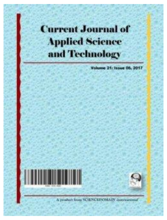

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Application of Hazard Analysis Critical Control Points System (HACCP) during Production of Tarhana

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Authors' contributions

This work was carried out in collaboration between all authors. Author MMAER designed the study, wrote the protocol, wrote the first draft of the manuscript and managed the literature searches. Author MGEG designed the study, wrote the protocol, managed the analyses of the study, performed the statistical analysis and managed the literature searches. Author MFYH designed the study, wrote the protocol, managed the analyses of the study and managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

The aim of this study is development of Hazard Analysis and Critical Control Points (HACCP) system during production of Tarhana on small scale production. Tarhana is known as a traditional fermented food widely consumed in Middle East countries. Since Tarhana prepared by traditional method, homemade and consumed widely, its safety is very important in terms of consumer health. Therefore, HACCP system as food safety tool was adopted during preparation of Tarhana. Hazard analysis of raw materials and during different production steps was established with different control measures could be used in controlling various identified hazards. HACCP plan was

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implemented, three critical control points: reception raw materials, fermentation and drying steps were determined during production of Tarhana. Critical limits, corrective actions and monitoring procedures for each critical control points were established, verification procedures were also discussed.

Keywords: Food safety; GMPs; HACCP; SSOPs; Tarhana.

1. INTRODUCTION

Tarhana is one of the most important traditional fermented foods in Turkey, it has a high quality value especially nutritional and sensory characteristics. Tarhana is basically produced by mixing yogurt, wheat flour, yeast (*Saccharomyces cerevisiae*, in some regions), salt, and different raw and cooked vegetables such as tomatoes, onions, green and red peppers and spices as basil, mint, dill, paprika, Tarhana herb *Echinophora sibthorpiana*, etc.). Production of Tarhana is followed by lactic and alcoholic fermentation for one to seven days [1,2]. After fermentation, Tarhana dough is usually dried by using sun dried domestically or an industrial scale modern drying methods such as conventional hot air drying, microwave drying [3,4].

The low moisture content (6–9 %) and pH (3.8–4.4) make Tarhana as a poor medium for growth pathogenic and spoilage organisms; in the same time, Tarhana is not hygroscopic and it can be stored for 2–3 years without any signs of deterioration [5]. In the same time, Organic acid production during the fermentation and lowering the moisture content below 10% by drying have bacteriostatic effect on pathogenic microorganisms and increase product shelf life [6].

Tarhana could be produced by using different types of ingredients, production techniques and drying methods, therefore Tarhana have different composition, rheological and functional/nutritional properties and sensory attributes [1,7,2]. According to Daglıoglu [3], four types of Tarhana have been defined by the Turkish Standardization Institute: (1) flour Tarhana, (2) goce Tarhana, (3) semolina Tarhana, and (4) mixed Tarhana. In the same time, different flours of cereal and legume flours such as rye, maize, barley, soybean, oat and chickpea could be used other than wheat flour in the production of Tarhana [8]. Also, some researchers produced Tarhana with fortified, supplemented or replaced wheat flour and/or some amount of yoghurt by adding other cereals, legumes, wheat germ, or wheat bran for improving the functional characteristics of Tarhana [9]. The same time, Ozdemir et al. [10], reports that, cereal and legume flours other than wheat flour (rye, maize, barley, soybean, and chickpea) can also be used in the production of Tarhana.

The utilization of oat and oat-based foods for human consumption has increased considerably in recent years, Oat (*Avena sativa L.*) has a positive nutritional effects and it is generally consumed as a whole-grain cereal, which includes all the nutritionally valuable portions. Oat could be used as a breakfast food or snack product, in the same time, it is an excellent source of dietary fiber, such as ß-glucan and arabinoxylans, and also contains a considerable amount of protein, B complex vitamins, unsaturated fatty acids, including linoleic acid, vitamin, and minerals along with bioactive phytochemicals, such as phenolic compounds that provide specific health benefits. Clinical studies have demonstrated that consumed oat as whole grain is effective against diabetes, blood glucose, total blood cholesterol, and low-density lipoprotein cholesterol levels, and it also protects against some types of cancer [11,8]. Kilci and Gocmen [8] used steel-cut oats (SCO) for replacing wheat flour in the Tarhana formulation at the levels of 10%, 20%, 30% and 40% (w/w). Substitution of wheat flour in Tarhana formulation with SCO positively affected the mineral contents of prepared Tarhana. SCO additions also increased phenolic acid contents of Tarhana samples. In the same time, addition SCO did not have a negative effect on sensory properties of Tarhana samples and resulted in acceptable soup properties in terms of overall acceptability. So, SCO addition improved the nutritional and functional properties of produced Tarhana with increasing antioxidant activity, phenolic content and phenolic acids. Erkan et al. [12] used barley flour in Tarhana production in order to produce a new food product with relatively high ß-glucan content. ß-glucan is known to have cholesterol lowering effect, regulate blood glucose level and have insulin response in diabetics and even reduce the risk of cancer. The level of ß-glucan in Tarhana samples was lower than that of barley flours due to the decrease in ß-glucan content during fermentation. Utilization of barley flour in Tarhana production resulted in acceptable soup properties in terms of most of the sensory properties. Slightly lower values in color and taste could be compensated by the health benefits of barley products.

Organic acid production during the fermentation of Tarhana and lowering its moisture content below 10% by drying have bacteriostatic effect on pathogenic microorganisms and increase product shelf life [6]. Although it could be noticed that low pH value (acidity) and low water content inhibition the growth and multiplication of food pathogenic microorganisms. But according to researches several pathogenic bacteria can survive for over than 2 hours in foods having a pH value of 2 to 2.5. Since Tarhana has a pH value of approximately 4.0 and it was made from a lot of ingredients, so it could be a good medium for growth of microorganisms. Not only microbiological hazards, but also physical and chemical hazards could be occurring during production of Tarhana [13,14].

The most affective and well-known system for controlling biological, chemical and physical hazards and their risks during food processing is Hazard Analysis Critical Control Point (HACCP) system. HACCP is known as a combined system of hazards identification and risk assessment [15]. Through implementation of HACCP system, different hazards (biological, chemical and physical) in any processing step of food chain production can be identified and risks can be classified, then control measures of those hazards can be established. Other benefits of establishing HACCP system during food processing are reduced need for final inspection and analysis of a food product, higher customer satisfaction and trust in product safety, and improved food safety. The use of HACCP system for controlling food safety is not new. The Pillsbury Company was the first food industry applied HACCP system in the year of 1960. Pillsbury had been contracted by National Aeronautics and Space Administration (NASA) in conjunction with U.S. Army Natick Laboratories to design and produce foods for space flights. The cooperative HACCP program which evolved had the goal of nearly 100% assurance that space foods produced would be free of microbial or viral pathogens. This systematic, preventative approach combines the principles of food microbiology, quality control, and risk assessment was named HACCP system [15]. HACCP system is a systematic approach to the identification, assessment of risk and control of the biological, chemical and physical hazards associated with each part of the food system from production to consumption, following the seven basic principles, 1) Identification of hazards that may be present from harvest through ultimate consumption and preventive measures for controlling them, 2) Determination of Critical Control Points (CCPs) required to control the identified hazards, 3) Establishment of critical limits that must be met at each CCP, 4) Establish appropriate monitoring procedures for each identified CCPs, 5) Establishment of corrective actions should be taken when CCPs are not under control, 6) Establishment of procedures for verification that HACCP system is working according to the plan and 7) Documentation records concerning all procedures and records appropriate to principles 1 through 6, National Advisory Committee on Microbiological Criteria for Foods [16].

Therefore, applying HACCP system as a food safety tool during production of Tarhana is very important. So the aim of this investigation is the implementation HACCP system during production of Tarhana on small scale production. Hazard analysis of raw materials and during different production steps of Tarhana was established. A simple HACCP plan was planned, critical control points of production steps were determined, critical limits, corrective actions and monitoring procedures for each critical control points were established, verification procedures were also discussed.

2. MATERIALS AND METHODS

2.1 Materials

Cow and goat milk used in yoghurt preparation were kindly obtained from Agriculture and Veterinary Research and Experiments Center, Qassim University. Starter Yo-flex culture (Yc-183) was obtained from Christian Hansen (Copenhagen, Denmark) which is a mixed strain culture (1: 1) of *Streptococcus thermophiles* and *Lactobacillus delbrueckii* subsp. *Bulgaricus*. Wheat flour was obtained from Saudi Grains Organization (SAGO), Qassim region. Oat (*Avena sativa*), barley (*Hordeum valgare*) grains, tomato paste, chopped dry onion, paprika, salt and baker's yeast were purchased from the local market, Buraidah, Qassim region. Oat and barley grains were ground by using a hammer mill and sieved through 212 μm sieve then kept in refrigerator until analyzed. The reagents used for the chemical analyses were of analytical grade.

2.2 Methods

2.2.1 Preparation of Tarhana

Different Tarhana samples were prepared from cow or goat yoghurt with wheat, oat or barley flour and the abbreviation codes of prepared Tarhana samples are listed in Table 1.

Table 1. Abbreviation codes of prepared different Tarhana samples

Tarhana sample code	Raw materials used in Tarhana preparation
TCW	Cow yoghurt with wheat flour
TCO	Cow yoghurt with oat flour
TCB	Cow yoghurt with barley flour
TGW	Goat yoghurt with wheat flour
TGO	Goat yoghurt with oat flour
TGB	Goat yoghurt with barley flour

Cow and goat yoghurt samples used in Tarhana processing were prepared according to the method reported by Tamime and Robisons [17], (Fig. 1). For Tarhana preparation, (Fig. 2), wheat, oat or barley flour (400 g), cow or goat yoghurt (160 g), tomato paste (40 g), chopped dry onion (20 g), dry paprika (8 g), table salt (4 g) and baker's yeast (10 g), were mixed for 5 min using a Hobart mixer (N 50, Canada). The dough was put in the closed plastic containers and left for fermentation at 30°C for 72 h in an incubator. The fermented dough's were divided into 2 cm diameter pieces, placed on the trays, and dried at 55°C for 48 hours in an air convection oven. The dried samples were ground into granulated form in a hammer mill equipped with 1 mm opening screen. The end Tarhana samples were kept in closed glass containers at room temperature [18].

2.2.2 Physical properties

The pH of different prepared Tarhana dough samples during fermentation period and Tarhana powder samples were measured according to the method of Adeleke and Odedeji, [19] using a pH meter (HANNA, HI 9025) already standardized with buffer solutions of pH 4.0 and 7.0. Tarhana samples were analyzed for titratable acidity (calculated as % of lactic acid) as reported by Ling, [20]. The moisture content of Tarhana was determined by oven drying methods according to the methods described in [21]. Water Activity of Tarhana samples was determined using AQUA LAB (model series 3), USA by methods described by Landrock and Proctor [22].

2.2.3 Microbiological analysis

Different prepared Tarhana samples were microbiologically analyzed before and after drying process. Prepared Tarhana samples (10 g from each) were aseptically taken, homogenized in 90 ml of sterile diluent (0.1% peptone water) with a Stomacher (Seward, Model 400, England) for 30 sec., serial dilutions were prepared in peptone water [23].

Tarhana samples were examined for total viable bacterial counts, [24], lactic acid bacteria [25], yeasts and molds [26] and coliforms [27]. After incubation, the colonies (30-300 colonies) developed on agar plates were counted. Each value represents the mean of duplicate and results were expressed as Log Colony Forming units per gram (log CFU/g) [28].

2.2.4 Application of HACCP system

According to the NACMCF, [16] and NACMCF, [29], HACCP system was implemented during different preparation steps of Tarhana samples based on the following seven principles:

1) Conduct a hazard analyses; 2) Identify the critical control points (CCPs); 3) Establish critical limits for preventive measures associated with each identified CCP; 4) Establish CCP monitoring requirements; 5) Establish corrective actions to be taken when monitoring indicates then a deviation from an established critical limit; 6) Establish verification procedures and 7) Establish record-keeping and documentation procedures. The results were summarized with reference to CCPs and their monitoring on the HACCP worksheet.

2.2.5 Statistical analysis

Data were expressed as the means ± SE. Statistical analysis was carried out using the PROC ANOVA followed by Duncan's Multiple Range Test with $p \leq 0.05$ being considered statistically significant to compare between means according to [30]. All procedures were triplicate using Statistical Analysis System program [31].

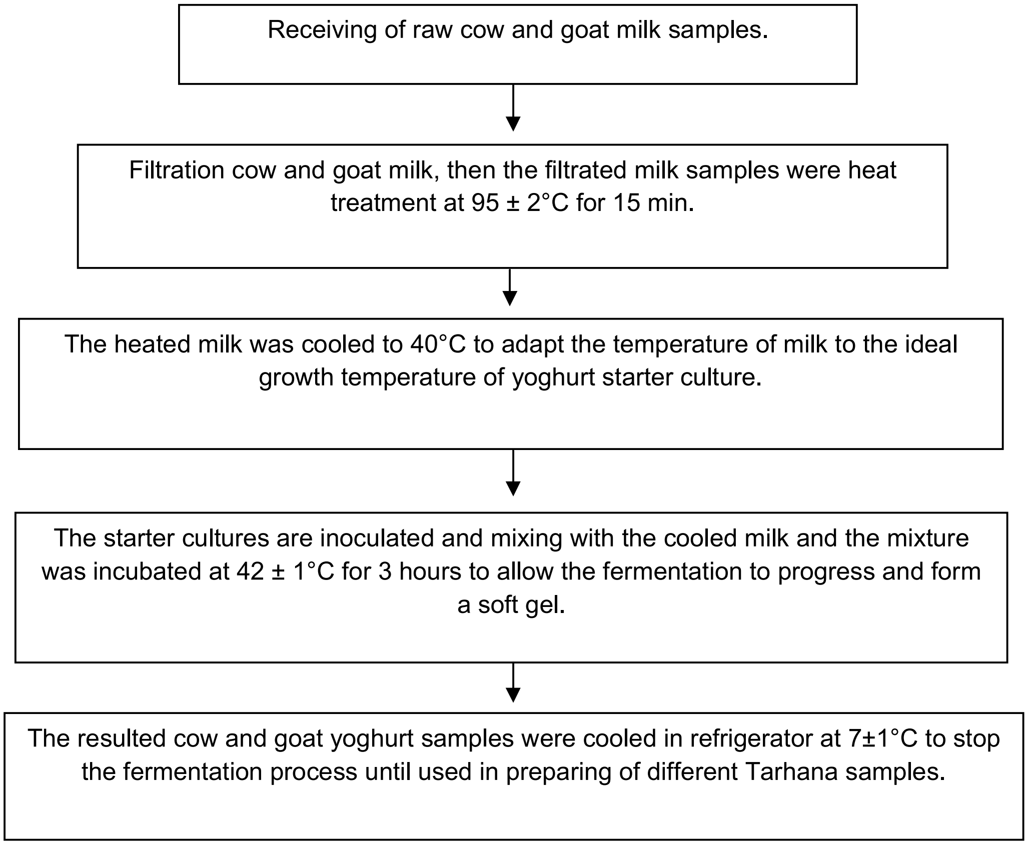

Fig. 1. Flow diagram of preparation steps of cow and goat yoghurt samples

3. RESULTS AND DISCUSSION

3.1 Development and Application of HACCP System during Production Tarhana

3.1.1 Description of product

Tarhana is a famous and highly consumed wet or dry fermented food. The product is manufactured by mixing cereals flour, yoghurt, baker' s yeast, vegetables, salt and spices, followed by fermentation for 1 to 6 days. Since Tarhana has a valuable nutritional value, it is consumed by consumers of different ages.

3.1.2 Developing the flow diagram of Tarhana production

Different production steps of producing yoghurt and Tarhana sample were described in Figs. 1 and 2, respectively, the flow diagrams included various production steps from the receipt of the raw materials until the final product (yoghurt or Tarhana) is obtained.

3.1.3 Development and application of HACCP plan during production Tarhana

HACCP plan is a document contained different food safety hazards, control measures, critical control points, critical limits for each identified critical control point, monitoring procedures and corrective actions should be taken if critical control points are out of control.

3.1.4 Hazard analysis

Hazard analysis during production of Tarhana sample is established by identification of different food safety hazards (biological, chemical and physical), with various raw material and production steps of Tarhana as listed in Table (2), at the same time, control measures of each identified hazard were determined. As seen in Table (2), different biological, chemical and physical hazards were identified during receiving different raw materials used in production Tarhana. Hazards could be listed as pathogenic bacteria (e.g. *Staphylococcus aureus*, *Bacillus cereus* and *Salmonella sp.*), spore forming bacteria and yeast and mold (biological), the most important microbiological hazards were spore forming bacteria and presence of yeast and mold as presence of them could resulted presence of mycotoxins. Therefore, mycotoxins, pesticides residues, heavy metals and different impurities, foreign materials were identified as chemical and physical hazards, respectively (Table 2).

Control measures such as certified suppliers of raw ingredients complain with raw materials specifications and good manufacturing practices (GMPs) could be used in controlling the aforementioned food safety hazards. So, the receipt of raw ingredients used in Tarhana production should be in accordance with the standards and requirements of the particular source of regulations and circulars issued by the Ministry of Municipal and Rural Affairs (https://www.momra.gov.sa/GeneralServ/Forms.aspx) and Saudi Food & Drug Authority (https://www.sfda.gov.sa/ar/food). At the same time, microbiological, chemical and physical characteristics of ingredients used in production Tarhana should be under the upper limits given in Guides of microbiological specifications and criteria for foods & harmful residues in food. As presented in Fig. 2, different production steps of Tarhana were illustrated and the hazard analysis results of these steps were tabulated in Table 2 with listed various control measures could be used to prevent, eliminate and reduce each identified hazard (biological, chemical and physical) to an acceptable level. Fermentation of Tarhana dough is an important production step. Fermentation is carried out to enhance the different characteristics of Tarhana as taste, aroma, texture and nutritional value and safety since fermentation is realized for inhibiting pathogenic microorganisms originated from different raw materials and during different preparing steps. So, utilization of pure of baker' s yeast in fermentation of Tarhana is very concern as control measures in addition to sanitation standard operating procedures (SSOPs) and good manufacturing practices (GMPs) in the production of Tarhana. Drying of fermented Tarhana dough is performed for controlling different biological hazards (pathogenic bacteria, spore forming bacteria and yeast and mold) from raw ingredients and during different preparation steps. SSOPs, GMPs, acidity, pH and water activity of Tarhana could be used as control measures for controlling the identified biological hazards (Table 2). Grinding and packaging dried Tarhana are also an important production steps related to physical hazards (foreign materials), so SSOPs, GMPs and sieving could be used as control measures for those steps.

3.1.5 Critical control points

Critical control points (CCPs) are processing step where control measures could be performed to prevent, eliminate and reduce any identified hazards (biological, chemical and physical) to an acceptable level [32]. A decision tree was used for identified preparation step could be established as CCP during Tarhana production and the results were shown in Table 3. It could be noticed that, receiving raw materials of Tarhana production is the first identified CCP, as listed in Table 3, three types of hazards biological, chemical and physical were identified so this step could be used as CCP for controlling the identified hazards listed in Table 3. The second identified CCP during Tarhana production is fermentation, (Table 3), in Tarhana production fermentation is carried out for preventing different biological hazards (Pathogenic bacteria, spore forming bacteria and yeast and mold) could be presented from various raw materials and during different production steps. Fermentation conditions as time, incubation temperature, addition of yoghurt and baker' s yeast affect the formation of organic acids during fermentation which will low pH of Tarhana dough, so low pH inhibition the growth of different pathogens in Tarhana and hence increase the shelf-life of Tarhana. The results of Tarhana pH during fermentation period (3 days) and Tarhana powder were presented in Table 4. It could be noticed that the final pH of Tarhana dough's prepared from wheat, oat and barley cereals with cow yoghurt were 4.54, 4.59 and 4.74, respectively, where Tarhana dough's prepared from the aforementioned cereals and replacement cow yoghurt by goat yoghurt have final pH of 4.47, 4.70 and 4.54, respectively. About the acidity of produced Tarhana it could be noticed the relationship with lowest pH of different Tarhana dough's and powders and development their acidity as listed in Table 5. The final acidity (as lactic acid) of prepared Tarhana with cereals of wheat, oat and barley and addition of cow and goat yoghurt were 1.02, 1.49, 1.47 and 1.17, 0.78, 2.12, respectively. According to Abou-Zeid [33], the final pH and percentage of acidity of Tarhana were in the range of 4.348 and 1.8-2.3. As reported by Dalgic and Belibagh [34], drying is an important step in Tarhana production. Low moisture content (6–11%) and low pH (3.8–4.4) provide a bacteriostatic effect on pathogenic microorganisms and hence increase the shelf-life of Tarhana. So, the third CCP during production of Tarhana is drying and the food safety hazard could be controlled by its biological hazards as presented in Table 3. The moisture content and water activity of Tarhana dough's and powders were presented in Table 6. The moisture content of dried prepared Tarhana with cereals of wheat, oat and barley and addition of cow and goat yoghurt were 6.11, 4.61, 4.44 and 6.27, 4.42, 4.03, respectively. At the same time, water activity of the aforementioned dried prepared Tarhana samples were 0.221, 0.160, 0.153 and 0.232, 0.145, 0.151, respectively (Table 6).

3.1.6 Critical limits

Critical limits of each identified CCP during Tarhana production were determined and tabulated in Table 7. The critical limits of receiving raw ingredients should be listed in supplier guarantee specifications of each ingredients established by Ministry of Municipal and Rural Affairs (www.momra.gov.sa) and Saudi Food & Drug Authority (www.sfda.gov.sa). So, levels of different hazards in raw ingredients should be under the maximum values listed in guides of microbiological specifications and criteria for foods and harmful residues in food (www.momra.gov.sa). At the same time, microbiological, chemical and visual inspections of all raw materials should be taken into consideration according to established HACCP plan. The conditions of fermentation and drying steps as temperature and time were established as critical limits for fermentation and drying steps during production of Tarhana. Temperature and time of fermentation were 30 ± 2°C and 72 hr, respectively, where their values for drying step were 55 ± 2°C and 48 hr, respectively.

3.1.7 Monitoring procedures

Visual inspection of supplier guarantee for each ingredient used in Tarhana production could be established as monitoring procedures for CCP of receiving raw ingredients. Where checking temperature and time of fermentation and drying steps (second and third CCP during Tarhana production) could be used as monitoring procedures for these CCPs. At the same time, measuring pH, acidity and water activity of prepared Tarhana could be used as monitoring procedure for the same aforementioned two steps (Table 7).

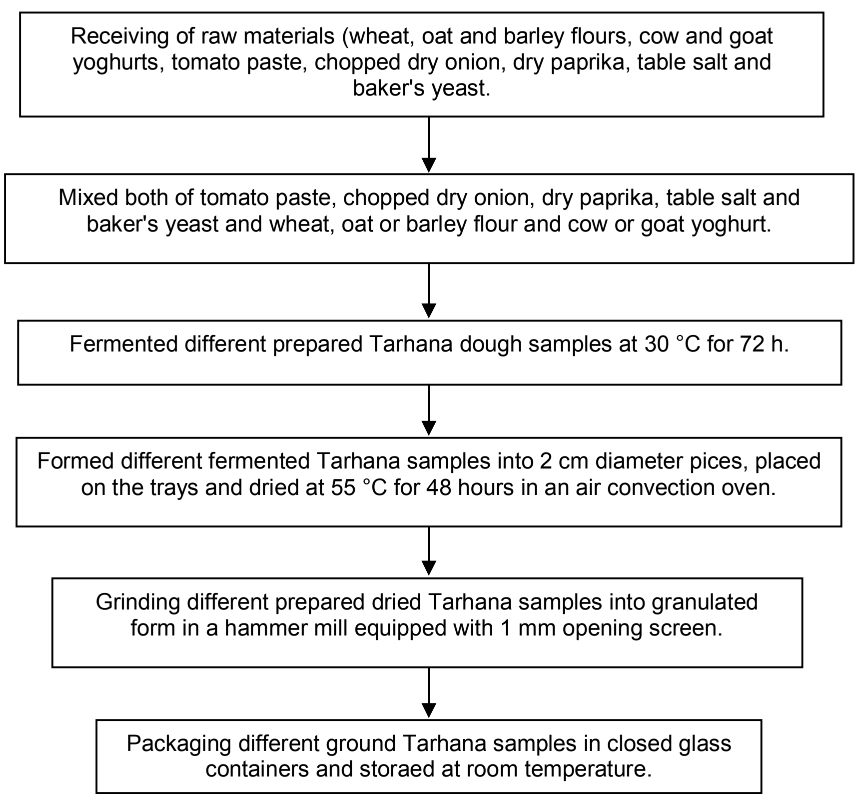

Fig. 2. Flow diagram of preparation steps of Tarhana samples

Table 2. Hazard analysis of raw materials and different preparation steps of Tarhana samples

Preparation step	Hazard			Control measures
	Biological	Chemical	Physical	
Receiving of different raw materials	Pathogenic bacteria, spore forming bacteria and yeast and mold.	Mycotoxins, pesticides residues and heavy metals.	Different impurities and foreign materials.	Certified suppliers, complains with raw materials specifications and good manufacturing practices
Mixing of raw materials	Pathogenic bacteria, spore forming bacteria and yeast and mold.	Non	Foreign materials.	Sanitation standard operating procedures and good manufacturing practices.
Fermentation	Pathogenic bacteria, spore forming bacteria and yeast and mold.	Non	Non	Sanitation standard operating procedures, good manufacturing practices, acidity and pH.
Formed and dried	Pathogenic bacteria, spore forming bacteria and yeast and mold.	Non	Foreign materials.	Sanitation standard operating procedures, good manufacturing practices, acidity, pH and water activity of Tarhana.
Grinding	Non	Non	Foreign materials.	Sanitation standard operating procedures, good manufacturing practices and sieving.
Packaging	Non	Non	Foreign materials.	Sanitation standard operating procedures and good manufacturing practices.

Table 3. Critical control points (CCPs) during preparing Tarhana samples

Preparation step	Decision tree questions*				CCP	Hazard
	Q1	Q2	Q3	Q4		
Receiving of different raw materials	Yes	Yes	-	-	CCP	Biological, chemical and physical.
Mixed of raw materials	Yes	No	Yes	Yes	-	-
Fermentation	Yes	Yes	-	-	CCP	Biological
Formed and dried	Yes	Yes	-	-	CCP	Biological
Grinding	Yes	No	No	-	-	-
Packaging	Yes	No	No	-	-	-

**: NACMCF [16].*
Q1: Do preventative control measures exist?
Q2: Is the step specifically designed to eliminate or reduce the likely occurrence of a hazard to an acceptable level?
Q3: Could contamination with identified hazard(s) occur in excess of acceptable levels?
Q4: Will subsequent step(s) eliminate or reduce the hazard to an acceptable level?

Table 4. Changes in pH of Tarhana dough during fermentation period and pH of Tarhana powder

Tarhana samples	Fermentation period (days)				Tarhana powder
	Zero	One	Two	Three	
TCW	4.71 ± 0.98[ab]	4.64 ± 0.05[b]	4.60 ± 0.05[c]	4.54 ± 0.02[bc]	4.85 ± 0.01[d]
TCO	4.69 ± 0.01[b]	4.65 ± 0.02[b]	4.63 ± 0.02[c]	4.59 ± 0.01[b]	4.74 ± 0.01[e]
TCB	4.84 ± 0.02[a]	4.82 ± 0.03[a]	4.79 ± 0.01[a]	4.74 ± 0.01[a]	5.03 ± 0.01[b]
TGW	4.69 ± 0.01[b]	4.54 ± 0.02[c]	4.51 ± 0.01[d]	4.47 ± 0.02[c]	4.88 ± 0.01[c]
TGO	4.79 ± 0.01[ab]	4.76 ± 0.01[a]	4.72 ± 0.01[ab]	4.70 ± 0.41[a]	5.58 ± 0.01[a]
TGB	4.78 ± 0.01[ab]	4.75 ± 0.02[a]	4.67 ± 0.01[bc]	4.54 ± 0.02[bc]	4.34 ± 0.01[f]

Data are the mean ± SE, n = 3,
Means having the same letter within each property are not significant difference at p≥0.05

Table 5. Development in acidity (% as lactic acid) of Tarhana dough during fermentation period and acidity of Tarhana powder

Tarhana samples	Fermentation period (days)				Tarhana powder
	Zero	One	Two	Three	
TCW	0.32 ± 0.03[b]	0.47 ± 0.02[c]	0.79 ± 0.04[a]	0.95 ± 0.03[a]	1.02 ± 0.02[c]
TCO	0.35 ± 0.01[ab]	0.49 ± 0.03[c]	0.68 ± 0.02[b]	0.86 ± 0.03[b]	1.49 ± 0.03[b]
TCB	0.42 ± 0.03[a]	0.76 ± 0.02[a]	0.79 ± 0.01[a]	0.85 ± 0.03[b]	1.47 ± 0.03[b]
TGW	0.36 ± 0.05[ab]	0.62 ± 0.01[b]	0.76 ± 0.03[a]	0.86 ± 0.03[b]	1.17 ± 0.00[c]
TGO	0.30 ± 0.02[b]	0.60 ± 0.03[b]	0.67 ± 0.03[b]	0.72 ± 0.03[c]	0.78 ± 0.03[d]
TGB	0.39 ± 0.03[ab]	0.77 ± 0.02[a]	0.81 ± 0.00[a]	0.90 ± 0.00[ab]	2.12 ± 0.02[a]

Data are the mean ± SE, n = 3,
Means having the same letter within each property are not significant difference at p≥0.05

Table 6. Moisture content (%) and water activity of Tarhana dough after fermentation up to three days and Tarhana powder

Tarhana samples	Tarhana dough		Tarhana powder	
	Moisture content (%)	Water activity	Moisture content (%)	Water activity
TCW	39.34 ± 0.04[e]	0.962 ± 0.01[c]	6.11 ± 0.01[b]	0.221 ± 0.01[b]
TCO	43.97 ± 0.27[c]	0.977 ± 0.01[a]	4.61 ± 0.02[c]	0.160 ± 0.00[c]
TCB	45.79 ± 0.36[b]	0.968 ± 0.02[b]	4.44 ± 0.03[d]	0.153 ± 0.02[cd]
TGW	42.56 ± 0.35[d]	0.955 ± 0.00[d]	6.27 ± 0.05[a]	0.232 ± 0.00[a]
TGO	41.64 ± 0.44[d]	0.972 ± 0.01[ab]	4.42 ± 0.04[d]	0.145 ± 0.03[d]
TGB	46.92 ± 0.33[a]	0.972 ± 0.03[ab]	4.03 ± 0.03[e]	0.151 ± 0.05[d]

Data are the mean ± SE, n = 3,
Means having the same letter within each property are not significant difference at p≥0.05

3.1.8 Corrective actions

Different corrective actions for each identified CCP during production of Tarhana were established and presented in Table 7. A corrective action for the receiving raw ingredients used in Tarhana production was reject any doubtful ingredients as it not accompanied by supplier guarantee. Check and repair fermentation and drying conditions (temperature and time) and reprocess if necessary were the corrective actions could be established when monitoring procedures of fermentation and drying steps had been indicated that, the critical limits of those steps were exceeded or the aforementioned CCPs were out of control.

3.1.9 Verification procedures

The verification procedures for each identified CCP were established and presented in Table 7. Auditing of supplier guarantee and Visual inspection of characteristics for each ingredient used in Tarhana production were the verification procedures could be established for verifying that receiving raw ingredients step is not out of control. Regarding to fermentation and drying steps, checked the conditions of fermentation and drying steps (temperature and time) could be taken as verification procedures for verifying the aforementioned two CCPs.

Table 7. HACCP worksheet for prepared Tarhana samples

CCP	Hazard	Critical limits	Monitoring	Corrective actions	Verification	Record keeping
Receiving of raw materials	Biological, chemical and physical	Supplier guarantees specifications of ingredients.	Visual inspection of supplier guarantee and sensory characteristics of each ingredient.	Reject any doubtful ingredients.	Auditing of supplier guarantee and visual inspection of characteristics for each ingredients.	Supplier guarantee
Fermentation	Biological	Compliance with general recommendation of good manufacturing practices. Temperature and time of incubation 30 ± 2°C for 72 hrs.	Checked of temperature and time of inculpation and pH acidity of Tarhana.	Check and repair incubation conditions and reprocess if necessary (increase time of incubation).	Checked the incubation conditions and the final pH and acidity of Tarhana.	Reports of checked temperature and time of inculpation and pH and acidity of Tarhana.
Formation and drying	Biological	Compliance with general recommendation of good manufacturing practices. Temperature of drying 55 ± 2°C for 48 hrs.	Checked temperature and time of drying process and pH, acidity and water activity of Tarhana.	Check and repair drying conditions and reprocess if necessary (increase time or temperature of drying).	Checked the drying conditions and testing the pH, water activity, acidity and microbiological load of Tarhana.	Reports of checked the drying conditions and testing the pH, water activity, acidity and microbiological load of Tarhana.

Table 8. Microbiological analysis of different prepared Tarhana samples before and after drying

Tarhana samples	Microbiological analysis (log cfu/g)							
	Total viable bacteria		Lactic acid bacteria		Coliform group		Yeast and mold	
	Before drying	After drying	Before drying	After drying	Before drying	After drying	Before drying	After drying
TCW	3.74	2.78	4.44	2.35	≤1	≤1	4.35	2.48
TCO	5.86	3.38	5.79	2.75	≤1	≤1	5.51	3.90
TCB	3.45	2.70	4.24	2.48	≤1	≤1	3.30	2.30
TGW	4.20	2.85	3.83	2.58	≤1	≤1	4.59	2.70
TGO	7.05	6.00	6.40	5.70	≤1	≤1	6.12	5.08
TGB	4.89	3.30	4.92	3.93	≤1	≤1	4.93	3.88

Data are the mean n = 3,
≤1: viable colony was not detected at detection limit < log CFU/g

Fermentation and drying steps were performed especially for controlling the safety of Tarhana as pH, acidity and water activity of the product were sufficient for controlling microbial growth especially pathogenic bacteria, spore forming bacteria, yeast and mold [33,34]. So measuring the pH, acidity and water activity of produced Tarhana were the most verification procedures for verifying the fermentation and drying steps during Tarhana production as those steps related directly with the safety of Tarhana [33,34]. With respect to that, microbiological analysis of Tarhana as end product was very important verification procedure could be established for verifying the development HACCP plan during production of Tarhana. Counts of total bacteria, lactic acid bacteria, coliform, yeast and mold for produced Tarhana before and after drying were determined and the results were presented in Table 8. It could be noticed that, the effect of drying step in reducing microbiological load of produced Tarhana especially those related to its safety. Tested microbiological criterion (total bacterial count) of Tarhana prepared with cereals of wheat, oat and barley and addition of cow and goat yoghurt were 3.74, 5.86, 3.45 and 4.20, 7.05, 4.89 log cfu/g, respectively, on the other hand the same tested microbiological criterion was declined to 2.78, 3.38, 2.70 and 2.85, 6.00, 3.00 log cfu/g, for the aforementioned Tarhana samples, respectively, (Table 8). In the same time, coliform group counts were not detected at detection limit < log cfu/g before or after drying for any prepared Tarhana samples.

Finally it could be reported that, the low microbial load in the different prepared Tarhana samples reflect the high sanitary conditions during the different preparing steps and no post-production contamination was occurring.

3.1.10 Record keeping procedures

Record keeping documents for each identified CCP during Tarhana production were presented in Table 7. It could be observed that, keeping of supplier guarantee for each ingredient used in producing Tarhana was the record documents for CCP of receiving raw ingredients. At the same time, reports of checking different conditions (temperature and time) of fermentation and drying of Tarhana were the documents should be keeping for these CCPs.

Finally it could be reported that, Tables 2, 3 & 7 and Figs. 1 & 2 show formal documents that pulls together the keys information of HACCP plan for Tarhana production, and contain details of all that is critical to product safety. An important role of HACCP system is to help the food processor build safety of produced Tarhana through identification of key or critical control measures that prevent, eliminate or reduce different hazards (biological, chemical and physical) to acceptable level as previously listed in Tables 2 and 3. A HACCP worksheet contained the seven principles of HACCP system were presented in Table 7.

4. CONCLUSION

Tarhana is known as a traditional fermented food widely consumed in Middle East countries. Although most of consumed Tarhana is homemade there is an interest in producing Tarhana under industrial scale. Therefore during production of Tarhana it is important to establish a more effective food safety system knows HACCP. HACCP system could be used for identifying different food safety hazards (biological, chemical and physical) from incoming raw materials and during different production steps and different control measures could be established to prevent, eliminate and reduced identified hazards to acceptable level. Finally it could be concluded that the use of good quality raw ingredients and controlling system were very important during production of Tarhana especially during fermentation and drying steps. HACCP system is needed in order to improve the safety of prepared Tarhana (microbiological load) so the protection of consumer could be ensured. Finally, HACCP system could evaluate the different sources of hazards during various production steps of Tarhana and control their occurring.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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