested fruits	2	9	4	72	(71, 167, 168)
		C: Contamination due to fungicide residues (Thiabendazole, Carbendazim, Iprodione)	7	9	3	189	Certified products from reliable vendors have to be used. The contaminated parts have to be	2	9	2	36	(97, 135)

CP	Processing stage	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections	List of literatures
							removed. Storage conditions have to be held at an optimal degree. Humidity needs to be checked. Effective washing procedure must be implemented					
		P: Contamination of raw materials by foreign objects.	4	2	2	16	Not significant	-	-	-	-	(79–81, 129)
	Receiving barley	B: Microbiological contamination due to the toxigenic genera (*Alternaria, Fusarium, Aspergillus, Penicillium*)	6	9	5	270	Barley must be purchased from reliable vendors and include quality certificates which demonstrate moisture content of grains. Defective portion must be rejected.	2	9	3	54	(72, 73)
		C: Mycotoxins (Deoxynivalenol/nivalenol, Ochratoxin A, Zearalenone) contamination stems from mold growth as a result of improper storage after harvesting, as well as inappropriate environmental conditions during crop growth.	6	9	3	162	Barley must be purchased from reliable vendors and include quality certificates which demonstrate moisture content of grains. Defective portion must be rejected.	2	9	3	54	(72, 74)
		C: Pesticide contamination such as insecticide (organophosphorous) and fungicides (triazoles)	6	9	5	270	Certified products from reliable vendors have to be used. The contaminated parts have to be removed. Storage conditions have to be held at an optimal degree. Pesticide analysis has to be done.	2	9	3	54	(97, 135)

Implementation of FMEA to Tükenmez Production

CP	Processing stage	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections	List of literatures
		C: Contamination due to the rodents (mouse urinary aeroallergens)	6	9	4	216	Adopt environmentally friendly Integrated Pest Management (IPM) programmes. Monitor rodents and utilize baits and traps.	2	9	3	54	(75, 139)
		P: Contamination caused by physical pollutants such as feces, urine and hair carried by rodents	6	9	4	216	Adopt environmentally friendly Integrated Pest Management (IPM) programmes. Monitor rodents and utilize baits and traps.	2	9	3	54	(75, 139)
	Receiving juniper seeds	-	-	-	-	-	-	-	-	-	-	
2	Cutting	B: Microbial growth caused by unhealthy practices without attention to personal hygiene	8	9	3	216	Personnel should be developed through training, which highlights the significance of the utilization of food processor tools like gloves, arm sleeve covers and bonnet.	2	9	3	54	(5, 42, 47, 50, 96)
		B: Contamination stems from incorrect handling of personnel during food processing	6	8	7	336	Food personnel has to be taught the correct handwashing techniques and their importance along with hygiene training. Hands should be washed using quality approved disinfectants and personnel hygiene should be checked continuously.	2	8	3	48	(123–128)
		B: Cross-contamination as a result of poor manual cleaning and storage of kitchen equipment such as knives and cutting boards	6	8	6	288	Proper cleaning procedure (disinfection, washing, rinsing, and cleaning) must be applied. To verificate, microbiological analysis has to be performed periodically. If	2	8	4	64	(76, 104–107)

CP	Processing stage	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections	List of literatures
							raw and cooked foods are processed concurrently, different storage containers and cutting tools must be utilized as equipment.					
		C: Cleaning agent residues as a result of insufficient rinsing of equipments by personnel	5	5	3	75	Not significant	-	-	-	-	(68)
		P: Contamination from the staff (Hair, nail, jeweleries, etc.) because of inappropriate implementations throughout process	5	4	6	120	Personnel should be developed through training, which highlights the significance of the utilization of food processor tools like gloves, arm sleeve covers and bonnet.	2	4	5	40	(77, 78, 121, 122)
		P: Contamination which stems from physical environment due to the dust and impurities.	5	3	3	45	Not significant	-	-	-	-	(79–81, 129)
3	Wrapping in cloth pouch	B: Microorganisms (*Pseudomonas aeruginosa, Klebsiella aerogenes, Staphylococcus saprophyticus, E. coli*) can pass from a poorly cleaned or contaminated cloth to hands.	5	9	5	225	Staff must be trained. Appropriate cleaning methods has to be applied. Cloth pouch must not be used repeatedly.	2	9	2	36	(108)
		B: Microbial growth caused by unhealthy practices without attention to personal hygiene	8	9	3	216	Personnel should be developed through training, which highlights the significance of the utilization of food processor tools like gloves, arm sleeve covers and bonnet.	2	9	3	54	(5, 42, 47, 50, 96)

Implementation of FMEA to Tükenmez Production

CP	Processing stage	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections	List of literatures
		C: Chemical contamination due to pesticides utilized in the processing phases of natural fabrics (storage)	6	8	5	240	Reliable vendor must be prefered. Storage conditions have to be held at an optimal degree.	2	7	3	42	(109)
		P: Foreign materials from the cloth pouch	5	4	3	60	Not significant	-	-	-	-	(108, 109)
		P: Contamination which stems from physical environment due to the dust and impurities.	5	3	3	45	Not significant	-	-	-	-	(79–81, 129)
		P: Contamination from the staff (Hair, nail, jewelleries, etc.) because of inappropriate implementations throughout process	5	4	6	120	Personnel should be developed through training, which highlights the significance of the utilization of food processor tools like gloves, arm sleeve covers and bonnet.	2	4	5	40	(77, 78, 121, 122)
4	Filling into the jar	C: Lead and cadmium contamination from clay pot	6	7	3	126	Any container, as given in TS 4403-4404-4422 (1985), must pay attention to the acceptable limits for lead and cadmium quantities released from the surface of the container at the end of contact with the 4% acetic acid solution for 24 hours.	2	7	3	42	(144)
		C: Cleaning agent residues as a result of insufficient rinsing of filling equipments by personnel	5	5	3	75	Not significant	-	-	-	-	(68)
		P: Foreign matter in filling funnel	5	4	3	60	Not significant	-	-	-	-	(79–81, 129)

Implementation of FMEA to Tükenmez Production

CP	Processing stage	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections	List of literatures
		P: Contamination which stems from physical environment due to the dust and impurities.	5	3	3	45	Not significant	-	-	-	-	(79–81, 129)
5	Wrapping the mouth of the jar	B: Microorganisms from the unclean wrapping material	5	9	4	180	Staff must be trained. Appropriate cleaning methods has to be applied. Wrapping material must not be used repeatedly.	2	9	2	36	(108)
		B: Microbial growth caused by unhealthy practices without attention to personal hygiene	8	9	3	216	Personnel should be developed through training, which highlights the significance of the utilization of food processor tools like gloves, arm sleeve covers and bonnet.	2	9	3	54	(5, 42, 47, 50, 96)
		P: Foreign materials from the wrapping material	5	4	3	60	Not significant	-	-	-	-	(108, 109)
		P: Contamination from the staff (Hair, nail, jewelleries, etc.) because of inappropriate implementations throughout process	5	4	6	120	Personnel should be developed through training, which highlights the significance of the utilization of food processor tools like gloves, arm sleeve covers and bonnet.	2	4	5	40	(77, 78, 121, 122)
6	Putting cube into jute sack	-	-	-	-	-	-	-	-	-	-	
7	Storage on the field	B: Mold growth stems from moisture changes due to inappropriate storage conditions	6	9	3	162	Certified products from reliable vendors have to be used. The contaminated parts have to be removed. Storage conditions have to be held at an optimal degree. Humidity needs to be checked.	2	9	3	54	(85)

Implementation of FMEA to Tükenmez Production

CP	Processing stage	Failures and cause	O	S	D	RPN	Corrective actions	O	S	D	RPN after corrections	List of literatures
		B: Microbial growth due to temperature fluctuation on the field.	8	9	3	189	Temperature of the field needs to be checked regularly with an appropriate thermometer.	2	9	2	36	(83–85)
		B: Microbiological reproduction caused by inappropriate storage conditions	5	8	6	240	Adequate facilities for hygienic storage must be provided. Appropriate cleaning methods has to be applied. To verificate Periodical controls must be carried out.	2	8	4	64	(83–85)
8	Removal of cloth pouch	B: Microbial growth caused by unhealthy practices without attention to personal hygiene	8	9	3	216	Personnel should be developed through training, which highlights the significance of the utilization of food processor tools like gloves, arm sleeve covers and bonnet.	2	9	3	54	(5, 42, 47, 50, 96)
		P: Contamination from the staff (Hair, nail, jewelleries, etc.) because of inappropriate implementations throughout process	5	4	6	120	Personnel should be developed through training, which highlights the significance of the utilization of food processor tools like gloves, arm sleeve covers and bonnet.	2	4	5	40	(77, 78, 121, 122)
		P: Contamination which stems from physical environment due to the dust and impurities.	5	3	3	45	Not significant	-	-	-	-	(79–81, 129)

Appendix C: Pareto Tables and Diagrams

Table C. 1. Ekşi Ayran Production Pareto Table

Stages	Total RPN for Step	RPN	RPN (cumulatively)	Total RPN after Corrective Actions	RPN after Corrective Actions	RPN after Corrective Actions (cumulatively)
Water supply	1569	17.60%	17.60%	314	16.86%	16.86%
Receiving yoghurt	592	6.64%	24.24%	108	5.80%	22.66%
Receiving lemon	1168	13.10%	37.34%	216	11.60%	34.26%
Mixing	696	7.81%	45.15%	214	11.49%	45.75%
Collecting of churn fat on top	528	5.92%	51.07%	174	9.34%	55.10%
Washing and Squeezing	965	10.82%	61.90%	180	9.67%	64.77%
Mixing	456	5.11%	67.01%	88	4.73%	69.49%
Boiling and Curdling	631	7.08%	74.09%	130	6.98%	76.47%
Filtration	460	5.16%	79.25%	46	2.47%	78.94%
Manual Bottling	1358	15.23%	94.48%	300	16.11%	95.06%
Storage	492	5.52%	100.00%	92	4.94%	100.00%
Total	**8915**			**1862**		

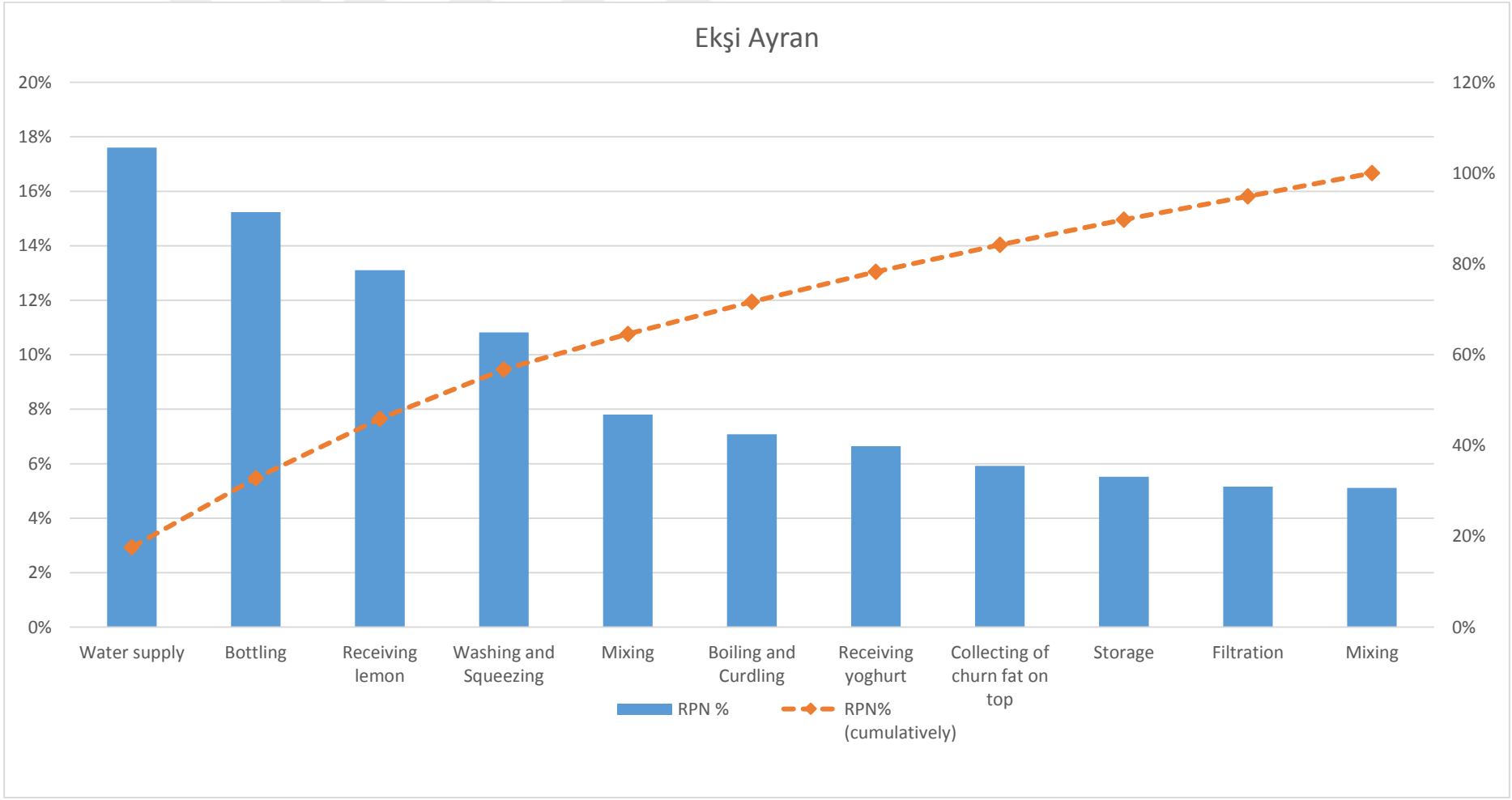

Figure C. 1. Pareto Diagram for Ekşi Ayran Production

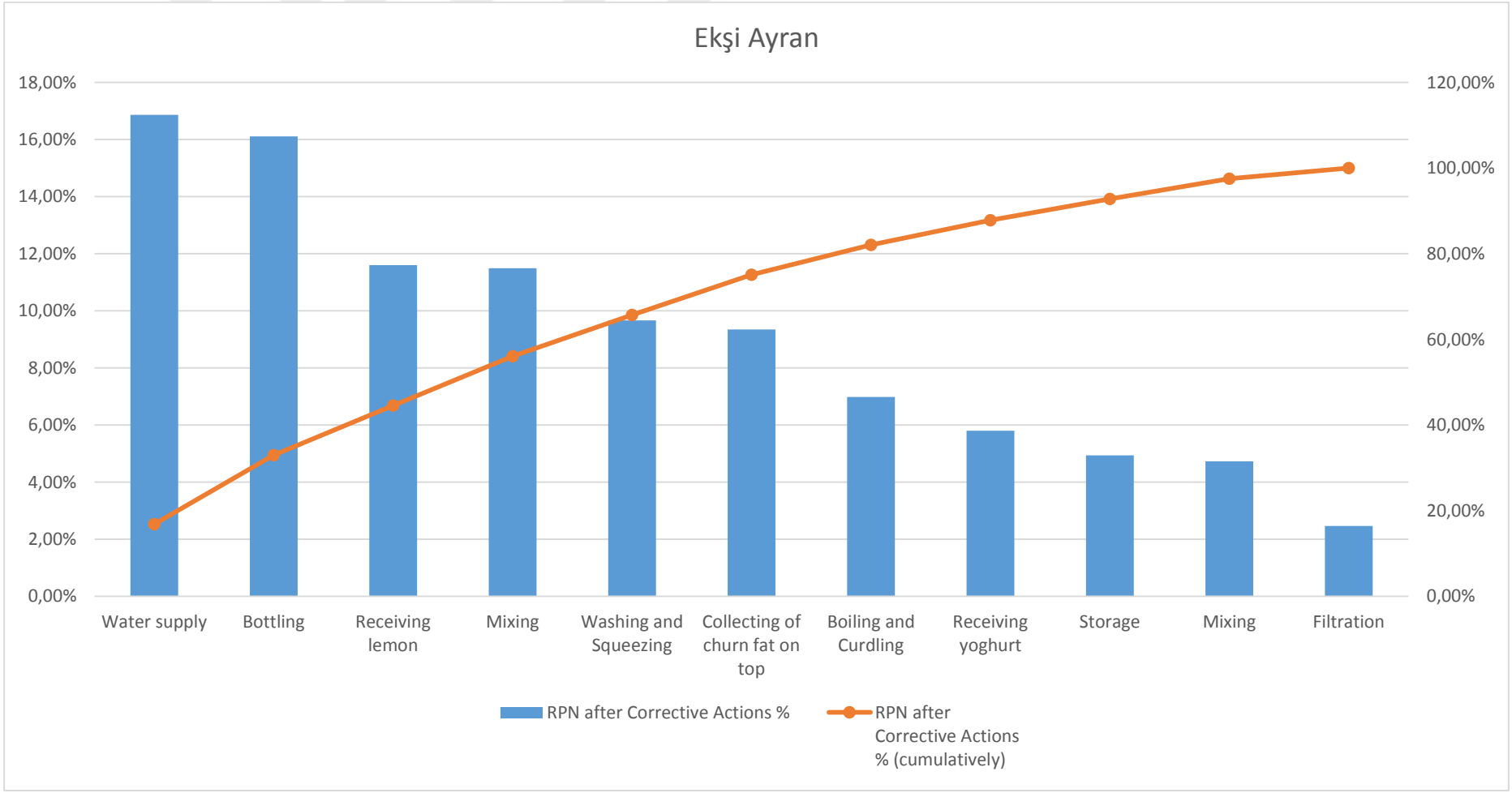

Figure C. 2. Pareto Diagram for Ekşi Ayran Production after Corrective Actions

Table C. 2. Çükündür Suyu Production Pareto Table

Stages	Total RPN for Step	RPN	RPN (cumulatively)	Total RPN after Corrective Actions	RPN after Corrective Actions	RPN after Corrective Actions (cumulatively)
Water supply	1569	15.32%	15.32%	314	15.58%	15.58%
Receiving beet	675	6.59%	21.91%	150	7.44%	23.02%
Receiving molasses	585	5.71%	27.62%	108	5.36%	28.38%
Receiving dried pepper	1008	9.84%	37.47%	207	10.27%	38.66%
Receiving salt	185	1.81%	39.28%	36	1.79%	40.44%
Receiving stale bread	639	6.24%	45.52%	108	5.36%	45.80%
Receiving barley flour	1242	12.13%	57.64%	306	15.19%	60.99%
Peeling and cutting (Beets)	1080	10.55%	68.19%	206	10.22%	71.21%
Filling into wide-mouth jar	576	5.63%	73.82%	94	4.67%	75.88%
Kneading dough	968	9.45%	83.27%	182	9.03%	84.91%
Wrapping with cloth pouch	906	8.85%	92.12%	172	8.54%	93.45%
Mixing	315	3.08%	95.19%	40	1.99%	95.43%
Storage for 3 weeks	492	4.80%	100.00%	92	4.57%	100.00%
Total	**10240**			**2015**		

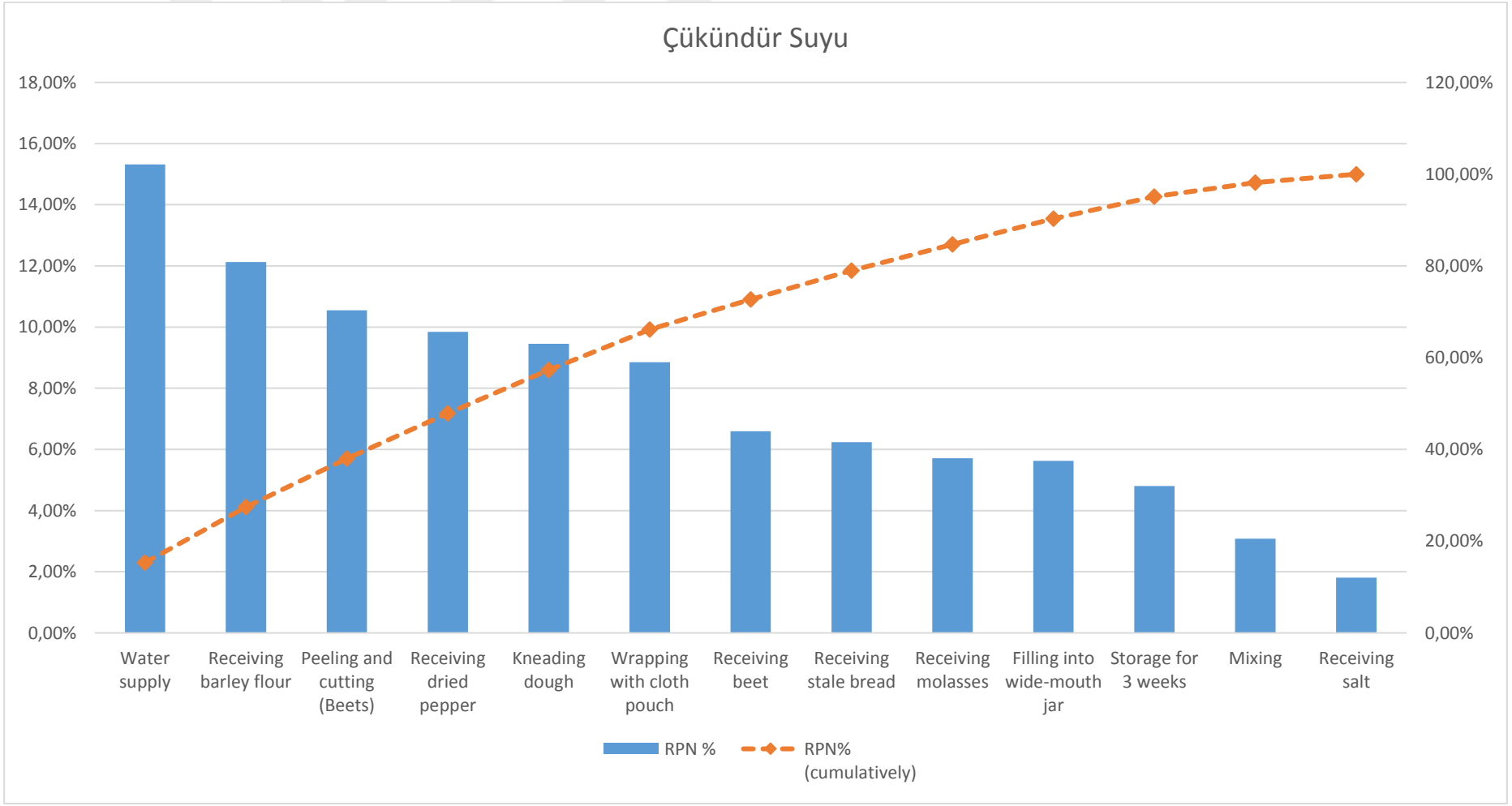

Figure C. 3. Pareto Diagram for Çükündür Suyu Production

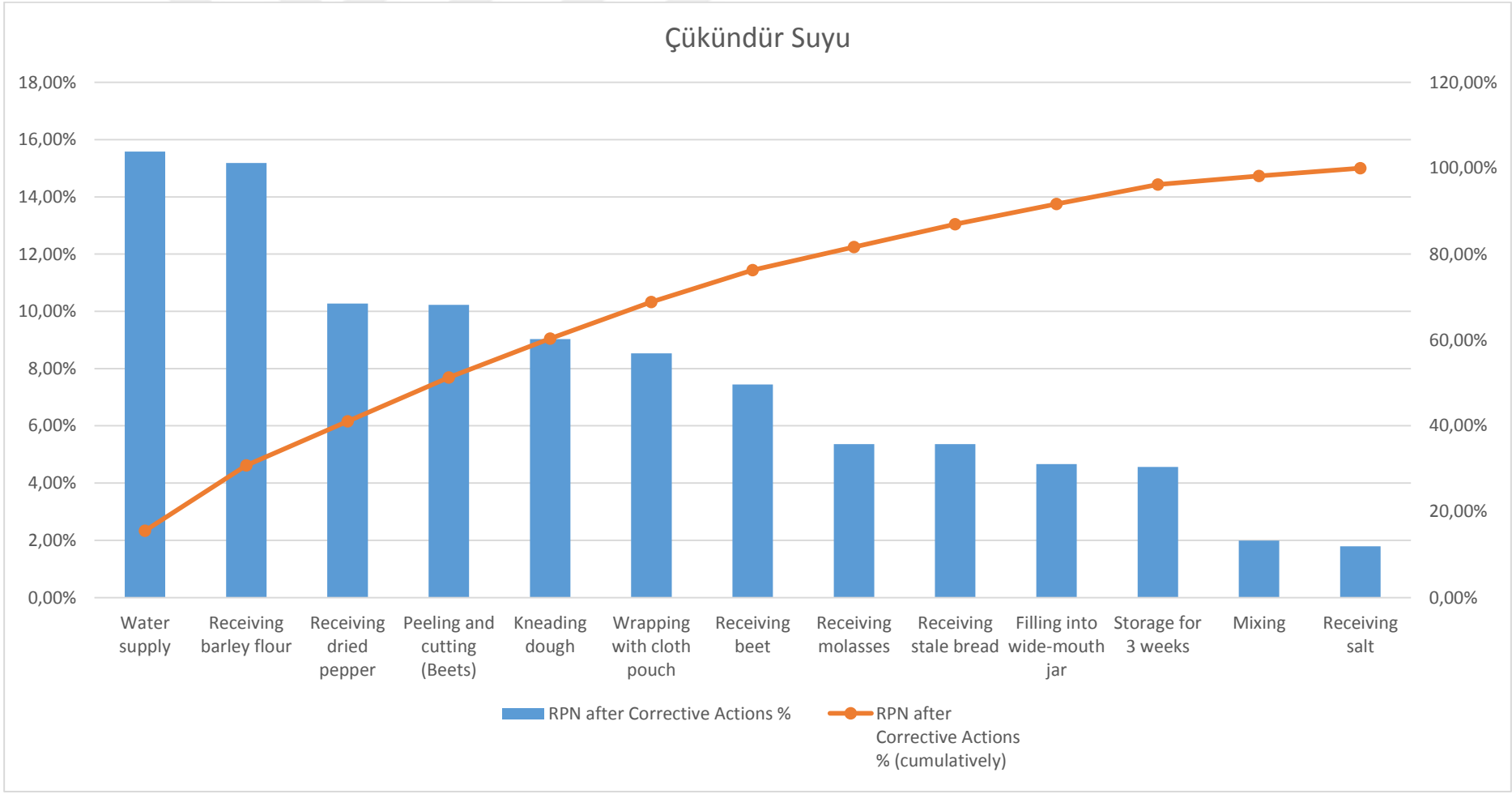

Figure C. 4. Pareto Diagram for Çüküdür Suyu Production after Corrective Actions

Table C. 3. Gilaburu Production Pareto Table

Stages	Total RPN for Step	RPN	RPN (cumulatively)	Total RPN after Corrective Actions	RPN after Corrective Actions	RPN after Corrective Actions (cumulatively)
Obtaining gilaburu	702	9.72%	9.72%	162	9.61%	9.61%
Water supply	1569	21.72%	31.44%	314	18.62%	28.23%
Washing	725	10.04%	41.48%	314	18.62%	46.86%
Crushing	747	10.34%	51.82%	196	11.63%	58.48%
Filling into plastic drums	855	11.84%	63.65%	166	9.85%	68.33%
Storage in dark place at 25 C°	492	6.81%	70.46%	92	5.46%	73.79%
Pressing by hand	776	10.74%	81.20%	142	8.42%	82.21%
Manual Bottling	1358	18.80%	100.00%	300	17.79%	100.00%
Total	**7224**			**1686**		

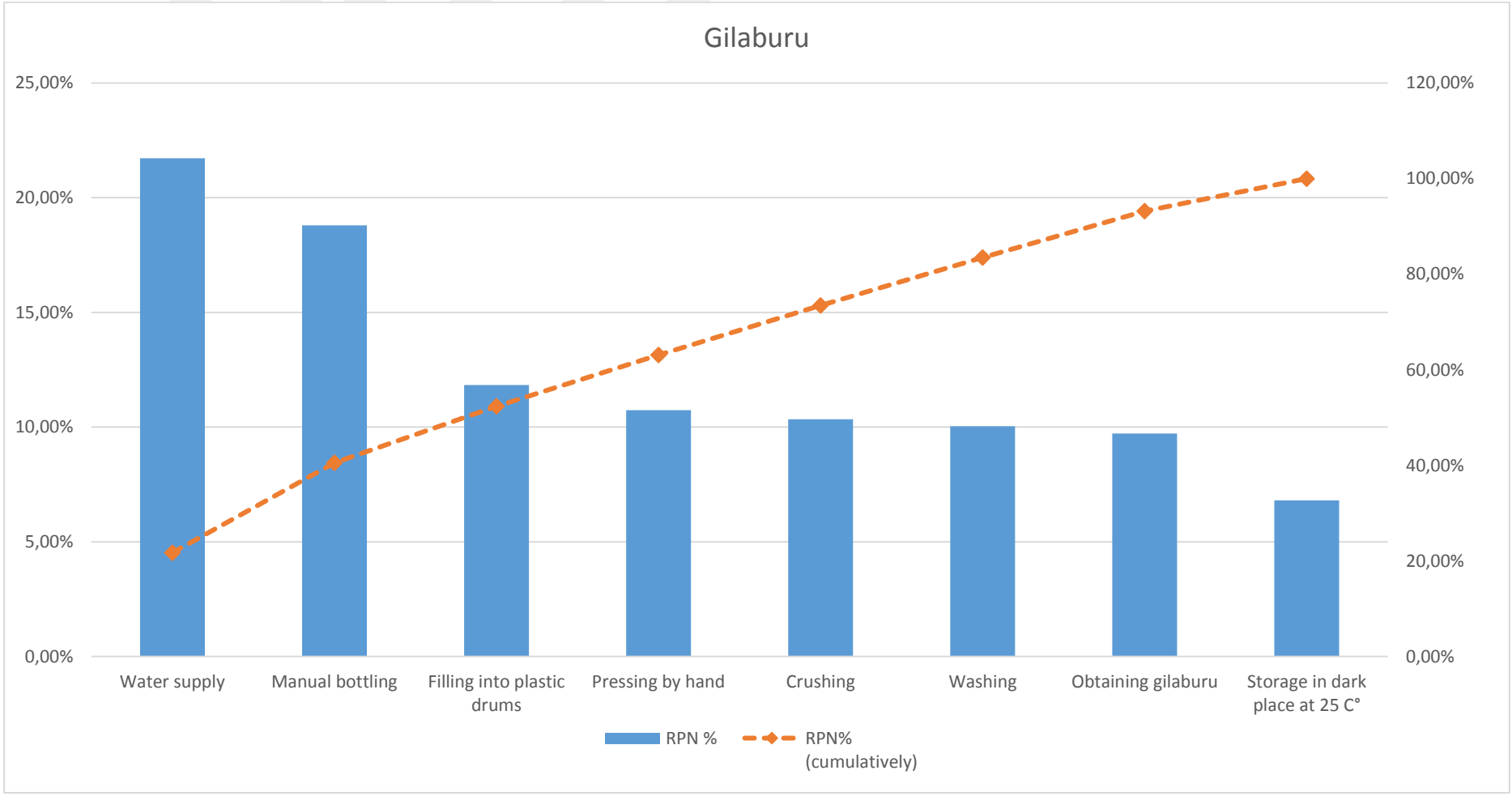

Figure C. 5. Pareto Diagram for Gilaburu Production

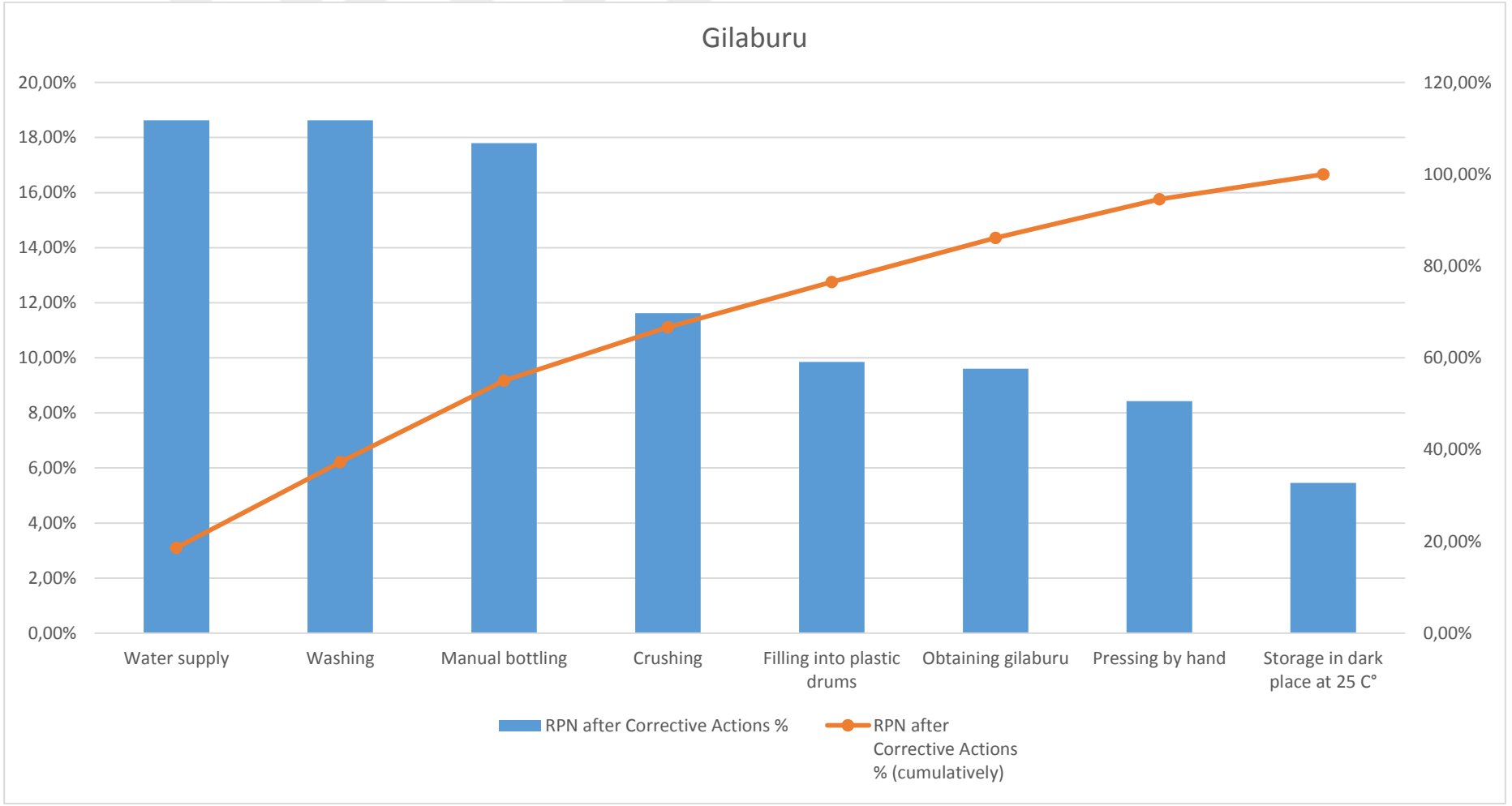

Figure C. 6. Pareto Diagram for Gilaburu Production after Corrective Actions

Table C. 4. Hardaliye Production Pareto Table

Stages	Total RPN for Step	RPN	RPN (cumulatively)	Total RPN after Corrective Actions	RPN after Corrective Actions	RPN after Corrective Actions (cumulatively)
Water supply	1569	15.12%	15.12%	314	15.54%	15.54%
Receiving barley	1242	11.97%	27.09%	306	15.15%	30.69%
Receiving mustard	588	5.67%	32.75%	108	5.35%	36.04%
Receiving grape	804	7.75%	40.50%	144	7.13%	43.16%
Washing grape with stalk	965	9.30%	49.80%	180	8.91%	52.07%
Wrapping with cloth pouch	906	8.73%	58.52%	172	8.51%	60.59%
Filling into the clay	306	2.95%	61.47%	42	2.08%	62.67%
Closing the mouth of the pot with grape leaves	615	5.93%	67.40%	108	5.35%	68.02%
Embedding clay into the soil	618	5.95%	73.35%	154	7.62%	75.64%
Storage for 3 weeks	948	9.13%	82.49%	146	7.23%	82.87%
Filtration	460	4.43%	86.92%	46	2.28%	85.14%
Manual Bottling	1358	13.08%	100.00%	300	14.85%	100.00%
Total	**10379**			**2020**		

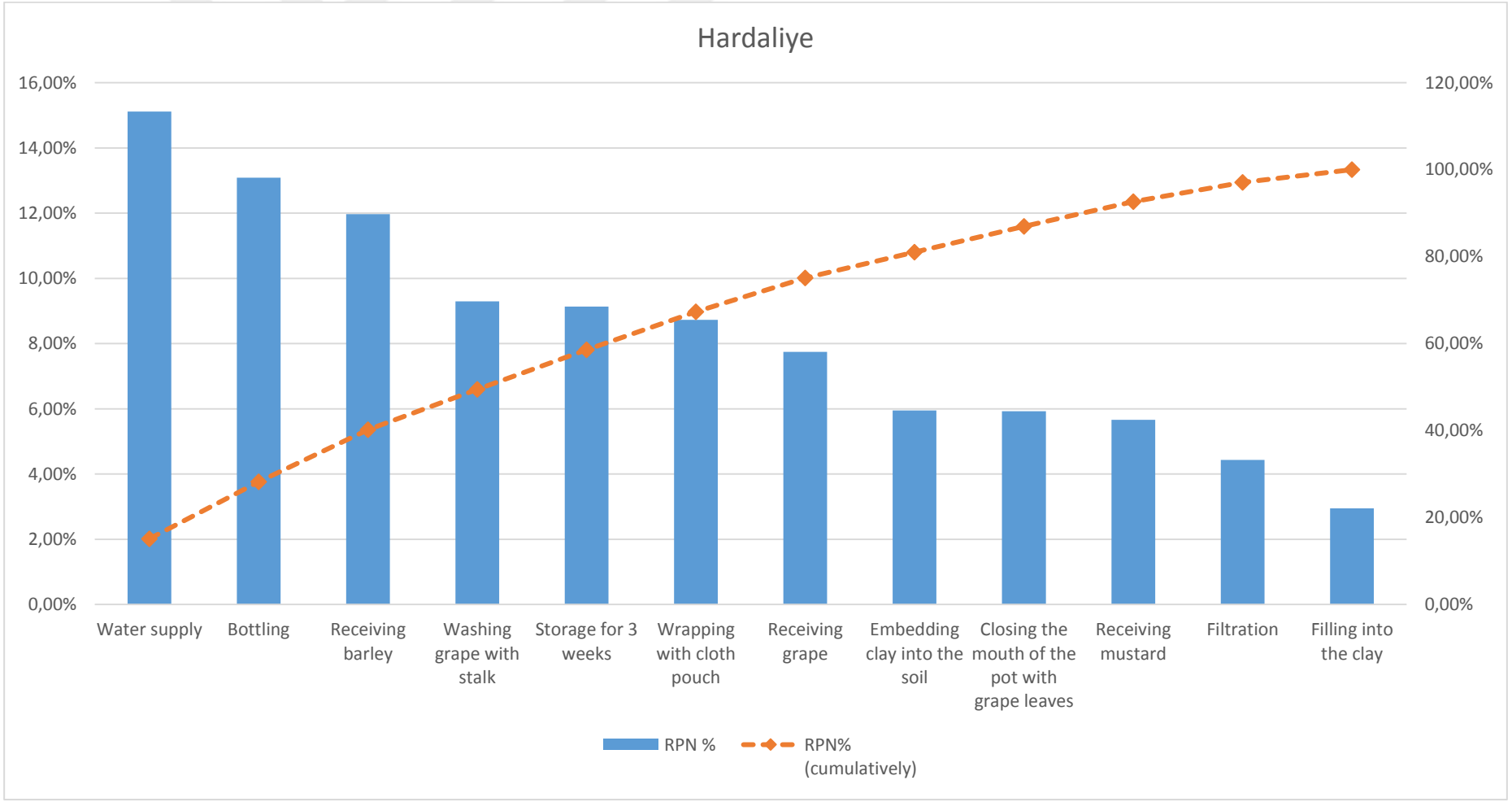

Figure C. 7. Pareto Diagram for Hardaliye Production

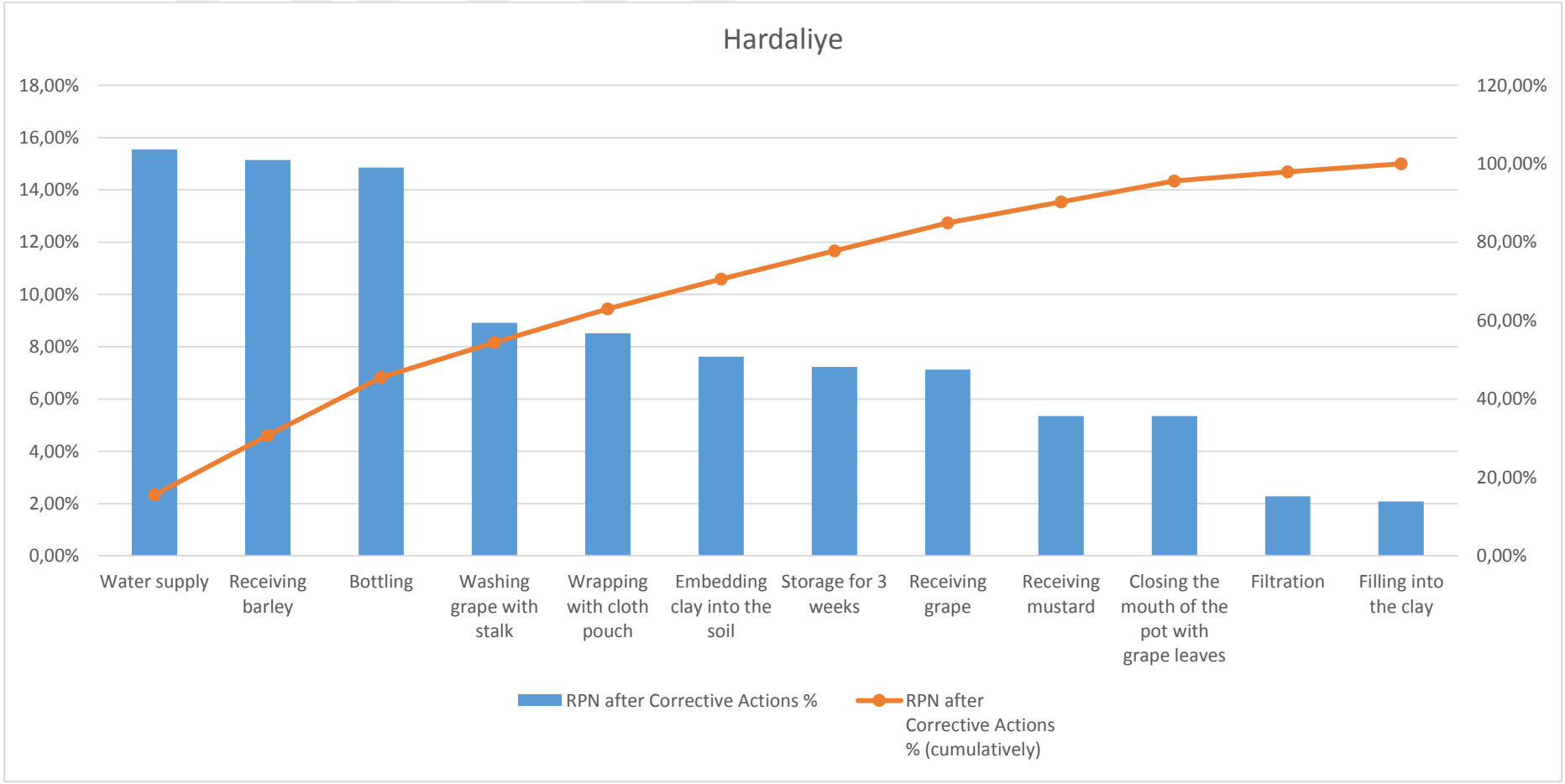

Figure C. 8. Pareto Diagram for Hardaliye Production after Corrective Actions

Table C. 5. Hayva Şerbeti Production Pareto Table

Stages	Total RPN for Step	RPN	RPN (cumulatively)	Total RPN after Corrective Actions	RPN after Corrective Actions	RPN after Corrective Actions (cumulatively)
Water supply	1569	18.10%	18.10%	314	17.82%	17.82%
Receiving quince	772	8.91%	27.01%	180	10.22%	28.04%
Receiving saffron	900	10.38%	37.39%	216	12.26%	40.29%
Receiving honey	1317	15.20%	52.59%	270	15.32%	55.62%
Receiving vinegar	387	4.47%	57.05%	108	6.13%	61.75%
Crushing quince with peel and kernel	1035	11.94%	68.99%	206	11.69%	73.44%
Boiling in a copper pot	576	6.65%	75.64%	44	2.50%	75.94%
Mixing with wooden spoon (Saffron)	603	6.96%	82.60%	134	7.60%	83.54%
Mixing (Honey, Vinegar)	315	3.63%	86.23%	40	2.27%	85.81%
Pouring into the closed-mouth jar	701	8.09%	94.32%	158	8.97%	94.78%
Storage for a week	492	5.68%	100.00%	92	5.22%	100.00%
Total	**8667**			**1762**		

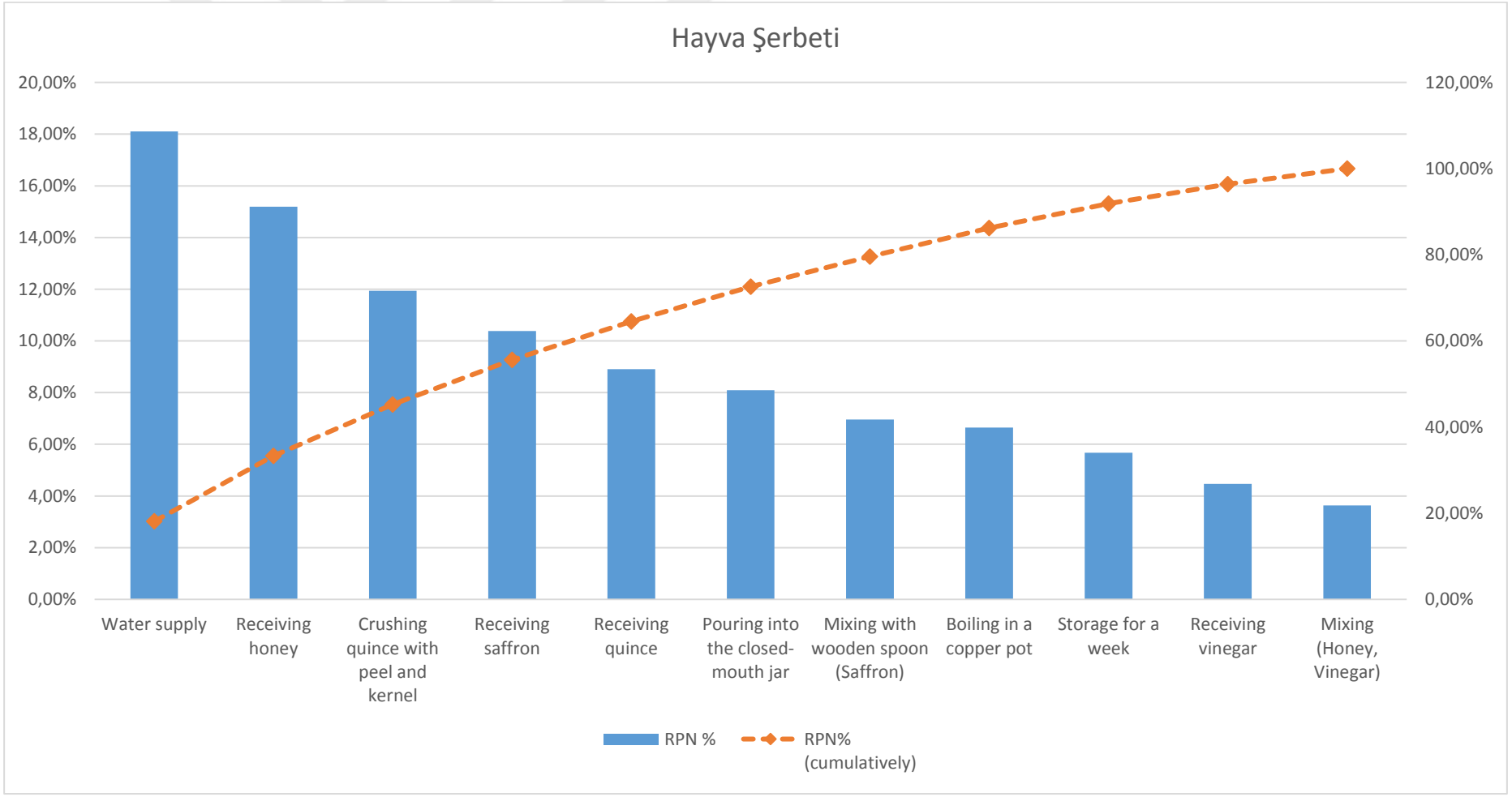

Figure C. 9. Pareto Diagram for Hayva Şerbeti Production

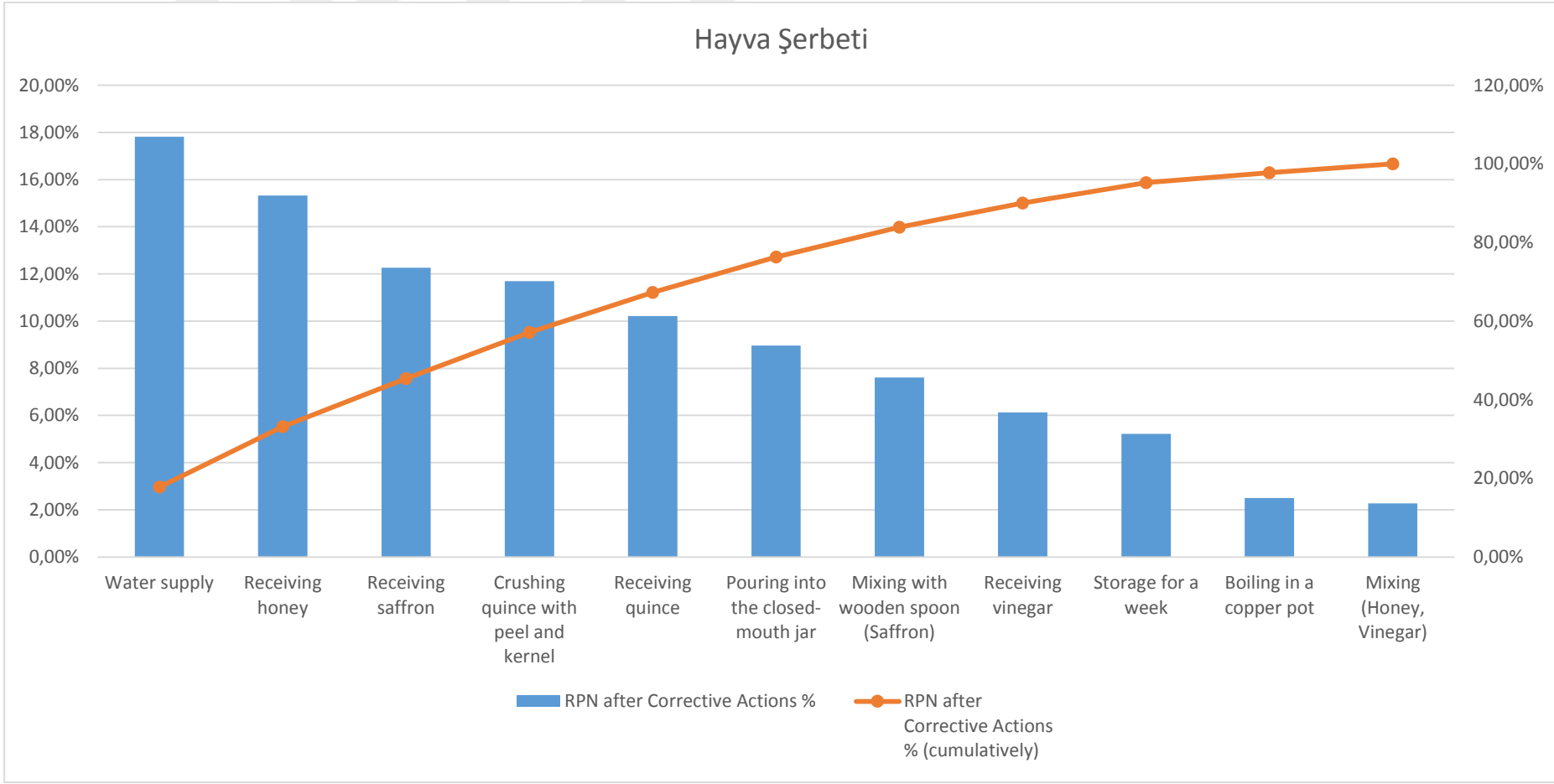

Figure C. 10. Pareto Diagram for Hayva Şerbeti Production after Corrective Actions

Table C. 6. Kefir Production Pareto Table

Stages	Total RPN for Step	RPN	RPN (cumulatively)	Total RPN after Corrective Actions	RPN after Corrective Actions	RPN after Corrective Actions (cumulatively)
Raw milk	2823	41.05%	41.05%	434	37.16%	37.16%
Boiling	576	8.38%	49.43%	44	3.77%	40.93%
Cooling	218	3.17%	52.60%	0	0.00%	40.93%
Addition of kefir grains	591	8.59%	61.19%	126	10.79%	51.71%
Wrapping mouth with cloth pouch	576	8.38%	69.57%	130	11.13%	62.84%
Storage in refrigerator	615	8.94%	78.51%	94	8.05%	70.89%
Removal of kefir grains with sterile sieve	120	1.74%	80.25%	40	3.42%	74.32%
Manual Bottling	1358	19.75%	100.00%	300	25.68%	100.00%
Total	**6877**			**1168**		

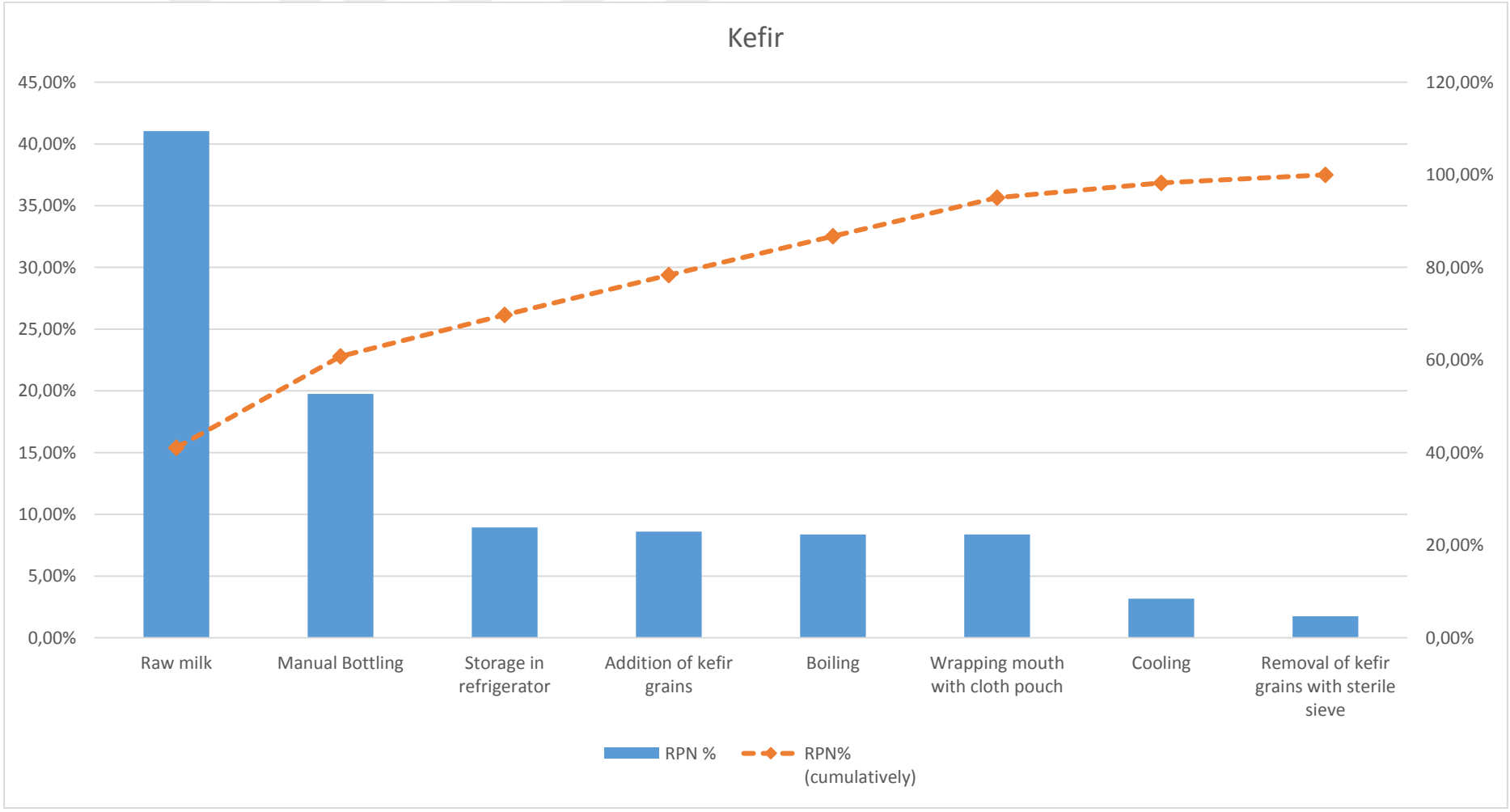

Figure C. 11. Pareto Diagram for Kefir Production

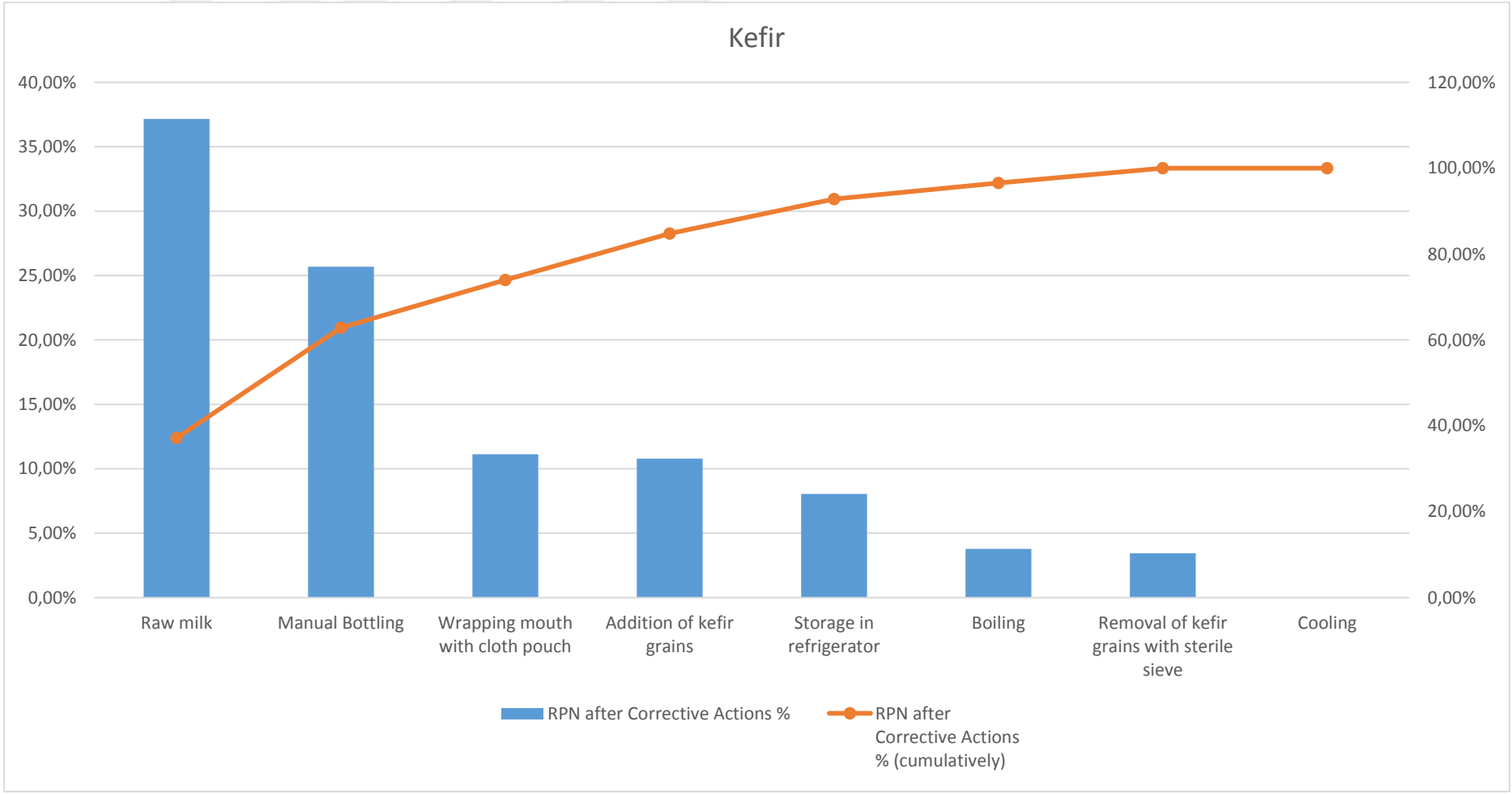

Figure C. 12. Pareto Diagram for Kefir Production after Corrective Actions

Table C. 7. Mişmiş Şerbeti Production Pareto Table

Stages	Total RPN for Step	RPN	RPN (cumulatively)	Total RPN after Corrective Actions	RPN after Corrective Actions	RPN after Corrective Actions (cumulatively)
Water supply	1569	16.85%	16.85%	314	19.26%	19.26%
Receiving apricot	963	10.34%	27.19%	234	14.36%	33.62%
Receiving sugar	185	1.99%	29.18%	36	2.21%	35.82%
Removing the apricot kernel	624	6.70%	35.88%	158	9.69%	45.52%
Arranging on a tray	462	4.96%	40.84%	54	3.31%	48.83%
Interspersing sugar	752	8.07%	48.91%	138	8.47%	57.30%
Storage in sun for 2 days	444	4.77%	53.68%	40	2.45%	59.75%
Boiling	576	6.18%	59.86%	44	2.70%	62.45%
Storage for a day	444	4.77%	64.63%	40	2.45%	64.90%
Kneading	968	10.39%	75.02%	182	11.17%	76.07%
Filtrating through cheese cloth	525	5.64%	80.66%	50	3.07%	79.14%
Manual Bottling	1358	14.58%	95.24%	300	18.40%	97.54%
Storage in sun for 5 days	444	4.77%	100.00%	40	2.45%	100.00%
Total	**9314**			**1630**		

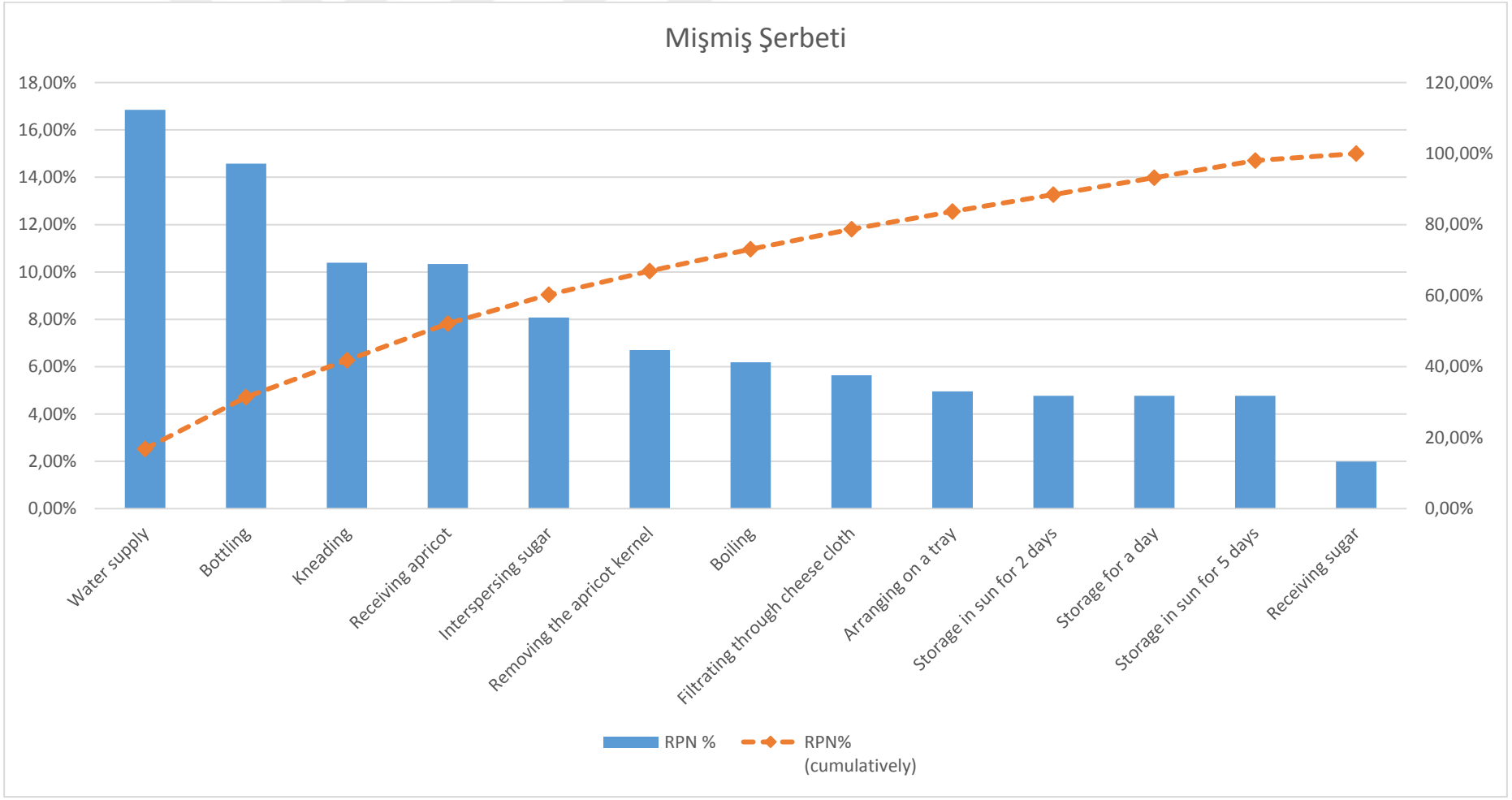

Figure C. 13. Pareto Diagram for Mişmiş Şerbeti Production

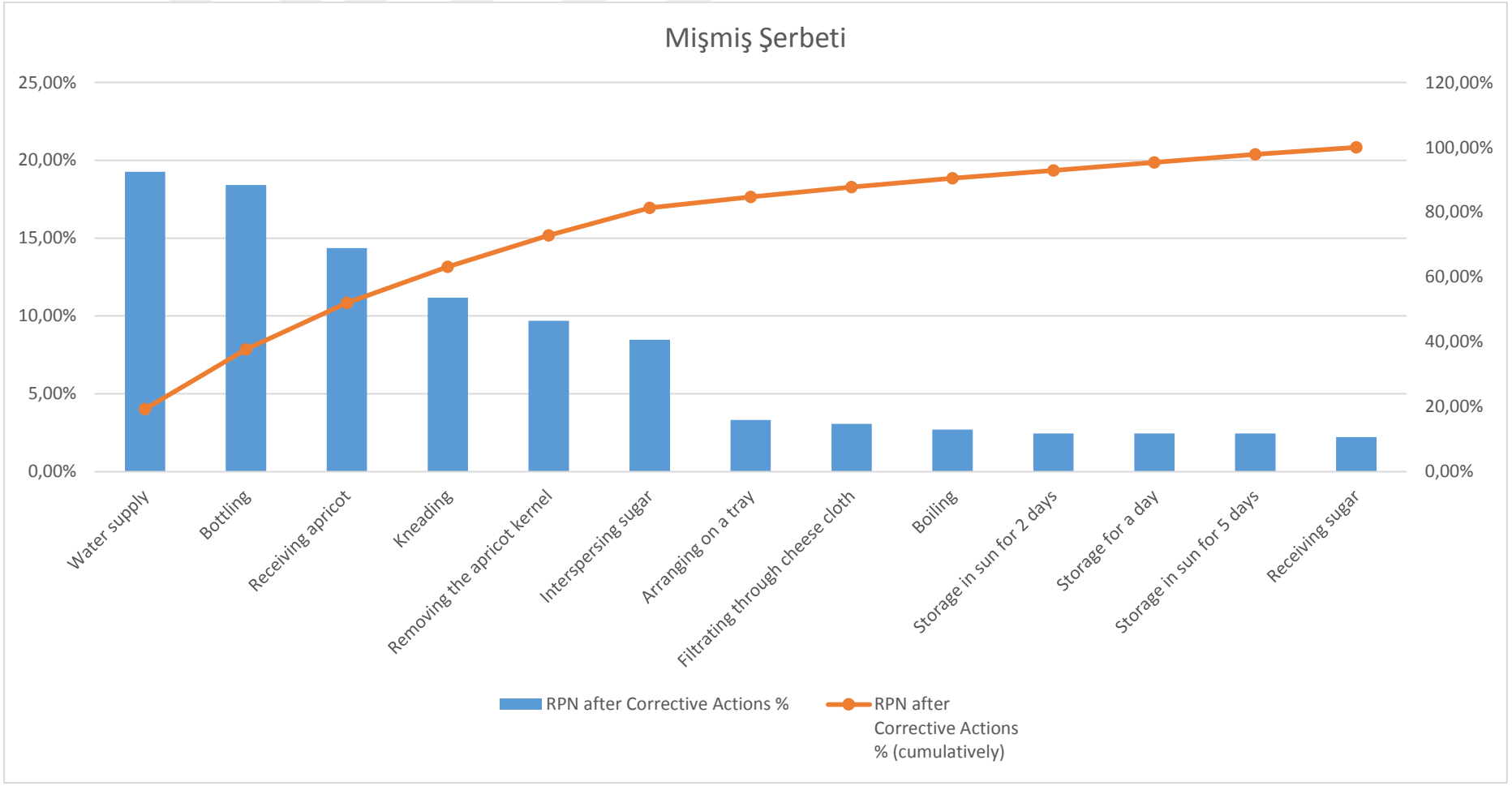

Figure C. 14. Pareto Diagram for Mişmiş Şerbeti Production after Corrective Actions

Table C. 8. Şalgam Suyu Production Pareto Table

Stages	Total RPN for Step	RPN	RPN (cumulatively)	Total RPN after Corrective Actions	RPN after Corrective Actions	RPN after Corrective Actions (cumulatively)
Water supply	1569	13.21%	13.21%	314	13.84%	13.84%
Receiving turnip	990	8.33%	21.54%	198	8.73%	22.57%
Receiving carrot	1395	11.74%	33.28%	270	11.90%	34.47%
Receiving salt	185	1.56%	34.84%	36	1.59%	36.05%
Receiving dried pepper	1008	8.48%	43.33%	207	9.12%	45.18%
Receiving bulgur flour	909	7.65%	50.98%	162	7.14%	52.32%
Kneading dough	968	8.15%	59.12%	182	8.02%	60.34%
Wrapping with cloth pouch	906	7.63%	66.75%	172	7.58%	67.92%
Storage for 3 days	492	4.14%	70.89%	92	4.05%	71.97%
Peeling and cutting (Turnip)	1080	9.09%	79.98%	206	9.08%	81.05%
Mixing	315	2.65%	82.63%	40	1.76%	82.81%
Storage for 3 days	492	4.14%	86.77%	92	4.05%	86.87%
Peeling and cutting (Carrot)	1080	9.09%	95.86%	206	9.08%	95.95%
Storage for a month	492	4.14%	100.00%	92	4.05%	100.00%
Total	**11881**			**2269**		

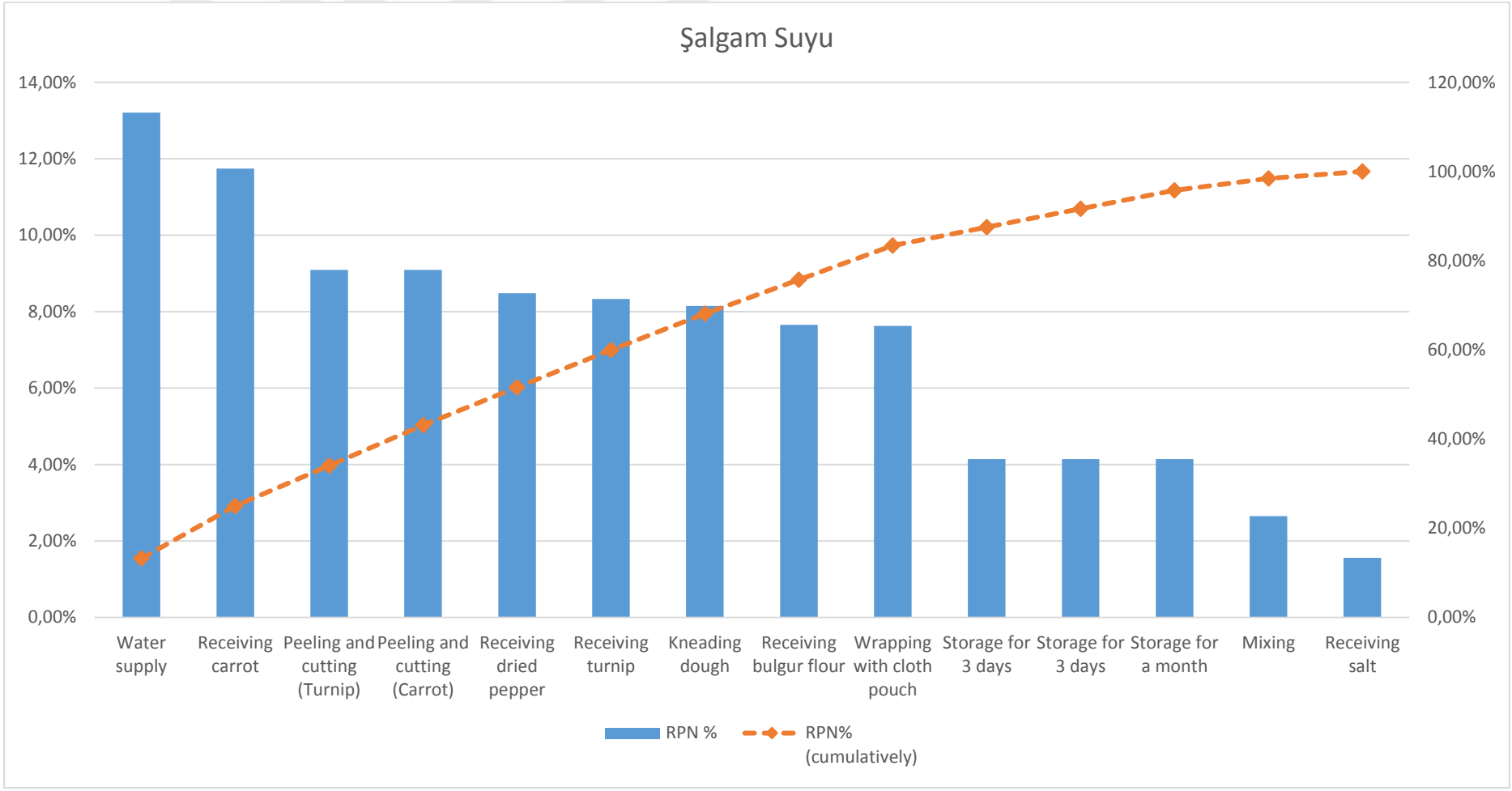

Figure C. 15. Pareto Diagram for Şalgam Suyu Production

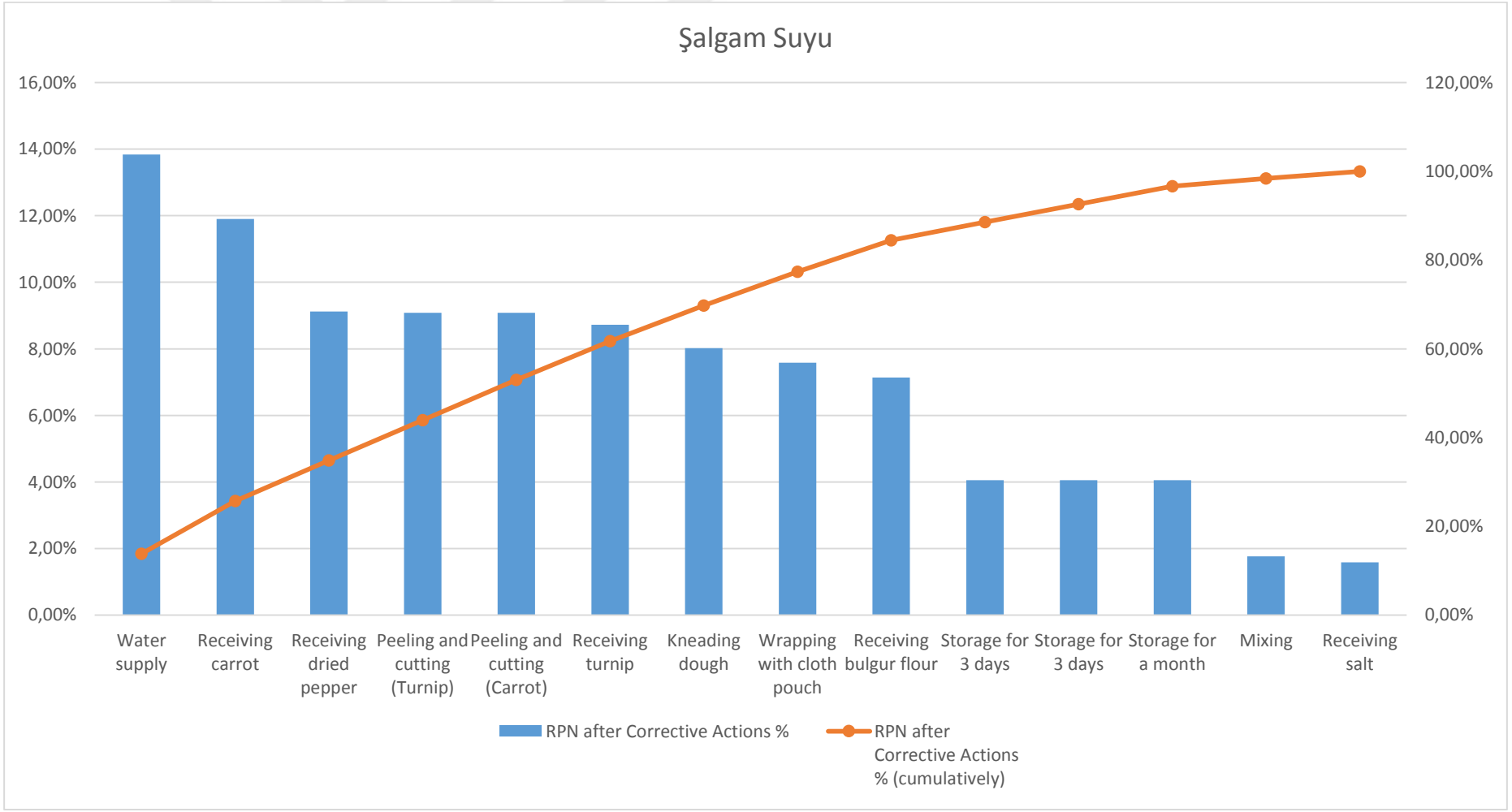

Figure C. 16. Pareto Diagram for Şalgam Suyu Production after Corrective Actions

Table C. 9. Töngel Şerbeti Production Pareto Table

Stages	Total RPN for Step	RPN	RPN (cumulatively)	Total RPN after Corrective Actions	RPN after Corrective Actions	RPN after Corrective Actions (cumulatively)
Water supply	1569	15.55%	15.55%	314	16.81%	16.81%
Receiving honey	1371	13.59%	29.14%	270	14.45%	31.26%
Receiving barley	1134	11.24%	40.37%	270	14.45%	45.72%
Receiving medlar	772	7.65%	48.02%	180	9.64%	55.35%
Receiving hazelnut	429	4.25%	52.28%	54	2.89%	58.24%
Washing	725	7.18%	59.46%	116	6.21%	64.45%
Place into the closed wooden bucket	531	5.26%	64.72%	94	5.03%	69.49%
Storage for 2 days (Medlar/Honey/barley)	540	5.35%	70.07%	92	4.93%	74.41%
Kneading	968	9.59%	79.67%	182	9.74%	84.15%
Storage in an open container for a day	312	3.09%	82.76%	36	1.93%	86.08%
Stirring	723	7.16%	89.92%	118	6.32%	92.40%
Filtration through a cheese cloth	525	5.20%	95.13%	50	2.68%	95.08%
Storage in a closed wooden külek	492	4.88%	100.00%	92	4.93%	100.00%
Total	**10091**			**1868**		

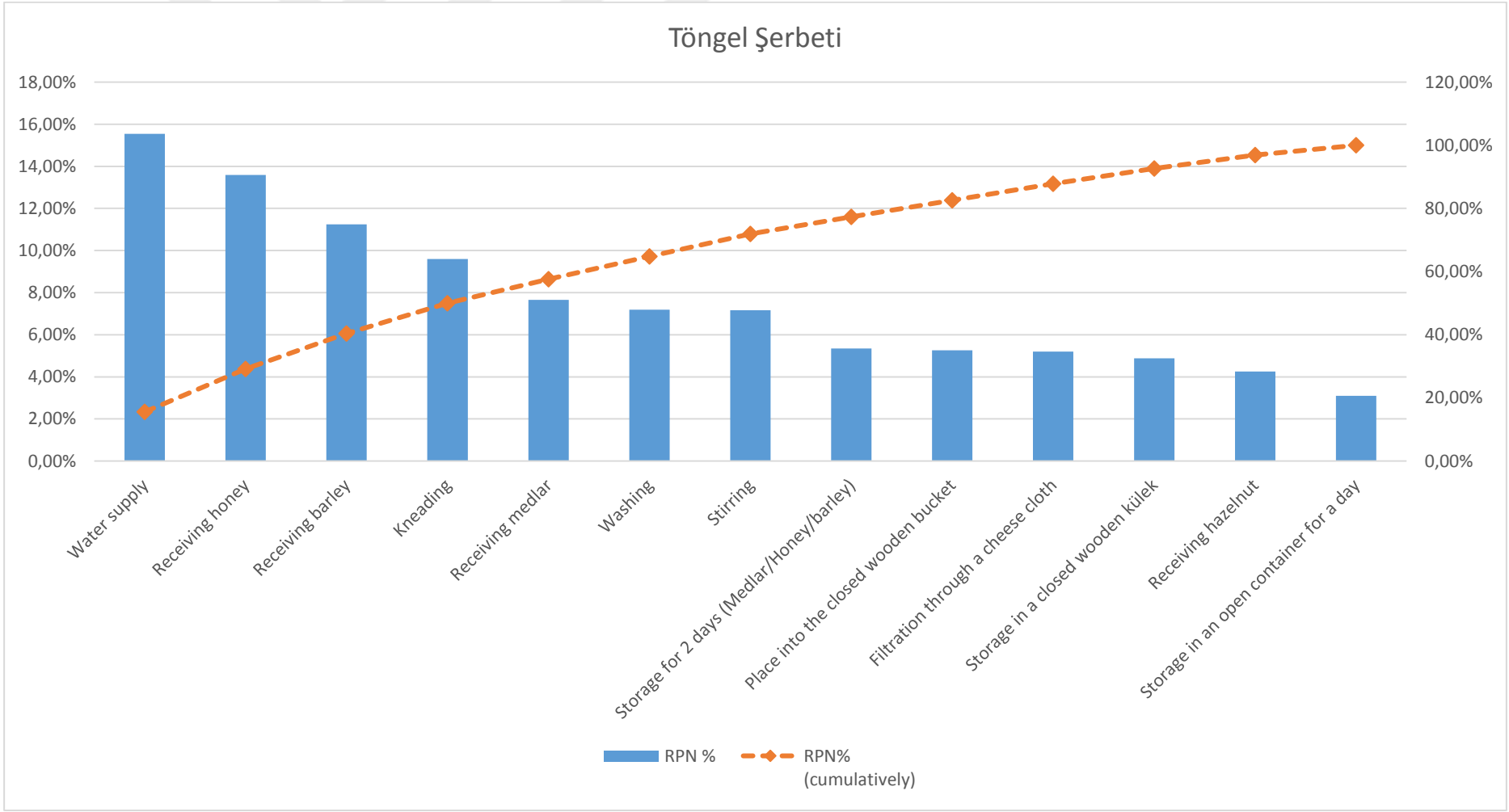

Figure C. 17. Pareto Diagram for Töngel Şerbeti Production

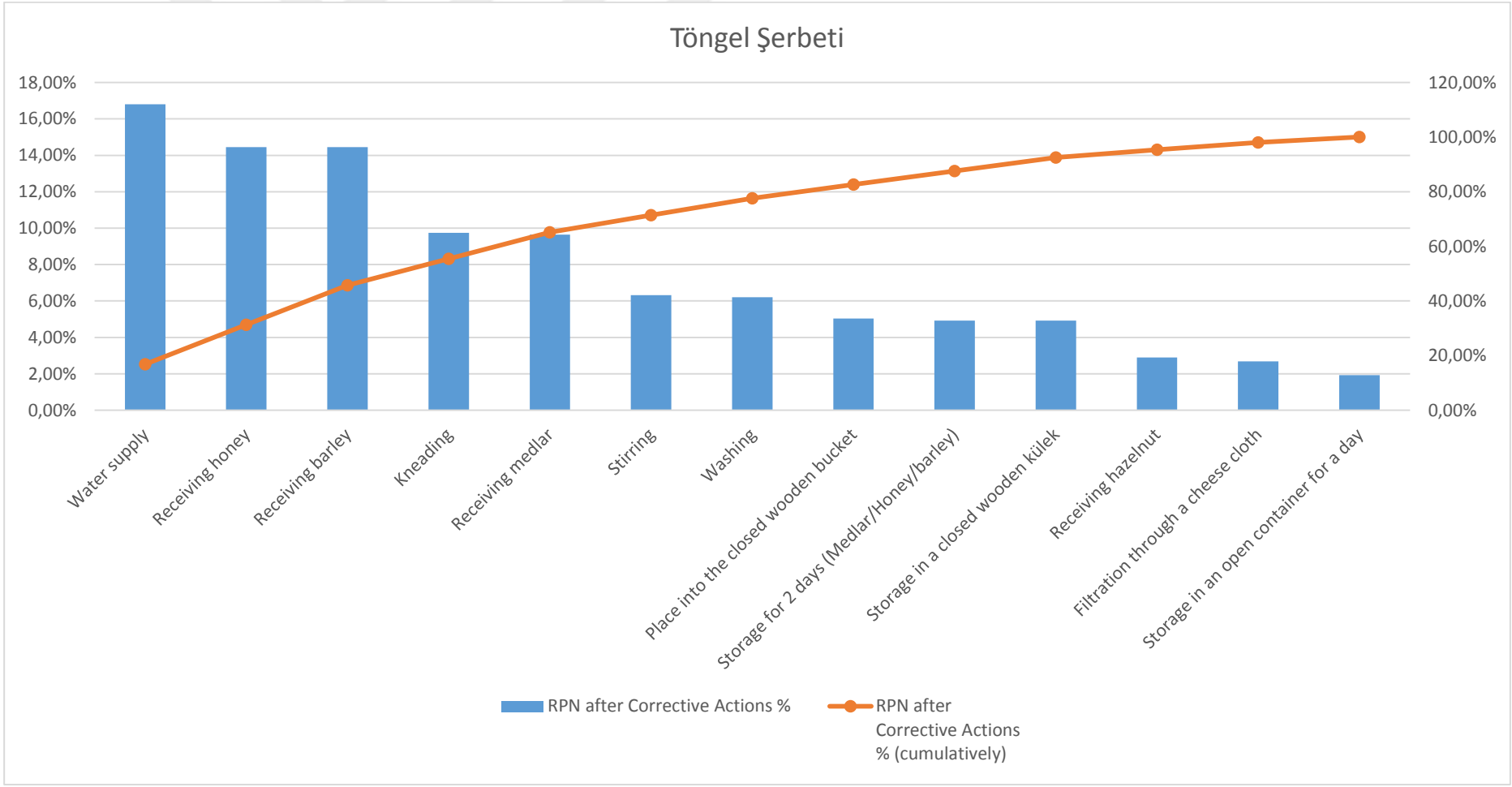

Figure C. 18. Pareto Diagram for Töngel Şerbeti Production after Corrective Actions

Table C. 10. Tükenmez Production Pareto Table

Stages	Total RPN for Step	RPN	RPN (cumulatively)	Total RPN after Corrective Actions	RPN after Corrective Actions	RPN after Corrective Actions (cumulatively)
Water supply	1569	16.50%	16.50%	314	15.20%	15.20%
Receiving medlar	756	7.95%	24.45%	180	8.71%	23.91%
Receiving quince	772	8.12%	32.57%	180	8.71%	32.62%
Receiving apple	772	8.12%	40.69%	180	8.71%	41.34%
Receiving pear	664	6.98%	47.68%	144	6.97%	48.31%
Receiving barley	1134	11.93%	59.61%	270	13.07%	61.38%
Receiving juniper seeds	0	0.00%	59.61%	0	0.00%	61.38%
Cutting	1080	11.36%	70.97%	206	9.97%	71.35%
Wrapping in cloth pouch	906	9.53%	80.49%	172	8.33%	79.67%
Filling into the jar	306	3.22%	83.71%	42	2.03%	81.71%
Wrapping the mouth of the jar	576	6.06%	89.77%	130	6.29%	88.00%
Putting cube into the jute sack	0	0.00%	89.77%	0	0.00%	88.00%
Storage on the field	591	6.22%	95.99%	154	7.45%	95.45%
Removal of cloth pouch	381	4.01%	100.00%	94	4.55%	100.00%
Total	**9507**			**2066**		

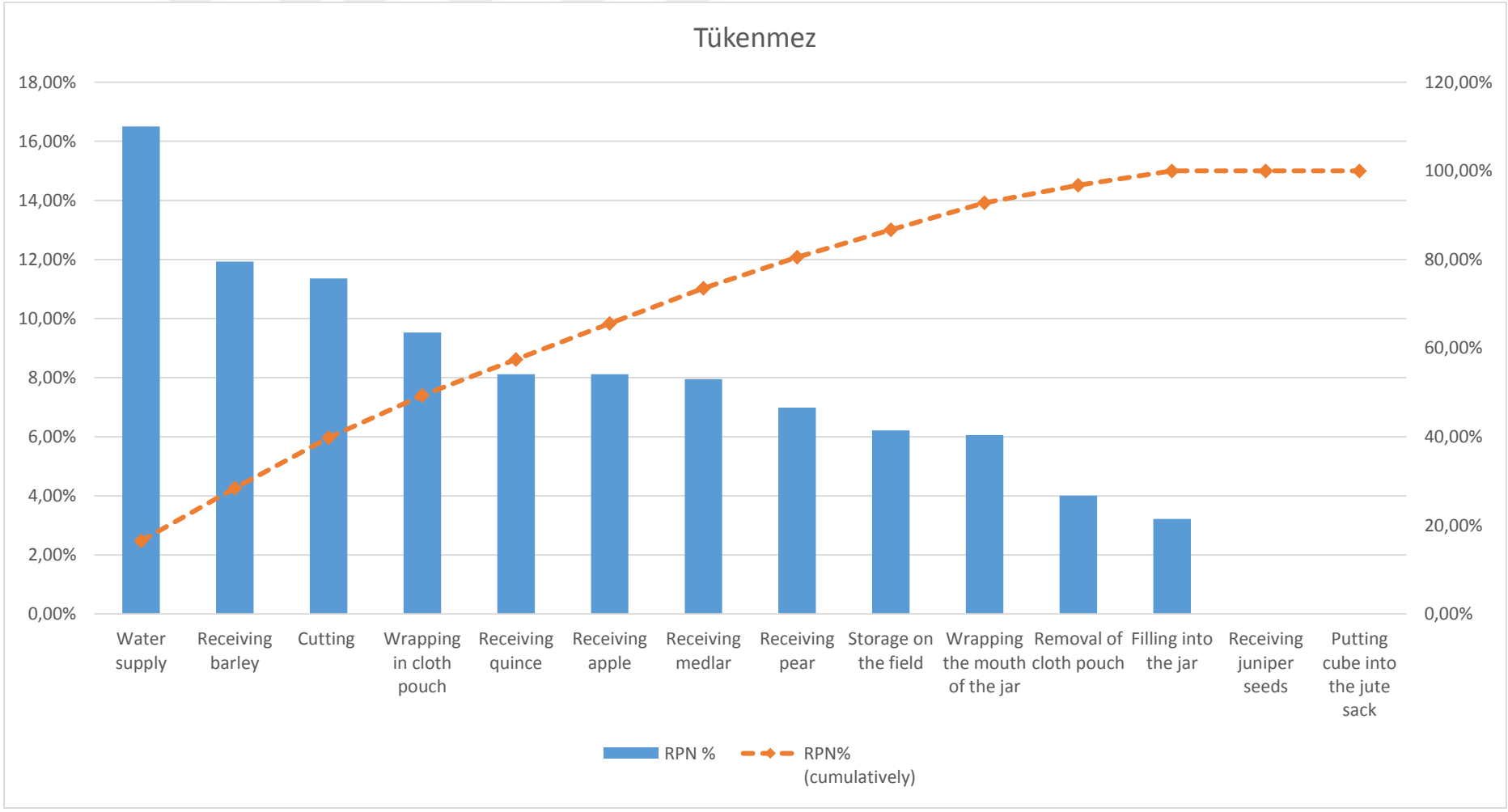

Figure C. 19. Pareto Diagram for Tükenmez Production

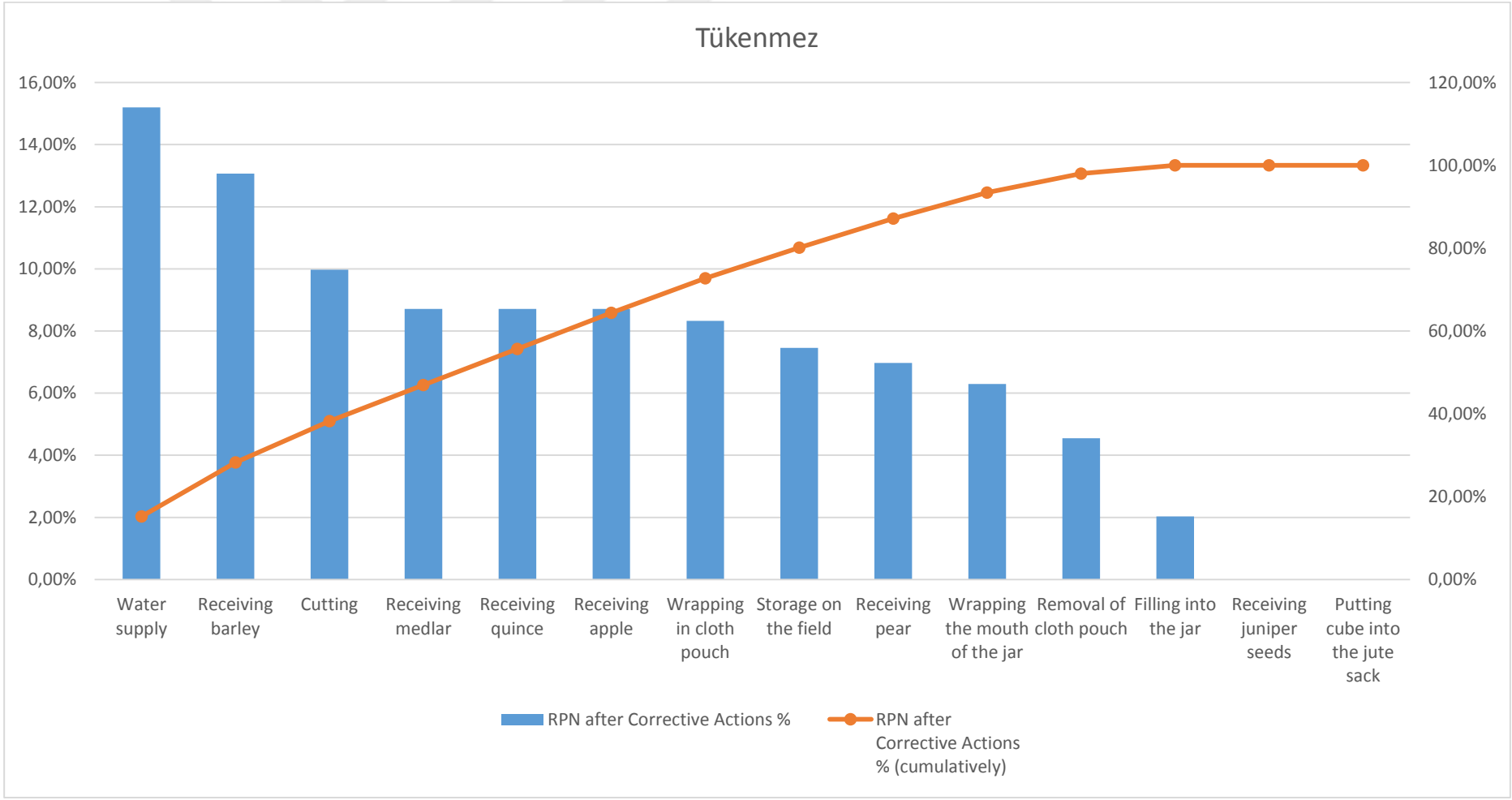

Figure C. 20. Pareto Diagram for Tükenmez Production after Corrective Actions

Appendix D: Nutrional Value Tables

Table D. 1. Nutritional Values of Ekşi Ayran

Ingredients	Weight (g)	Energy (kcal)	Water (g)	CHO (g)	Calcium (Ca) (mg)	Sodium (Na) (mg)	Potassium (K) (mg)	Phosphorus (P) (mg)	Magnesium (Mg) (mg)	Vitamin D (IU)	Isoleucine (mg)	Leucine (mg)	Valine (mg)	Ref.
Yogurt	10000.00	6900.00	8639.00	424.00	13200.00	5300.00	19100.00	11000.00	1300.00	4400.00	16800.00	35900.00	18100.00	TürKomp
Water	10000.00	0.00	9998.00	0.00	0.00	200.00	0.00	0.00	200.00	0.00	0.00	0.00	0.00	USDA
Total	20000.00	6900.00	18637.00	424.00	13200.00	5500.00	19100.00	11000.00	1500.00	4400.00	16800.00	35900.00	18100.00	
1 portion	200.00	69.00	186.37	4.24	132.00	55.00	191.00	110.00	15.00	44.00	168.00	359.00	181.00	

Table D. 2. Nutritional Values of Çüküdür Suyu

Ingredients	Weight (g)	Energy (kcal)	Water (g)	CHO (g)	Protein	Total Dietary Fiber (g)	Sodium (Na) (mg)	Potassium (K) (mg)	Phosphorus (P) (mg)	Magnesium (Mg) (mg)	Niacin (mg)	Vitamin C (mg)	Ref.
Red Beet	1000.00	440.00	881.70	80.20	12.30	12.80	1210.00	2790.00	290.00	200.00	2.31	82.00	TürKomp
Molasses (Güneydoğu)	98.00	237.16	37.67	58.09	1.11	0.21	9.80	815.36	39.20	41.16	0.00	0.00	TürKomp
Barley Flour	50.00	172.50	6.06	37.26	5.25	5.05	2.00	154.50	148.00	48.00	3.13	0.00	USDA
Salt	15.00	0.15	0.01	0.03	0.00	0.00	5611.35	1.50	0.00	0.45	0.00	0.00	TürKomp
Water	3000.00	0.00	2999.40	0.00	0.00	0.00	60.00	0.00	0.00	60.00	0.00	0.00	USDA
Bread	25.00	69.00	7.91	12.53	2.35	1.08	85.75	28.25	19.25	6.25	0.22	0.00	TürKomp
Total	4188.00	918.81	3932.74	188.12	21.01	19.14	6978.90	3789.61	496.45	355.86	5.66	82.00	

Table D. 3. Nutritional Values of Gilaburu

	Vitamin A (µg/100 g)	Vitamin E (µg/100 g)	β-carotene (µg/100 g)	Lycopen (µg/100 g)	Catechin (mg/100 g)	Gallic acid (mg/100 g)	Chlorogenic acid (mg/100 g)	Caffeic acid (mg/100 g)	Ref.
Gilaburu	22 ± 4	810 ± 104	980 ± 118	584 ± 62	28.496-35.204	10.829- 11.817	2.951-4.433	2.626-3.835	(59, 169)

Table D. 4. Nutritional Values of Hardaliye

Ingredients	Weight (g)	Energy (kcal)	Water (g)	CHO (g)	Protein	Total Dietary Fiber (g)	Sodium (Na) (mg)	Potassium (K) (mg)	Phosphorus (P) (mg)	Magnesium (Mg) (mg)	Niacin (mg)	Vitamin C (mg)	Ref.
White Grape (müşküle)	5000.00	3400.00	4115.00	740.00	23.50	69.50	200.00	11450.00	900.00	650.00	12.30	175.00	TürKomp
Black Grape (Hönüsü)	10000.00	7500.00	8035.00	1690.00	45.00	137.00	300.00	25300.00	2100.00	1400.00	24.20	390.00	TürKomp
Barley (2-row)	250.00	797.50	24.63	138.23	24.38	52.73	140.00	1295.00	750.00	330.00	11.18	0.00	TürKomp
Mustard	100.00	85.00	78.14	3.12	5.19	4.20	0.00	0.00	0.00	0.00	0.00	0.00	TürKomp
Total	15350.00	11782.50	12252.77	2571.35	98.07	263.43	640.00	38045.00	3750.00	2380.00	47.68	565.00	
1 portion	200.00	153.52	159.65	33.50	1.28	3.43	8.34	495.70	48.86	31.01	0.62	7.36	

Table D. 5. Nutritional Values of Hayva Şerbeti

Ingredients	Weight (g)	Energy (kcal)	Water (g)	CHO (g)	Total Dietary Fiber (g)	Sodium (Na) (mg)	Potassium (K) (mg)	Phosphorus (P) (mg)	Magnesium (Mg) (mg)	Vitamin C (mg)	Ref.
Quince	5000.00	2850.00	4190.00	765.00	95.00	200.00	9850.00	850.00	400.00	750.00	USDA
Honey	3000.00	9120.00	513.00	2472.00	6.00	120.00	1560.00	120.00	60.00	15.00	USDA
Vinegar	1000.00	30.00	990.10	8.70	0.00	110.00	560.00	90.00	50.00	0.00	TürKomp
Water	15000.00	0.00	14997.00	0.00	0.00	300.00	0.00	0.00	300.00	0.00	USDA
Saffron	6.00	18.60	0.71	3.92	0.23	8.88	103.44	15.12	15.84	4.85	USDA
Total	24006.00	12018.60	20690.81	3249.62	101.23	738.88	12073.44	1075.12	825.84	769.85	
1 portion	200.00	100.13	172.38	27.07	0.84	6.16	100.59	8.96	6.88	6.41	

Table D. 6. Nutritional Values of Kefir

	Weight (g)	Energy (kcal)	Water (g)	CHO (g)	Calcium (Ca) (mg)	Sodium (Na) (mg)	Potassium (K) (mg)	Phosphorus (P) (mg)	Magnesium (Mg) (mg)	Vitamin D (g)	Isoleucine (mg)	Leucine (mg)	Valine (mg)	Ref.
Total	100	65	87.5	4	0.12	120	150	100	120	0.08	210	340	220	(30)
1 portion	200	130	175	8	0.24	240	300	200	240	0.16	420	680	440	

Table D. 7. Nutritional Values of Mişmiş Şerbeti

Ingredients	Weight (g)	Energy (kcal)	Water (g)	CHO (g)	Total Dietary Fiber (g)	Sodium (Na) (mg)	Potassium (K) (mg)	Phosphorus (P) (mg)	Magnesium (Mg) (mg)	Vitamin C (mg)	Ref.
Apricot	5000.00	960.00	1727.00	222.40	40.00	20.00	5180.00	460.00	200.00	200.00	USDA
Granulated Sugar	3000.00	4000.00	0.30	999.20	0.00	140.00	40.00	160.00	0.00	0.00	TürKomp
Water	1000.00	0.00	1999.60	0.00	0.00	40.00	0.00	0.00	40.00	0.00	USDA
Total	9000.00	4960.00	3726.90	1221.60	40.00	200.00	5220.00	620.00	240.00	200.00	
1 portion	200.00	110.22	82.82	27.15	0.89	4.44	116.00	13.78	5.33	4.44	

Table D. 8. Nutritional Values of Şalgam Suyu

Ingredients	Weight (g)	Energy (kcal)	Water (g)	CHO (g)	Protein	Total Dietary Fiber (g)	Sodium (Na) (mg)	Potassium (K) (mg)	Phosphorus (P) (mg)	Magnesium (Mg) (mg)	Niacin (mg)	Vitamin C (mg)	Ref.
Turnip	4000.00	1040.00	3681.60	172.00	32.40	76.40	720.00	6920.00	600.00	320.00	29.00	1012.00	TürKomp
Black Carrot	3000.00	1260.00	2629.80	240.30	26.10	74.40	2460.00	7680.00	870.00	510.00	36.33	0.00	TürKomp
Salt	200.00	2.00	0.08	0.44	0.00	0.00	74818.00	20.00	0.00	6.00	0.00	0.00	TürKomp
Water	10000.00	0.00	9998.00	0.00	0.00	0.00	200.00	0.00	0.00	200.00	0.00	0.00	USDA
Bulgur Flour	200.00	684.00	18.00	151.74	24.58	25.00	34.00	820.00	600.00	328.00	10.23	0.00	USDA
Total	17400.00	2986.00	16327.48	564.48	83.08	175.80	78232.00	15440.00	2070.00	1364.00	75.56	1012.00	
1 portion	200.00	34.32	187.67	6.49	0.95	2.02	899.22	177.47	23.79	15.68	0.87	11.63	

Table D. 9. Nutritional Values of Töngel Şerbeti

Ingredients	Weight (g)	Energy (kcal)	Water (g)	CHO (g)	Protein (g)	Total Dietary Fiber (g)	Sodium (Na) (mg)	Potassium (K) (mg)	Phosphorus (P) (mg)	Magnesium (Mg) (mg)	Niacin (mg)	Vitamin C (mg)	Ref.
Medlar	3000.00	1260.00	2166.00	240.00	0.00	60.00	120.00	7890.00	0.00	0.00	0.00	0.00	(170)
Honey	500.00	1520.00	85.50	412.00	1.50	1.00	20.00	260.00	20.00	10.00	0.61	2.50	USDA
Hazelnut	1000.00	6460.00	29.70	53.60	142.40	154.70	30.00	5930.00	3180.00	1490.00	17920.00	0.00	TürKomp
Barley	20.00	63.80	1.97	11.06	1.95	4.22	11.20	103.60	60.00	26.40	0.89	0.00	TürKomp
Water	5000.00	0.00	4999.00	0.00	0.00	0.00	100.00	0.00	0.00	100.00	0.00	0.00	USDA
Total	9520.00	9303.80	7282.17	716.66	145.85	219.92	281.20	14183.60	3260.00	1626.40	17921.50	2.50	
1 portion	200.00	195.46	152.99	15.06	3.06	4.62	5.91	297.97	68.49	34.17	376.50	0.05	

Table D. 10. Nutritional Values of Tükenmez

Ingredients	Weight (g)	Energy (kcal)	Water (g)	CHO (g)	Protein	Total Dietary Fiber (g)	Sodium (Na) (mg)	Potassium (K) (mg)	Phosphorus (P) (mg)	Magnesium (Mg) (mg)	Niacin (mg)	Vitamin C (mg)	Ref.
Medlar	5000.00	2100.00	3610.00	400.00	0.00	100.00	200.00	13150.00	0.00	0.00	0.00	0.00	(170)
Quince	3000.00	1710.00	2514.00	459.00	12.00	57.00	120.00	5910.00	510.00	240.00	6.00	450.00	USDA
Apple (Granny Smith)	3000.00	1740.00	2563.80	408.30	13.20	84.00	30.00	3600.00	360.00	150.00	3.78	0.00	USDA
Pear (Santa Maria)	1000.00	540.00	846.20	109.60	5.10	35.00	30.00	1360.00	150.00	100.00	3.18	35.00	TürKomp
Dried Cherry	100.00	333.00	0.00	80.45	1.25	2.50	13.00	376.00	0.00	0.00	0.00	19.30	USDA
Dried Black Grape	100.00	312.00	16.34	71.53	2.35	7.20	26.00	969.00	70.00	45.00	0.00	0.00	TürKomp
Barley	100.00	319.00	9.85	55.29	9.75	21.09	56.00	518.00	300.00	132.00	4.47	0.00	TürKomp
Juniper Seed	20.00	21.00	0.00	2.50	1.75	1.50	0.00	0.00	0.00	0.00	0.00	22.50	
Water	15000.00	0.00	14997.00	0.00	0.00	0.00	300.00	0.00	0.00	300.00	0.00	0.00	USDA
Total	27320.00	7075.00	24557.19	1586.67	45.40	308.29	775.00	25883.00	1390.00	967.00	17.43	526.80	
1 portion	200.00	51.79	179.77	11.62	0.33	2.26	5.67	189.48	10.18	7.08	0.13	3.86	

8. CURRICULUM VITAE

Personal Information

Name	Hasan Kaan	**Surname**	Kavsara
Place of Birth	Denizli	**Date of Birth**	26.08.1993
Nationality	T.C.	**ID No:**	26356555018
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Education Status

Degree	Department	Name of the Schools	Year of Graduation
Postgraduate	Department of Nutrition and Dietetics	Yeditepe Üniversitesi	2017- Now
Undergraduate	Psychology	Yeditepe Üniversitesi	2014-2017
Undergraduate	Nutrition and Dietetics	Yeditepe Üniversitesi	2013-2017

Foreign Languages	Language Scores
English (YÖKDİL)	95
English (YDS)	71,25

Working Experience

Job	İnstitution	Duration (Year - Year)
Research Assistant	Yeditepe Üniversitesi	2018-halen

Computer Knowledge

Program	Usage
Microsoft Office	Very good
SPSS	Moderate

Others (Projects / Certificates / Awards)

Pedagojik Formasyon Eğitimi Programı Dönem 2. liği (CGPA: 3,88) İSTANBUL MEDENİYET ÜNİVERSİTESİ	2018
Sağlık Bilimleri Fakülte 2. liği (CGPA: 3,88) YEDİTEPE ÜNİVERSİTESİ	2017