# Ethnic Fermented Foods and Beverage of Iran

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## 12.1 Introduction

Iran locating in West Asia is bordered by the Caspian Sea, Persian Gulf, and Gulf of Oman. Iran's mountains however form both the political and the economic history of the country, is also surrounded by several broad basins, or plateaus with majority of agricultural and urban settlements (Pak and Farajzadeh 2007) (Fig. 12.1).

Iran has an uneven climate. In its northwest, the winters are cold with heavy snowfall and subfreezing temperatures during December and January, but it is rather mild during spring and autumn and dry and hot during the summers. In the south of Iran, however, the winters are mild; the summers are very hot with an average daily temperature above 38 °C (100.4 °F) in July. On the Khuzestan Plain, summer heat is going along with high humidity.

The majority of Iran population (around 67–80 %) consists of Iranic peoples. The largest groups in this category comprise Persians and Kurds, with smaller groups including Gilakis, Mazandaranis, Lurs, Tats, Talyshs, and Baluchs.

Approximately 30 % of Iran's total surface area is capable of farming, but they are not cultivated regarding its poor soil and inadequacy of water distribution in many areas. The variety of temperature in different parts of Iran and the diversity of climatic zones resulted in cultivation of different crops, comprising cereals, fruits, vegetables, cotton, sugar beets, sugarcane and pistachios, nuts, olives, spices like saffron (the largest producer in the world with approximately 81 % of the world's total output), raisin, tea, tobacco, and medicinal herbs.

Iranian food which is also denoted as Persian food is composed of small amounts of red meat and large amounts of grains like rice, fruits, and vegetables. The Iranian foods are mainly famed for their fresh taste and healthy properties.

Fermented foods are paying growing attention in Iran for their formation of a diversity of aromas, flavors, and textures from a single raw material. However, fermented foods are produced for a long

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time, they received quite little consideration from the native scientific organization, and little publications have been available during these years for many products (Campbell Platt 1987; Wood 2012). Even the researches have been done are not disseminated as publications in peer-reviewed international scientific journals to be available by others. This impedes research development and does not afford support to others to instigate research in the area. Therefore, many of the foods continue to be produced by small-scale plot producers. In this chapter, the production, microbiology, and biochemistry of a wide variety of native fermented foods and beverages of Iran are described. The main Iranian fermented foods are presented in Table 12.1.

## 12.2 Classification of Fermented Foods and Beverages of Iran

Fermented foods can be categorized regarding different points of view, for example, the kind of microorganism used in the preparation of fermented foods is considered as a basis to classify fermented foods in Southeast Asia. However, other classification techniques are also available which are based on commodity and/or function of the food. These different classification techniques indicate the different attitude of the authors. It is worthy to note that a classification technique, which works very well in one part of the world, is not appropriate

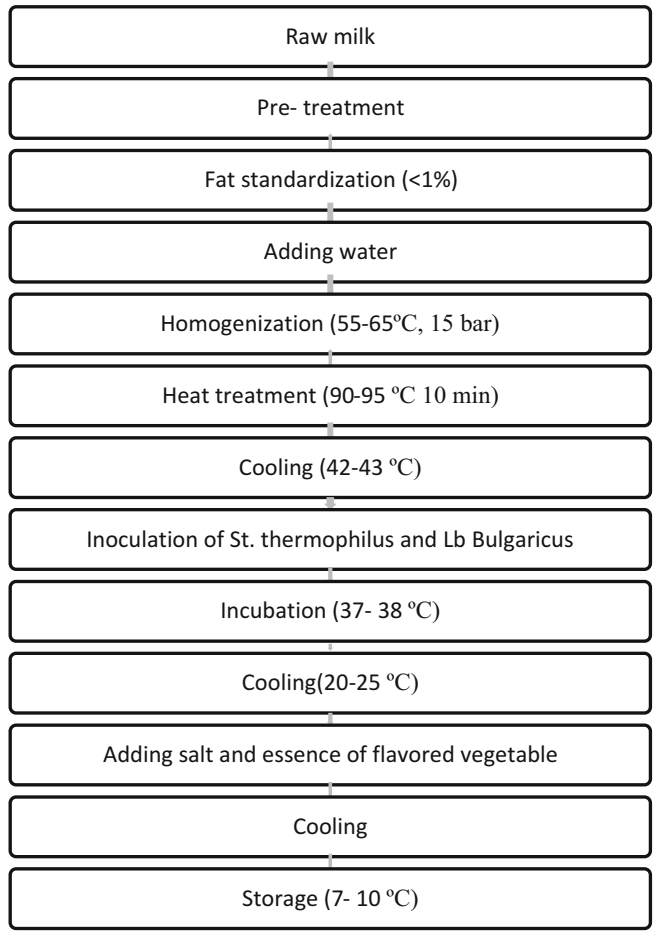


**Fig. 12.1** The industrial production of *Doogh* by two methods

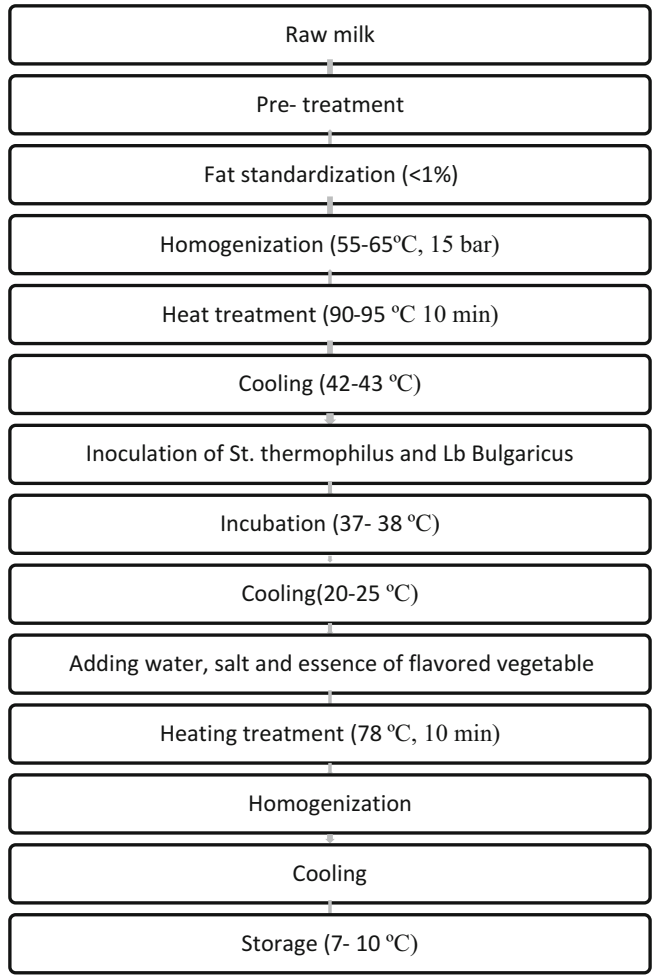


**Fig. 12.1** (continued)

in other parts, and when a classification method is invented, it is difficult to disseminate the foods.

In this chapter, Iranian fermented foods are manufactured using traditional fermentation process including:

1. Dairy products
2. Cereal-based products
3. Fruit- and vegetable-based products
4. Meat based, which will be discussed regarding their ingredients, manufacturing process, microbiology, biochemistry, and nutritional points of view in the next

## 12.3 Fermented Dairy Products

Fermented dairy products, also recognized as cultured dairy foods, cultured dairy products, and/or cultured milk products, are dairy foods which have been fermented mainly by lactic acid bacteria like *Lactobacillus*, *Lactococcus*, and *Leuconostoc* (Wouters et al. 2002). The action of fermenting increases the shelf life of the product, along with enhancing their taste and digestibility. A range of different cultured milk products are available in Iran, namely, *cheese*, *yogurt*, *kashk*, *Doogh*, and *kefir*.

**Table 12.1** Some common and uncommon ethnic fermented foods and beverages of Iran

| Name of product | Substrate | Microorganisms | References |
|---|---|---|---|
| Beverages | | | |
| *Doogh* | Animal milk | *St. thermophilus*, *Lb. bulgaricus* | Dana et al. (2011) |
| *Kefir* | Animal milk | *Lactobacillus helveticus*, *Lactobacillus delbrueckii* subsp. *bulgaricus*, *Lactococcus lactis* subsp. *lactis*, *Leuconostoc mesenteroides* subsp. *cremoris*, and *Kluyveromyces marxianus* | Oh et al. (2013) |
| *Vinegar* | Different fruits and seeds | Yeast and lactic acid bacteria (LAB) or molds and acetic acid bacteria (AAB) (the former being responsible for the alcoholic fermentation and the latter needed for the acetification) | Bhat et al. (2014) |
| *Wine* | Grape | Yeasts and bacteria. The latter can quickly turn the nascent wine into vinegar | Jackson (2008) |
| Dairy products | | | |
| *Cheese* | Animal milk | *Lc. lactis* subsp. *cremoris*, *Lc. lactis* subsp. *lactis*, *Lb. delbrueckii* subsp. *delbrueckii*, *Lb. delbrueckii* subsp. *lactis*, *Lb. helveticus*, *Lb. casei*, *Lb. plantarum*, *Lb. salivarius*, *Leuconostoc* spp., *Strep. thermophilus*, *Ent. durans*, *Ent. faecium*, and *Staphylococcus* spp., *Brevibacterium linens*, *Propionibacterium freudenreichii*, *Debaryomyces hansenii*, *Geotrichum candidum*, *Penicillium camemberti*, *P. roqueforti* | Karimi et al. (2011); Karimi et al. (2012) |
| *Yogurt* | Animal milk | *St. thermophilus*, *Lb. bulgaricus* | Han et al. (2014) |
| *Kashk* | Animal milk | *St. thermophilus*, *Lb. bulgaricus* | Soltani and Güzeler (2013); Noori et al. (2013) |
| Cereal-based products | | | |
| *Bread* | Flour, water | *Sour dough* (*Lactobacillus plantarum*, *Lactobacillus delbrueckii*, *and Leuconostoc mesenteroides*) | Rahnama et al. (2014); Khoshakhlagh et al. (2014) |
| *Tarkhineh* (*Tarkhowana or Doowina*) | Wheat meal (bulgur or cracked and bran-free parboiled wheat), sour doogh | *St. thermophilus*, *Lb. bulgaricus* | Mashak et al. (2014); TAJAABADY et al. (2011) |
| *Kashk-e zard* | Cereal flour (mainly wheat flour), yogurt, vegetable | *St. thermophilus*, *Lb. bulgaricus* | Mashak et al. (2014) |
| Fermented vegetable-based products | | | |
| *Sauerkraut* | Cabbage | *Leuconostoc mesenteroides*, *Lactobacillus plantarum*, *and L. brevis* | Owens (2014); Farnworth (2008) |
| *Pickle* | Vegetable | *Lactobacillus plantarum*, *Leuconostoc mesenteroides* | Farnworth (2008) |
| *Processed olive* | Olive | Natural of ingredients, *Lactobacillus plantarum* | Marsilio et al. (2005) |
| Fermented meat | | | |
| *Mahyaveh* | Sardines (*Sardinella sp.*) or anchovies (*Stolephorus sp.*), salt, mustard (*Brassica juncea*), water | Lactic acid bacteria (LAB) | Zarei et al. (2012) |

## 12.4 Milk as a Medium for Microbial Growth

### 12.4.1 Cheese

Cheese was firstly achieved inadvertently by an Arabian merchant when he keep his milk into a waterproof pouch making of a sheep's stomach (so-called Mashk) during a long day's trip at the desert (Classen et al. 1994). The rennet existed inside the Mashk and the heat of the sun converted the milk to separated curd and whey. Before using the cultures to prepare cheese, it was made by:

- Natural souring resulting the temperature
- Adding buttermilk or sour whey
- Addition of homemade starter

About 1900, Hansen in Denmark set commercial cultures for cheese making on the market which increase the production of cheese on a wider scale.

About 2000, names are allocated to cheeses according to their origin and country, source of milk, method of production, moisture content, the used cultures inventor, and method of ripening.

To produce cheese from milk, two main stages must be considered:

1. Concentrating the casein and fat of milk via coagulating the casein by proteolytic enzymes or lactic acid
2. Whey elimination after mechanical disturbance of the coagulated casein

Using these techniques, more than 1000 cheese varieties are created today. Higher varieties of cheeses are achieved by changing different aspects of cheese like the starter culture type, additional cultures, fermentation setting, renting, cutting the curd, scalding, whey removal, formation of green cheese, salting, adding spices, and ripening. The enormous diversity of cheeses makes its production advantageous even at small cottage industry. In Iran some cheeses are produced locally which are famous in both inside and outside of country.

### 12.4.2 *Lighvan* Cheese: An Iranian Traditional Cheese

Despite the progress and developments in manufacturing equipment and techniques, the rapid growth in production and type of industrial cheese in Iran, *Lighvan* is still produced and preferred in different area of the country (Abdi et al. 2006). Considering the pleasing organoleptic characteristic, *Lighvan* cheese is famous and commonly consumed in Iran (Mirzaei et al. 2008). The semihard white *Lighvan* cheese produced by sheep's milk or a combination of sheep's and goat's milk (the ratio of the latter is not more than 20–30 %) is ripened in brine. Regarding the fact that *Lighvan* cheese is prepared without any starter culture addition, the native microflora is effective in determination of cheese ripening (Mirzaei 2011). The instruments used in cheese making are severely artisanal and conventional with manual manufacturing phases. *Lighvan* cheese is manufactured at *Lighvan* village which is placed in Tabriz (the northeast of Iran). However, the Food and Drug Office try to convince the cheese producers of the village to use pasteurized milk to manufacture cheese; most traditional cheese makers believe the higher pleasant taste and flavor of cheese prepared with raw milk which can be attributed to the higher proteolytic and lipolytic enzyme activities of microflora in raw milk (Kafili et al. 2009). The producing procedure of *Lighvan* cheese is summarized in Fig. 12.2.

In addition to *Lighvan*, other cheeses like *Siahmazegan* and *Talesh* are also produced in Iran wherein their high fat content and specific flavor make them famous.

### 12.4.3 Yogurt

In Iran yogurt is being served in more healthy state by adding some vegetables like Prangos ferulacea, pennyroyal, mint, spinach, tarragon, grilled eggplant, cucumber, and shallot. In other words, the yogurts are being flavored. Yogurt is also available in drained states in Iran which are more nutritious compared to yogurt in a same volume.

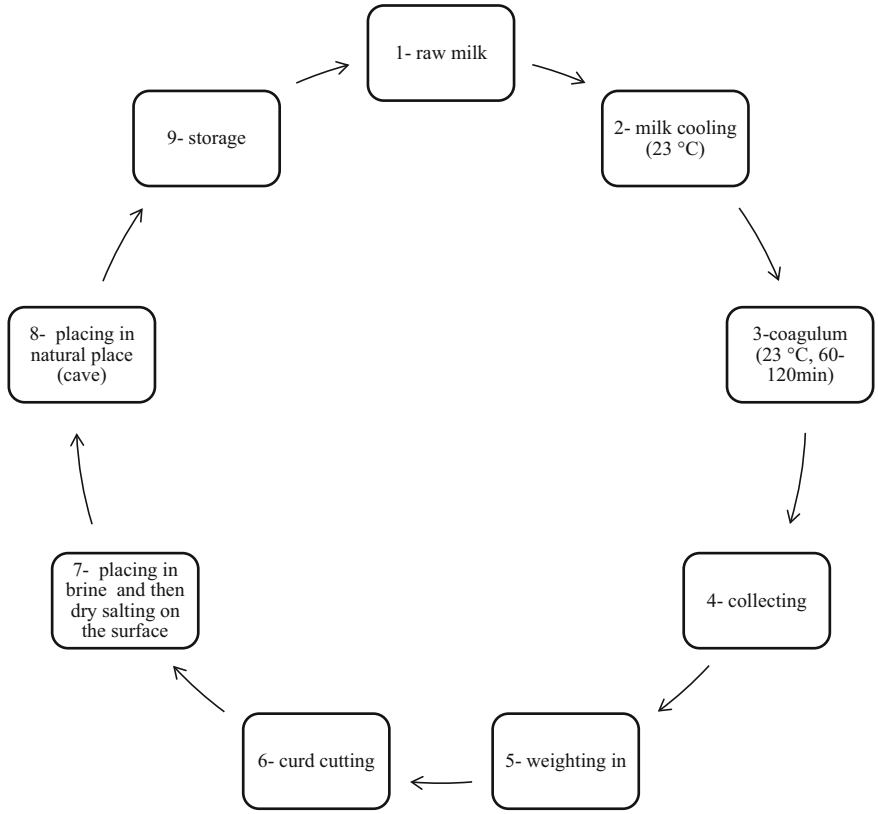


**Fig. 12.2** Flow diagram of Lighvan cheese production

### 12.4.4 *Kashk*

*Kashk* is another famous and accepted fermented Iranian dairy product. It is referred to in the tenth-century Shahnameh (a Persian book of poetry). Actually, this word may derive from the word Khushk (a Persian word means drying) which denotes that this product is manufactured by drying process (Noori et al. 2013). A low-fat dried yogurt with no cereal addition is identified as *kashk* in Iran, and it is used in many Iranian traditional foods (Shiroodi et al. 2012). *Kashk* is in whitish-yellow, semiliquid, or dried form which must be soaked and softened before being used in the latter form. In fact it was prepared in dried form traditionally but industrially is in liquid form. Dried *kashk* is a thick yogurt-type product manufactured by dehydration of domestic yogurt by sun-drying during summer in the different regions of Iran (Dehkordi et al. 2014). This product can be stored at room temperature for months without nutritional value loss or spoiling (Soltani and Güzeler 2013). Some chemical composition of dried *kashk* is presented in Table 12.2.

However, dried *kashk* is a highly nutritious fermented dairy product that can be used in diets of children and pregnant and lactating women (Ebrahimi et al. 2011). It may be contaminated due to inappropriate conditions of production and storage. Recently, *kashk* is manufactured in a healthier way in industrial dairy unit in two forms of traditional liquid *kashk* and industrial liquid *kashk*. These two have been significantly imparted in dairy products used in Iran, and specific standards are settled to consider them.

**Table 12.2** The microflora of kefir grain

| The microflora of kefir grain | |
|---|---|
| Yeast | Bacteria |
| *Candida kefir* | *Lactobacillus kefir* |
| *Kluyveromyces marxianus* | *Lactobacillus helveticus* |
| *Saccharomyces lactis* | *L. brevis* |
| *S. cerevisiae* | *L. casei* |
| *S. fragilis* | *L. plantarum* |
| | *Streptococcus lactis* |
| | *Leuconostoc mesenteroides* |
| | *Acetobacter aceti* |

**Table 12.3** Chemical composition of dried kashk (an Iranian fermented dairy product)

| Parameter | Mean |
|---|---|
| pH | 4.27 ± 0.24 |
| Acidity (LA %) | 1.40 ± 0.29 |
| Moisture (%) | 14.21 ± 2.54 |
| Fat (%) | 9.17 ± 3.10 |
| Protein (%) | 51.74 ± 3.57 |
| Salt (%) | 9.77 ± 1.44 |
| Ash (%) | 12.25 ± 1.50 |

Soltani and Güzeler (2013)

## 12.5 The Production of Traditional Liquid *Kashk*

It is manufactured by traditionally dried *kashk*. *Kashks* are put into a large container and washed by pressurized water (given inside from the one side of the container) repeatedly. Then *kashks* are milled and mixed with drinking water, edible salt, and maybe other spices like mint. The drinking water used is four to five times higher in amounts of the *kashks*, and the proportion of edible salt is 0.5–1 %. The mixture is subsequently passed throughout a filter and poured to the separator to standardize the fat ratio and separate small particles. The mixture is then homogenized (50–55 °C, 2 bar) and heated (85 °C, 15 s). It is then cooled before being filled in glass jars. In the final step, the jars are put in special boxes and stored at 4 ± 1 °C.

## 12.6 The Production of Industrial Liquid *Kashk*

This *kashk* is produced by yogurt in industrial units (Soltani and Güzeler 2013). Firstly, the raw milk is checked considering its chemical and microbiological characteristic. The standardized milk (fat ratio about 0.4–0.6 %) is pasteurized (90–95 °C, 5 min) and then cooled (43 ± 1 °C). The starter culture (*Streptococcus thermophilus* and *Lactobacillus delbrueckii* subsp. *bulgaricus*) at amount 1–2 % is added to milk and incubated (37 °C, 6–7 h). At the final step, the produced yogurt is homogenized (50–55 °C, 2 bar), and its dry matter is increased to about 18–19 % using quark separator. After adding edible salt (0.8–1 %) and whey powder (1–2 %), the mixture is exposed to heat treatment (88 °C, 10 min). It is then cooled (55 ± 5 °C), packed, and stored at +4 °C.

The chemical composition of traditional and industrial liquid *kashk* is presented in Table 12.3.

## 12.7 *Doogh*

*Doogh* as an Iranian drinking yogurt type is a dairy fermented beverage which comprises the main division of daily beverage utilization in Iran (Kiani et al. 2008). *Doogh* is frequently manufactured by combination of yogurt, drinking water, salt, and essence of flavoring vegetables like thyme, mint, and oregano. Two separate methods have been used to produce *Doogh* which are presented in Fig. 12.3.

According to codex standard, *Doogh* (yogurt drinking) is defined as a traditional dairy Iranian beverage on the basis of different milk fermentation (Esfandiari et al. 2013). This product is mainly consumed in Iran and is exported to other countries like Armenia, Azerbaijan, Afghanistan, Balkans, Iraq, and, to lesser extent, central Asia and some parts of the Middle East. *Doogh* is a derivative form of Persian word "dooshidan" which means "milking." Traditionally, *Doogh* meant a beverage product which is manufactured via the dilution of yogurt after a tough agitation step, in particular sacs prepared by goat and/or sheepskin naming "Mashk." *Doogh*, as a famous Iranian dairy beverage, with a growing

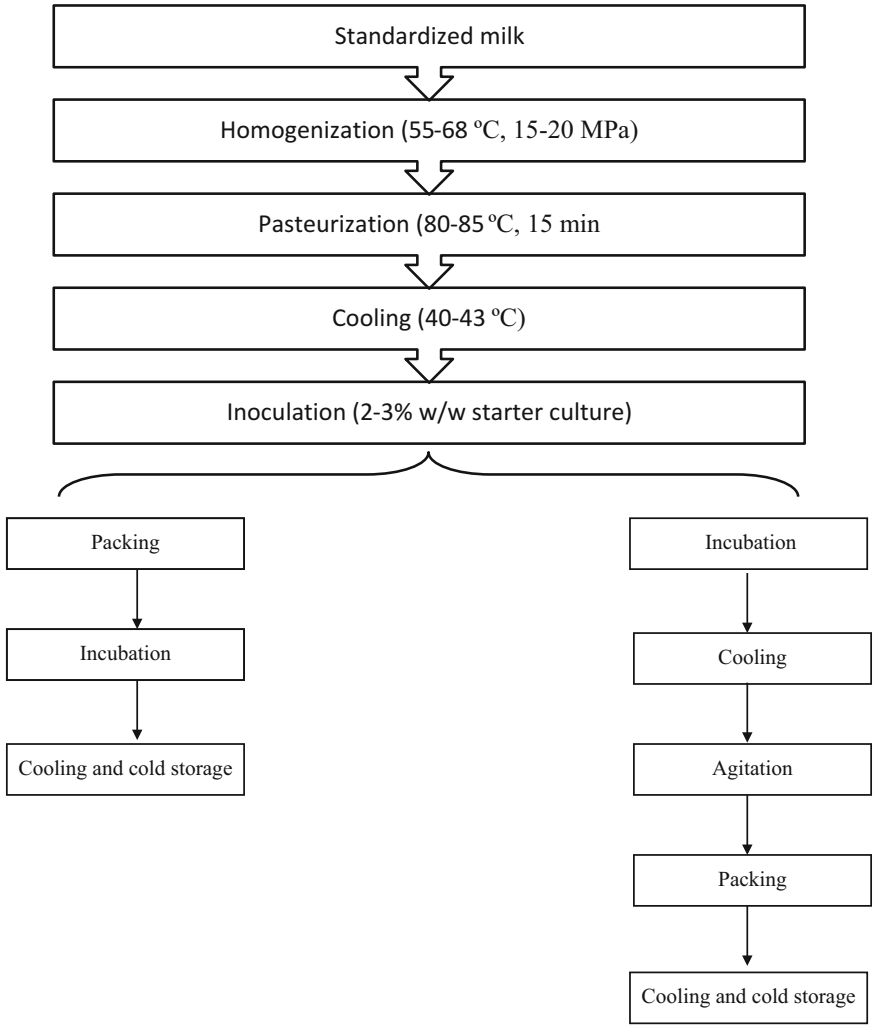


**Fig. 12.3** Main processing step of set and stirred yogurt

annual intake of 13 million tons, is accepted as the traditional national drink in Iran. The reputation of *Doogh* is not only due to its notable organoleptic properties but also due to its important health benefits to humans. Regarding the ISIRI statement, *Doogh* manufactured in Iranian dairy units is classified into four groups (Soltani and Güzeler 2013):

1. Noncarbonated and unheat treated
2. Noncarbonated and heat treated
3. Carbonated and unheat treated
4. Carbonated and heat treated

Heating and carbonating treatments are mainly used after fermentation. Heat treatment is applied to prevent the starter microorganism activity and possible cross contamination and also to lengthen the shelf life of the final product.

## 12.8 Some Properties of *Doogh*

Fermented dairy products are usually categorized into either viscous, diluted, beverage, or carbonated products. Considering this classification, *Doogh* is placed in diluted group; however, it has

been carbonated recently to make a bubbly alternative of the traditional product (Nilsson et al. 2008). *Doogh* is naturally an acidic beverage and prone to phase separation similar to other acidified milk drinks. The phase separation mainly occurred due to low pH-induced aggregation of casein (Foroughinaia et al. 2007). During the making of acidified beverages like *Doogh* by yogurt dilution, the particles of fragmented acid casein gel are separated, resulting in critical loss of stability and higher sedimentation in particles as mentioned (Lucey et al. 1999). It is worthy to consider that the edible salt addition in the production of *Doogh* makes a key role in phase separation enhancement (Köksoy and Kılıç 2003). So the consumers will shake the product before consumption. In order to inhibit this occurrence, different researches have been conducted to increase the stabilization of *Doogh* using different gums like guar (Foroughinaia et al. 2007), tragacanth (Azarikia and Abbasi 2010), gellan, and pectin (Kiani et al. 2010). The results indicated that using one gum is more effective to enhance the stability of *Doogh* compared to a combination of different gums. It has also been concluded that there is no relationship between the stabilization capability of gum and the pH range of *Doogh* produced.

## 12.9 Cereal-Based Fermented Products

### 12.9.1 Bread

Respecting the results of studied one at national level in Iran, per capita utilization of bread is about 160 kg, which is greatly higher compared to the world average (Alami et al. 2014). The quality of bread has been denoted considering different factors including:

1. Sensory characteristic like its shape, volume, taste, color, and texture
2. Nutritional values like vitamins, iron, and calcium amounts
3. Health consideration like its microbial contamination and prohibited additive addition

"Traditional Iranian breads" are mainly popular due to their diversity, taste, and quality. However, the quality of urban breads has diminished in some cases; on the other hand, because of the use of sodium bicarbonate, rural breads have high quality, since they are mainly dependent on sourdough which is rich in lactobacilli and baker's yeast). Lactic acid bacteria (LAB) which are used in sourdough as starter cultures contribute to the breads' organoleptic and protective properties against microbial spoilage (Mollakhalili Meybodi et al. 2015).

Commonly, five types of bread are produced in Iran, namely, *Sangak*, *Taftoon*, *Barbari*, *Lavash*, and *village* breads (Faridi et al. 1983) which are discussed in the succeeding text separately.

### 12.9.2 *Barbari* Bread

*Barbari* is a famous flatbread which is widely used in the northern and northwestern area of Iran (Ghanbari and Farmani 2013). It has 70–80 cm length and 25–30 cm width with a thickness of about 3.5 mm. The bread is prepared by mixing all the ingredients to reach a suitable consistency and then is fermented for about 2 h. The dough are shaped in balls and then flattened into an oval shape and rested for 20 min. Subsequently, about 0.5–1 % of a mixture containing flour, water, and oil is poured on the surface to create polished and brown surface after baking. Final proof and baking times are, respectively, about 15 and 8–12 min.

### 12.9.3 *Sangak* Bread

*Sangak* is a commonly used flatbread because of its good flavor and high nutritional value. The name *Sangak* is derivative from its way of baking on a hotbed of small pebble gravels in the oven. It is manufactured by whole wheat flour which is shaped in triangular with 0.5–1 cm thickness. In traditional *Sangak* bread ovens, the temperature is set at 250–350 °C and is prepared for only a few minutes. The dough prepared for *Sangak*

bread has higher moisture content and lower consistency compared to others (Najafi et al. 2012).

### 12.9.4 *Taftoon* Bread

*Taftoon* is an Iranian flatbread manufactured by highly extracted soft white wheat flours. The bread is usually round with length of about 400–500 mm, width of 400–500 mm, and thickness of 2 mm. The ingredients of *Taftoon* bread are flour = 100 kg, water = 78–90 L, yeast = 450–650 g, and salt = 90–130 g, and its preparation method is similar to other bread (Salehifar and Shahedi 2010).

### 12.9.5 *Lavash* Bread

*Lavash* is also traditional Iranian white wheat flatbread that can be used to prepare a sandwich. The *Lavash* bread is lightly baked and can be served as an appetizer or a healthy snack (Mortazavi and Sadeghi 2013; Fazeli et al. 2004). It is oval shaped with 60–70 cm length, 30–40 cm width, and 2–3 cm thickness. The ingredients are highly extracted flour (100 %), yeast (1 %), salt (2 %), soda (0.25 %), and water (45 %) (Movahed et al. 2011). They are mixed thoroughly and fermented for 1–3 h. The dough balls are being flatted on a wooden surface using a roller. It is then heated at 200–250 °C for about 5 min.

### 12.9.6 *Tarkhineh*

*Tarkhineh* (Tarkhowana or Doowina in Kurdish) is a rare fermented cereal food (both commercially and in homes) which is traditionally prepared and consumed in the west of Iran (Kurdistan, Kermanshah, and Hamedan provinces) (Tabatabaee et al. 2012). It is prepared by soaking wheat (either bulgur or broken and bran-free partially boiled wheat) in sour *Doogh* which is then fermented for 7–10 days. Afterward, some flavoring agents like dried vegetables, salt, and spices are added to the mixture (doughlike mixture) and exposed in small pieces to sunlight to be dried. *Tarkhineh* is preferred to be consumed in Iran due to its natural taste/flavor and therapeutic effects (Ebrahimi et al. 2014). Its fermentation process mainly occurs as a result of the natural microorganisms present in the raw materials whose growth, activity, and role during the fermentation are influenced by environmental conditions, especially temperature and salt content. The microbial communities in *Tarkhineh* have been mainly identified as *L. nagelii*, *L. bifermentans*, *Leu. cermoris*, *L. fructosus*, *L. fermentum*, *L. intestinalis*, *L. agilis*, and *L. acidipiscis* (Tafvizi and Tajabadi Ebrahimi 2015).

### 12.9.7 *Kashk-e Zard*

*Kashk-e Zard* is also a cereal-based fermented product usually consumed in the southeastern part of Iran (Sistan and Baluchestan province) (Mashak et al. 2014). It is prepared by mixing cereal flour, usually wheat flour, yogurt, different vegetables, salt, and spices along with 1-week lactic and alcoholic fermentation. It is usually a combination of 65 % yogurt and 35 % wheat flour. The fermentation process occurred at two separate phases to create the final product. Firstly, wheat flour is mixed with yogurt to create a doughlike. After storing for 1 week in a closed pot and warm place, the yogurt is added again and the dough is kneaded to homogenize the product. At the end of this stage, spices and garlic are added and stored for 7–10 days for complete fermentation. Finally, the product is spread out to be dried. After drying, it is grounded to 1–3 mm granules. The products similar to this in other countries are called Tarhana (Turkey and Greece), *Kishk* (Lebanon and Egypt), *Kushuk* (Iraq), *Madeer-Oggt* (Saudi Arabia), Kichk (India), *Talkuna* (Finland), *Tahanya* (Hungary), and *Atole* (Scotland) (Mashak et al. 2014).

## 12.10 Fermented Vegetable

The common fermented vegetable consumed in Iran and their main characteristic are summarize in Tables 12.4 and 12.5 (Marsilio et al. 2005).

## 12.11 Olives

Olive (*Olea europaea* L.) is a subtropical fruit with significant economic importance. However, Mediterranean basin is the main region of olive production; some other countries like Iran are also important. It has been believed that Iran is the main center of olive production in the world considering both the origin and the diversification (Dastkar et al. 2013). To design olive fermentation process, particular biological and technological restrictions must be considered to lessen the expenses throughout the production and downstream processes. All Iranian olive fermentations occurred during these three fundamentally separate steps including pretreatment of raw material, fermentation, and product recovery.

## 12.12 Olive Brining and Fermentation Control

In order to control the fermentation process and the safety of final product, it is necessary to be aware of microorganisms that took part in olive fermentation. During the production of green olive, the bitterness is removed using alkaline treatment. However, the lactic acid bacteria dominate in the brine of green olives; the fermentative yeasts are present in the brines of black ones. *Saccharomyces cerevisiae* and *Candida boidinii* are, respectively, the most common recognized species in green olives and processed black olives (Arroyo-López et al. 2008).

**Table 12.4** The chemical composition of traditional liquid kashk (1) and industrial liquid kashk (2)

| | Mean | |
|---|---|---|
| Parameter | 1 | 2 |
| pH | 4.15 ± 0.07 | 3.78 ± 0.05 |
| Acidity (LA %) | 1.82 ± 0.13 | 1.54 ± 0.10 |
| Moisture (%) | 74.56 ± 0.19 | 81.41 ± 0.15 |
| Fat (%) | 1.99 ± 0.07 | 1.65 ± 0.06 |
| Protein (%) | 13.66 ± 0.22 | 8.59 ± 0.22 |
| Salt (%) | 2.54 ± 0.06 | 1.69 ± 0.07 |
| Ash (%) | 2.83 ± 0.06 | 2.30 ± 0.08 |

## 12.13 Pickled Vegetables

Pickled vegetables prepared in households or small factories are popular in Iran (Prajapati and Nair 2008; Farnworth 2008). The vegetables pickled in Iran are carrots, cucumbers, cabbage, cauliflower, garlic, and pepper. These products are mainly consumed as appetizers and almost every meal. It is called *jeruk* in Malaysia and has been famous since very early times.

## 12.14 Fermented Meat

### 12.14.1 *Mahyaveh*

*Mahyaveh* is a traditional fermented fish sauce widely consumed in the southern part of Iran (Zarei et al. 2012). This product is mostly produced according to the family tradition, availability of raw materials, consumer preferences, and climatic conditions of the region. Therefore, wide variations can be seen in production methods, proportions of raw materials, and composition between retail samples from different sources. *Mahyaveh* is typically composed of sardines (*Sardinella* sp.) or anchovies (*Stolephorus* sp.),

**Table 12.5** The main fermented vegetable consumed in Iran

| Product | Salt concentration | Condition | The dominant microflora | Acid (%) | PH |
|---|---|---|---|---|---|
| Olive | 2–3 % | Alkaline treatment, submerged | Natural of ingredients, *Lactobacillus plantarum* | 0.7–1 | 3.8 |
| Pickled vegetable | 1.5–6.6 % | Submerged | Natural of ingredients, *Lactobacillus plantarum*, *Pediococcus cerevisiae* | 0.6 | 3.8 |
| Black tea | – | | Natural of ingredients | – | 4.9 |

Stamer (1975)

salt, mustard (*Brassica juncea* L.) Czern, and water. It is traditionally prepared from fresh or dried fish, which are beheaded, washed, and packed along with salt and warm water into earthen or glass jars. The jars are allowed to stand under the sun or at ambient temperature for 25–30 days. The fish–salt mixture is then mashed into slurry and filtered through a stainless steel mesh. The brown liquid portion of fermented fish is then mixed with mustard and other spices. Various spices such as cumin (*Cuminum cyminum* L.), coriander (*Coriandrum sativum* L.), fennel (*Foeniculum vulgare* Mill.) seeds, black pepper (*Piper nigrum* L.), and thyme (*Thymbra capitata* L.) are added according to the consumer preferences. After a thorough mixing, the jars are placed at ambient temperature until the desirable taste and aroma are produced, usually after 10–15 days. Zarei et al. (2012) found that the pH of *mahyaveh* from different locations was in the range of 4.89–7.55, and the concentration of NaCl was in the range of 7.48–17.1 %. Moreover, they observed histamine (2.66 g/kg) was found to be the main biogenic amine in the Iranian fish sauce (Taheri et al. 2014). The high histamine content can be related to the high levels of bacterial count, especially *Enterobacteriaceae* and lactic acid bacteria in this product.

## 12.15 Conclusion

Fermenting foods have been used by humans for thousands of years, in all around the world. In fact, the fermentation process is considered as a controlled spoilage in which the enzymes manufactured by microorganisms break the carbohydrates, fats, and proteins into the simpler compounds. This breakdown resulted in the production of final products which are easier to digest, have increased nutritional value, and are without toxins.

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