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Traditional Fermented Foods of Turkey

Türkiye'deki Geleneksel Fermente Ürünler

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ABSTRACT

Fermentation is one of the oldest and most economical methods used to preserve and improve shelf-life, flavor, texture, and functional properties of foods. In general, lactic acid bacteria of various breeds predominate in food fermentation, including Lactococcus, Lactobacillus, Enterococcus, Streptococcus, Leuconostoc, and Pediococcus. However, in addition to these bacteria, yeast, and fungi also contribute to food fermentation. In Turkey, the most widely produced and consumed traditional foods are yogurt, buttermilk, kefir, kımız, tarhana, boza, pickles, shalgam juice, hardaliye, and sucuk. This review aims to identify the most common traditional fermented products and to emphasize some microbiological characteristics as well as the health effects of fermented products.

Keywords: *Fermentation, Healthy nutrition, Lactic acid bacteria, Traditional fermented food*

ÖZET

Fermantasyon, besinlerin raf ömrünü uzatmak, lezzetini, dokusunu ve fonksiyonel özelliklerini korumak ve geliştirmek için kullanılan en eski ve en ekonomik yöntemlerden biridir. Genel olarak besin fermantasyonunda, Lactoctoccus, Lactobacillus, Enterococcus, Streptococcus, Leuconostoc ve Pediococcus dahil olmak üzere çeşitli cinslerden laktik asit bakterileri baskındır. Ancak bu bakterilerin yanı sıra maya ve mantarlar da besin fermantasyonuna katkıda bulunur. Türkiye'de üretilen ve tüketilen en yaygın geleneksel besinler arasında yoğurt, ayran, kefir, kımız, tarhana, boza, turşu, şalgam suyu, hardaliye ve sucuk bulunur. Bu derleme, en yaygın geleneksel fermente ürünleri tanımlamayı, fermente ürünlerin bazı mikrobiyolojik özelliklerini ve sağlık açısından etkilerini vurgulamayı amaçlamaktadır.

Anahtar Kelimeler: *Fermantasyon, Sağlıklı beslenme, Laktik asit bakterileri, Geleneksel fermente ürünler*

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INTRODUCTION

The origin of Turkish nutritional culture goes back to Central Asia. When the settled life of the Turks, Turkish food culture has started to produce a wide variety of different foods and traditional Turkish nutrition culture has been shaped. The traditional food production methods have been survived to the present day. The most important production method is the food fermentation technique (Evren, Apan, Tutkun, & Evren, 2011). Production of fermented foods has been ongoing since the early ages and because the fermentation process increases the taste, flavor, structure, nutritional value, and shelf life of foods, it has an important place in the nutrition of people. It is consumed safely in all societies from undeveloped countries to developed countries (Coşkun, 2017; Demir, 2018; Kocatepe ve Tiril, 2015; Rezac, Kok, Heermann & Hutkins, 2018; Smid & Hugenholtz, 2010; Tangüler & Erten, 2013). Fermented products are superior in terms of nutritional value since they increase digestibility and increase essential amino acids and vitamin content naturally compared to non-fermented foods (Kocaadam ve Acar, 2016). In addition, these nutrients can be defined as safe foods since the metabolites formed by fermentation are thought to cause degradation of nutrients and prevent and/or destroy many of the pathogenic microorganisms (Demir, 2018). Fermentation processes in foods also offer products with rich nutritional properties and flavors for consumers. It has increased the interest of discovering natural food fermentation processes, diversity, and properties of microorganisms, associating the process with energy and product quality (Ray & Joshi, 2015). More recently, the consumption of fermented foods containing live microorganisms has emerged as an important dietary strategy for improving human health (Marco et al., 2017).

Common microorganism groups in fermentations are bacteria, yeast, and molds. The most important bacteria in the fermentation of foods are those that belong to the *Lactobacillaceae* family, which produce lactic acid from carbohydrates. Other important bacteria are *Acetobacter* (mainly from the fermentation of fruits and vegetables) and *Bacillus* (from the fermentation of legumes) that produce acetic acid. The yeast useful for the desired food fermentation is from the *Saccharomyces* family, especially *S. cerevisiae* (Liu, Han, & Zhou 2011; Sengun & Karabiyikli, 2011; Slashinski, McCurdy, Achenbaum, Whitney, & McGuire, 2012). Given the food fermentations (unlike yeast-containing alcoholic fermentation), the most common lactic acid bacteria in fermented products are primarily responsible for most microbial conversions, and lactic acid bacteria are of great industrial importance. Many are generally recognized as safe (GRAS) microorganisms (Rakhmanova, Khan, & Shah 2018; Silva, Teixeira & Gibbs, 2002).

For modern large-scale production of fermented food and beverages, it depends on the use of defined strain starter cultures that replace the unspecified strain mix traditionally used. Transitioning to defined strains means that both culture performance and product quality and consistency have been

significantly improved, while fewer strains are heavily used and trusted by the food and beverage industries (Ray & Joshi, 2015).

Live microorganisms are not always used in the production of food and/or beverages by fermentation. Yeast is required for fermentation of bread, beer, wine, and distilled alcoholic beverages. Many fermented foods are heat-treated after fermentation to increase food safety or prolong shelf-life. Thus, fermented sausages are usually cooked after fermentation, and heat treatment is applied to fermented vegetables such as soy sauce, sauerkraut. Even non-heat-treated fermented foods may contain low levels of live or viable organisms, due to unfavorable environmental conditions that reduce microbial populations over time. It is important to note, however, that the presence of viable microorganisms in the final product does not prevent the positive functional role (Rezac et al., 2018).

Recently, interest in the consumption of traditional fermented products produced in our country using various raw materials, microorganisms, and production techniques has increased. Among the most common traditional fermented products consumed in Turkey, there are many different products such as yogurt, buttermilk, kefir, tarhana, boza, pickles, shalgam juice, sucuk and hardaliye. This review aims to identify the most common traditional fermented products, highlighting some microbiological properties and health effects of fermented products.

Milk Based Fermented Products

In the Turkish Food Codex, fermented milk product is defined as the product that is formed as a result of low pH or coagulation of milk by fermentation of suitable microorganisms and keeps specific microorganisms active unless they are heat-treated (TGK, 2009). Fermented dairy products are an important part of human nutrition, as they have beneficial hypotensive, hypocholesterolemic, antioxidant, and antimicrobial effects (Pihlanto, 2013).

Most of the milk-based fermented foods are produced by fermentation of lactic acid bacteria, and species from the Gram (+) bacteria group, which include *Lactobacillus, Leuconostoc, Lactococcus, Streptococcus,* and *Pediococcus*, are used (Rakhmanova et al., 2018). Lactic acid bacteria increase the release of antimicrobial bacteriocins while preventing the proliferation of pathogens and microorganisms causing degradation and acidification (Rakhmanova et al., 2018; Şanlier, Gökcen, & Sezgin, 2019). Some of the positive effects of this condition on human health include modification of the intestinal microbiota, prevention, and treatment of inflammatory bowel disease in addition to anti-carcinogen and hypocholesterolemic effects. Besides, the conversion of milk sugar lactose to lactic acid is one of the important changes that occur during milk fermentation caused by lactic acid bacteria, providing health benefits by alleviating abdominal pain and diarrhea in individuals with lactose intolerance. Therefore, fermented dairy products provide various health benefits, such as modulating the gut microbiota and immune response and reducing a person's risk of

hypertension, diabetes, and high cholesterol (Şanlier et al., 2019). As an example of traditional and commercially produced fermented milk products in our country, we can give yogurt, torba (kese) yogurt, buttermilk, kımız, and kefir (Yörükoğlu ve Dayısoylu, 2016).

Yogurt

Yogurt, a traditional fermented milk product, has a long history shaped by the influence of various cultures. The first appearance of yogurt is stated to date back to 800 AD and it is accepted that the word yogurt comes from "dense" which means solidified or darkened in Central Asian Turkish (Kocaadam ve Acar, 2016). Yogurt with a pleasant taste, smooth and viscous gel consistency was first believed that they did the ancient nomadic Turks living in Central Asia, and the Middle East countries and Turkey are still being produced for centuries households (Kabak & Dobson, 2011; Kocaadam ve Acar, 2016). According to the Turkish Food Codex Fermented Milk Communiqué, yogurt is specifically expressed as a fermented milk product, in which symbiotic cultures of *Streptococcus thermophilus* and *Lactobacillus delbrueckii* subsp. *bulgaricus* are used (TGK, 2009). Yogurt, *L. delbrueckii* subsp. *bulgaricus, L. acidophilus, L. lactis* spp. *lactis, L. delbrueckii* subsp. *lactis* is defined as a coagulated milk product formed by lactic acid fermentation with *S. thermophilus* bacteria (Aryana & Olson, 2017; Evren ve ark., 2011*). Streptococcus thermophilus* and *Lactobacillus* use both in Turkey are legally required (Kabak & Dobson, 2011).

After the yogurt is purified from pathogenic microorganisms, the milk is obtained by fermentation with lactic acid bacteria at 40-45 °C. Since the necessary microorganisms are present in the structure of yogurt, it is used in the fermentation process itself (Kocaadam ve Acar, 2016). Although it has the same micronutrient composition as milk, yogurt contains more protein, vitamin B_2 and B_{12}, calcium, magnesium, potassium, and zinc. During the fermentation of milk to produce yogurt, folate is synthesized, protein, and conjugated linoleic acid content, shelf life, protein digestibility, and calcium absorption increase (Şanlier et al., 2019). Low-fat yogurt, non-fat yogurt, strained yogurt, whole yogurt, torba (kese) yogurt, and salted yogurt as there are many different types of yogurt in Turkey (Kabak & Dobson 2011). Various fruit and/or probiotic-added yogurts produced recently have made yogurt appeal to a wider audience (Kocaadam ve Acar, 2016).

Multiple researches, gastrointestinal infections, antimicrobial activity, improvement in lactose metabolism, decrease in serum cholesterol, immune system stimulation, anti-mutagenic properties, anti-carcinogen properties, anti-diarrheal properties, improvement in inflammatory bowel disease and the addition of selected strains to food products of *Helicobacter pylori* infection explained health benefits on suppression (Shah, 2007).

Torba (Kese) Yogurt

"Torba" yogurt is a concentrated fermented product with semi-solid texture made in Anatolia for centuries, with a tighter structure than yogurt (Salameh, Banon, Hosri & Scher, 2016). Also known as "Strained" or "Kese" yogurt. Products produced by similar strains with different methods in many countries such as the Balkans and Eastern Mediterranean countries, Turkey and the Indian sub-continent are available (Kesenkaş, 2010). Torba of yogurt is made from cow, goat, or sheep milk (Mohameed, Abu-Jdayil, & Al-Shawabkeh, 2004). The traditional method of making torba yogurt is to filter yogurt using a special cloth bag. The basic principle of using the traditional cloth bag method is to remove the serum from yogurt until the desired total solids level is reached (Köse, Erim Köse, & Altun, 2019; Yerlikaya, Akpınar, & Kılıç, 2015). Torba yogurt has a relatively high solids content (20-25%) and has a creamy texture (Kesenkaş, 2010). It is then packed and stored at refrigerator temperature (4 ºC). Salt can also be added to prolong the shelf life of the product. It is produced by straining in bags up to 12-18 hours to obtain a strong and tight mass (Salameh et al., 2016; Sömer & Başyiğit Kılıç, 2012). The overall nutrient content is significantly reduced during the preparation of bag yogurt. About 65% of yogurt is separated as serum and causes losses in nutrients such as sodium, potassium, calcium, phosphorus, and protein (Kabak & Dobson, 2011).

Buttermilk

Buttermilk is especially consumed salt yogurt drink popular during the summer months in Turkey (Salameh et al., 2016). Ayran has traditionally been produced at home in Anatolia for hundreds of years by mixing yogurt with water and salt (Altay, Karbancıoglu-Güler, Daskaya-Dikmen, & Heperken, 2013; Koksoy & Kilic, 2003). According to the Turkish Food Codex, buttermilk is defined as "fermented milk product prepared by adding water in yogurt or by adding *S. thermophilus* and *L. delbrueckii* subsp. *bulgaricus* cultures to milk separated from dry matter" (TGK, 2009). Buttermilk is a very low viscous liquid and maybe slightly yellowish (Kaur, Ghoshal, & Banerjee, 2019). The composition of the buttermilk varies depending on the type of milk used, the fat removal efficiency, and the dilution rate (Kabak & Dobson, 2011). Because of its low pH, buttermilk is prone to textural instability such as low viscosity and serum separation during storage. Unlike other acidic milk-based fermented products, salt in it causes more serum separation (Koksoy & Kilic, 2004). It has a sour taste. In addition to being used as a beverage, buttermilk can also be used in cooking such as sour cream (Baschali, Tsakalidou, Kyriacou, Karavasiloglou & Matalas, 2017).

Kefir

Kefir is a sour, acidic, slightly alcoholic fermented milk product that appears in the Caucasian mountains (Van Wyk, 2019). The word kefir comes from the word "keyif", which means "feeling good" in Turkish to indicate pleasure after drinking (Nielsen, Gürakan, & Ünlü, 2014; Nogay, 2019). Unlike other fermented dairy products, kefir is produced as a result of a fermentation process

containing mixed microflora bounded by a matrix of gelatinous, yellowish, irregularly shaped "kefir grains" (Farnworth, 2005; Kaur et al., 2019).

Kefir grains *L. bulgaricus, S. lactis, S. durans L. cellobiosis, S. avium, S. cremoris, L. kefir, L. kefiranofaciens, L. kefirgranum, L. parakefir, L. brevis, L. plantarum, L helveticus, L. acidophilus, L. delbrueckii, L.rhamnousus, L. casei, L. paracasei, L. fructivorans, L. hilgardi, L. fermentum, L. viridescens, L. lactis* subsp. *cremoris, S. thermophilus, Leuconostoc* spp., and *Leuconostoc mesenteroides* include lactic acid bacteria, yeast, and acetic acid bacteria (Evren ve ark., 2011; Van Wyk, 2019). The most common yeast type in kefir (both cereals and beverages) is *S. cerevisiae* (Van Wyk, 2019). It is produced by acid-alcohol fermentation of milk with the combination of these microorganisms found in kefir grains (Kabak & Dobson, 2011; Şanlier et al., 2019). Lactic acid bacteria produce lactic acid along with flavor components such as acetaldehyde, diacetyl, acetoin, ethanol, acetic acid, and carbon dioxide during fermentation. Kefir has a refreshing taste that is slightly acidic due to the presence of lactic acid (Altay et al., 2013).

Kefir can be made from all kinds of milk including cow, goat, sheep, camel, buffalo milk, and milk substitutes such as walnut milk, soy milk, rice milk, coconut milk and peanuts (Altay et al., 2013; Nielsen et al., 2014). It is produced by adding kefir grains to pasteurized milk for traditional kefir production and leaving it to fermentation for approximately one day at room temperature. After kefir is formed, kefir grains are strained and separated from fermented milk (Farnworth, 2005). Kefir is known for its easy digestibility and has a higher nutritional value. The composition of kefir microflora varies according to the type of kefir grain, culture medium, and production method. Complex interactions between the type and amount of milk, and yeast and lactic acid bacteria can affect the sensory and textural properties of kefir (Kaur et al., 2019).

As a source of potential health benefits of kefir, it is shown to the complex microbiota created by lactic acid, acetic acid bacteria and yeasts, and fermentation metabolites (Şanlier et al., 2019). Kefir has been the center of attention in recent years as it has pleasant organoleptic properties in addition to antimicrobial, antihypertensive, anti-carcinogen, hypocholesterolemic, antiinflammatory, antiallergenic, antibacterial, antioxidant, and probiotic effects. Kefir is rich in calcium, protein, and probiotics, which increases bone mineralization and formation and reduces bone damage. Regular consumption of kefir is beneficial for intestinal health and immune system. By regulating serum glucose levels, it relieves symptoms of lactose intolerance and is helps control obesity (Nogay, 2019). Although less well known than yogurt, it contains bioactive components that are formed during the production of kefir. It has been observed that these bioactive ingredients combine kefir as an important probiotic product and provide it with potential health benefits (Farnworth, 2005). It is also known that during fermentation, levels of vitamin B_1 and B_{12}, calcium, amino acids, folic acid, and vitamin K

increase in kefir. Many health benefits have been attributed to kefir, including increased immune responses to tumors and the treatment of hypertension and allergies (Kabak & Dobson, 2011).

Kımız

Kımız is an example of a light alcoholic fermented milk drink, also called 'koumiss', 'airag', or 'chigee', made from milk of mares and consumed in Central Asia (Kaur et al., 2019; Liu et al., 2011). Kımız is gray, light, and naturally carbonated and has an alcoholic, sharp, acidic taste. The fermentation process and the product obtained are similar to kefir, but unlike solid "kefir grains", they are produced from liquid starter culture. Kımızs alcohol content is slightly higher than kefir because the lactose content in the milk of mares is higher than that of cow milk. During fermentation, storage temperature maintained at 20-30 °C is required to improve flavor and control the process (Kabak & Dobson, 2011). Fermentation metabolites, *L. delbrueckii* subsp. *bulgaricus, L. acidophilus* are lactic acid bacteria, ethanol, and carbon dioxide (Evren ve ark., 2011; Kaur et al., 2019). In kımız fermentation, *Lactobacillus* is the dominant microorganisms and acidifies milk during fermentation and the yeasts turn the raw material into a carbonated, slightly alcoholic beverage. The carbon dioxide it contains gives the product a foamy appearance and contributes to the aroma. When strong foam and special sour taste are obtained, kımız is a product ready to be consumed immediately (Liu et al., 2011).

Kımızs health value has been recognized since ancient times and is considered the best beverage for health care therapy. Mare milk has been recognized as an important source of food for the elderly and the time of patient recovery (Kabak & Dobson, 2011; Liu et al., 2011). In addition, since the composition quality of mare milk is close to breast milk, it is considered to be an adequate source of nutrition for infants and to be effective in preventing some human pathologies (Kaur et al., 2019). The energy value of mare milk is lower than breast milk and cow milk due to low-fat content (Kabak & Dobson, 2011). Many studies have shown that kımız has therapeutic effects on cardiovascular and neurological diseases, tuberculosis, asthma, and diabetes (Liu et al., 2011). Also suitable for energy with weight gain and increased endurance (Kaur et al., 2019).

CEREAL BASED FERMENTED PRODUCTS

Fermented cereal products are generally produced by traditional methods and take an important place in daily nutrition (Şimşekli ve Doğan, 2015). With the physiological benefits of fermented foods and the importance of dietary fiber in human nutrition, the importance of cereal-based fermented products has started to increase (Şimşekli ve Doğan, 2015; Yörükoğlu ve Dayısoylu, 2016). Cereal products, carbohydrates, protein, vitamins, minerals, and fibers have important contributions to the diet in meeting daily needs. In general, natural fermentation of cereal leads to a decrease in the level of carbohydrates, as well as some indigestible polysaccharides and oligosaccharides. Some amino acids can be synthesized and the availability of group B vitamins, including B_3, B_5, B_9, can be improved.

Fermentation also provides optimum pH conditions for the enzymatic degradation of phytate in the form of complexes containing multivalent cations such as iron, zinc, calcium, magnesium, and proteins in cereals (Blandino, Al-Aseeri, Pandiella, Cantero & Webb, 2003; Çekal ve Aslan, 2017; Köten, Karahan, Eren-Karahan ve Yazman, 2019). The nutritional quality and sensory properties of cereal products are lower compared to milk and dairy products. Cereal products that are rich in carbohydrates but considered to be weak in terms of protein and amino acid balance are recommended to be consumed with more protein-rich foods (Demir 2018). Therefore, by fermenting these products, significant increases in both nutritional quality and sensory properties are achieved (Blandino et al., 2003). Among the cereal-based fermented products specific to our country, tarhana and boza are widely known (Şimşekli ve Doğan, 2015; Yörükoğlu ve Dayısoylu, 2016).

Tarhana

From prehistoric to today, societies have created their traditional products. Some of these products have been forgotten over time and some have survived to the present day (Yönel, Karagöz ve Güllü, 2018). Many traditional fermented food products are produced around the world, especially cereal (Blandino et al., 2003). In our country, "Tarhana" is one of the best examples of traditional fermented cereal products (Çakıroğlu, 2007). According to the Turkish Standards Institute (TSE) 2282 communiqué tarhana, "wheat flour/wheat crushing, semolina or a mixture of these products and yogurt, tomato, green or red pepper, onion, salt, flavor and fragrant herbal ingredients that are harmless to health and kneaded, semi-ready nutrients with high nutritional value increased durability, obtained by drying, grinding, and sieving after being left to fermentation (TSE, 2004). Tarhana, which is made by using different mixtures and spices in different regions is one of the foods commonly used in the nutrition of the Turkish people since it is a good source of protein, vitamins, and minerals because it contains components of vegetable and animal origin and it is cheap, durable and nutritious as well as easy to produce (Akbaş ve Coşkun, 2006; Demir, 2018; Köten ve ark., 2019; Şimşekli ve Doğan, 2015). Tarhana is one of the storage forms of yogurt prepared for the winter season in our country. Tarhana, which takes its place among the local Turkish soups, is among the indispensables of Turkish cuisine due to its high nutritional content and long shelf life (Yönel ve ark., 2018).

Tarhana, which has different production techniques in many regions of our country; wheat product (flour, crushing, semolina), yogurt, various vegetables, and spices are mixed and kneaded, and after the dough is left to the lactic acid fermentation for 1-7 days. The fermented dough at this stage is called wet tarhana. During the production of tarhana, the fermentation step is carried out by lactic acid bacteria (such as *S. thermophilus*, *L. lactis*, *L. diacetylactis*, *L. bulgaricus*, *L. acipdophilus*, *Leuconostoc cremoris*, and *L. caseiö*), and S. cerevisiae bread yeast in the structure of wheat. The characteristic sour and acidic taste of tarhana is revealed by the fermentation process (Çakıroğlu, 2007; Çekal ve Aslan, 2017; Köten ve ark., 2019).

Tarhana is mostly used as a soup, however, depending on the region and its production technique (e.g. sun drying), it can be produced as a clump or plate and then consumed like a snack after drying (Coşkun, 2014; Erinç ve Çifçi, 2018; Sormaz, Onur, Güneş ve Nizamlıoğlu, 2019). Some properties such as the materials used in the production of tarhana, production, and consumption vary according to the region, and therefore different names are given to tarhana (Çekal ve Aslan, 2017; Erinç ve Çifçi, 2018). In the notification of TSE 2282 Tarhana Standart communiqué, tarhana; has been described in four types: "flour tarhana", "göce tarhana", "semolina tarhana" and "mixed tarhana" (Kabak & Dobson, 2011; TSE, 2004). Apart from these varieties, it is found in various tarhana made in some regions such as cranberry tarhana and milky tarhana (Erinç ve Çifçi, 2018). In addition to wheat flour, other cereal and legume flour such as rye, corn, barley, soybeans, and chickpeas can be used in the production of tarhana (Kabak & Dobson, 2011).

Tarhana used to be produced and consumed only at home. Due to various reasons such as urban population growth and rapid urbanization, women's participation in working life, the need for ready-made foods has increased, and tarhana has also participated in rapidly growing industrial-scale production (Çekal ve Aslan, 2017; Köten ve ark., 2019). While the nutritional value and digestibility of nutrients increase with fermentation; it is also a product that can be stored without spoiling in the long shelf life period (Akbaş ve Coşkun, 2006; Yönel ve ark., 2018).

Tarhana, which is a traditional fermented product, has a complex feature in terms of content, but its role in individual nutrition seems to be underestimated or unaware (Yönel ve ark., 2018). Tarhana is rich in group B vitamins, calcium, iron, and zinc minerals. Tarhana is effective in reducing blood cholesterol levels, high blood pressure, and vascular diseases in terms of the fiber it contains (Çekal ve Aslan, 2017; Köten ve ark., 2019). Yogurt and lactic acid fermentation in tarhana are extremely beneficial for colon health and are effective in reducing associated with the risk of colon cancer (Çekal ve Aslan, 2017; Köten ve ark., 2019; Yönel ve ark., 2018). Tarhana, which has such high nutritional usefulness, plays an important role in the nutrition of pregnant and elderly people (Demir, 2018). It contributes to the bone development of babies and strengthens bones. It is an excellent nutritional supplement for babies who started supplementary food starting from the fourth month. For this purpose, it is a mixture that can be given to babies safely instead of food (Yönel ve ark., 2018).

Boza

Boza, a cereal-based fermented beverage; sugar is added after milling grains such as millet, wheat, rye, oats, corn, and rice by grinding and adding water. After, it is produced by fermentation with S. cerevisiae yeast and Lactic acid bacteria such as Lactobacillus, Lactococcus, Pediococcus, and Leuconostoc genus *Leuconostoc paramesenteroides*, *L. mesenteroides* subsp. *mesenteroides*, *L. mesenteroides* subsp. *dextranicum*, *L. oenos*, *L. coryniformis*, *L. confusus*, *L. sanfrancisco*, and *L. fermentum* (Evren ve ark., 2011; Pehlivanoğlu, Gündüz, Özülkü, & Demirci, 2015; Todorov et al.,

2008; Todorov & Dicks, 2007). Two fermentations take place in Boza. One is alcohol fermentation by yeast cells, and a volumetric increase is observed with CO_2 gas. The other is lactic acid fermentation, in which lactic acid bacteria play a role, and it provides the acidic character of the lactic acid degradation formed in this fermentation (Levent ve Algan Cavuldak, 2017). Lactic acid bacteria play an important role in the preservation, microbiological stability, and production of flavor compounds in these products (Todorov & Dicks, 2007). Due to the pleasant taste and high nutritional value of the brown, it has become a popular beverage for consumers of all ages and is usually consumed in the winter (Blandino et al., 2003). Since the number of lactic acid bacteria in boza is higher than the number of yeasts, lactic acid bacteria make up the dominant microflora in boza. Thanks to the antimicrobial compounds they produce, lactic acid bacteria prevent the development of bacteria that cause spoilage of nutrients and diseases caused by food. Thus, it plays an important role in the natural preservation of nutrients (Levent ve Algan Cavuldak, 2017).

It is considered to be a source of probiotic bacteria rich in Lactobacillus such as Boza, *L. plantarum, L. paracasei, L. rhamnosus* and *L. pentosus* (Baschali et al., 2017). Some microorganisms with probiotic characteristics found in the traditional fermented boza cannot be fully expressed as probiotic food due to the lack of specific starter culture during production or uncontrolled fermentation process. When the strains showing probiotic and antimicrobial properties are selected in starter cultures to be developed for boza production, the functional feature of the product will also be increased (Levent ve Algan Cavuldak, 2017). It is known to exhibit antiviral and antibacterial activity (Kaur et al., 2019). In addition to these beneficial effects, boza contains vitamins, minerals, carbohydrates, fiber, and protein and is therefore considered a nutritious and functional beverage (Şanlier et al., 2019).

Vegetable and Fruit Based Ferment Products

Since unprocessed fruits and vegetables are easily spoiled, fermentation, the oldest method of preserving fruits and vegetables, is very popular. Fermented fruits and vegetables such as shalgam juice, pickles, and hardaliye are an indispensable part of human nutrition. The dominant microorganism in the fermentation of fruits and vegetables is lactic acid fermentation that occurs spontaneously when it is suitable for lactic acid bacteria. Lactic acid bacteria fermentation involves oxidation of carbohydrates to carbon dioxide, alcohol, and organic acids that inhibit pathogen and cause of degradation microorganisms (Şanlier et al., 2019).

Shalgam Juice

Shalgam juice or its shortened name, shalgam is one of the regionally produced fermentation products (Kabak & Dobson, 2011; Üçok ve Tosun, 2012). Shalgam juice is a traditional Turkish fermented beverage (Coşkun, 2017). Shalgam juice in TS11149 standard, “Bulgur flour, sourdough,

drinking water, and edible salt are mixed and subjected to lactic acid fermentation. Then, after adding black carrot, shalgam, and chili powder, if desired, the mixture is subjected to lactic acid fermentation again. It is defined as a product made durable by optional heat treatment (TSE 2003). Shalgam juice, which is produced with lactic acid fermentation and is a red-colored, turbid and sour delicious beverage, is a country-specific beverage and the raw material is used a black (purple) carrot in its production, but bulgur flour (cetic), bread yeast (*S. cerevisiae*) or sourdough, shalgam radish, salt are other raw materials (Çankaya ve Tangüler, 2018; Erten, Tanguler, & Canbaş, 2008; Tanguler, Utus, & Erten, 2014; Üçok ve Tosun, 2012).

In shalgam fermentation, *L. plantarum* subsp. *arabinose, L. paracasei* subsp. Although there are various lactic acid bacteria such as *paracasei, L. fermentum, L. brevis., L. sanfranciscensis, L. pontis, L. fructivorans, L. reuteri*, yeasts such as *Saccharomyces cerevisiae* are also known to contribute to flavor development (Altay et al., 2013; Evren ve ark., 2011). The most important features of fermented products such as shalgam juice are that they are obtained as a result of lactic acid fermentation and have a significant amount of lactic acid content. This lactic acid they contain has a positive effect on the favorable sour taste and the long-lasting durability of fermented foods and beverages. Lactic acid, besides giving sour taste to shalgam juice, is easy to digest, appetizing and it is accepted as health products because it is an acidic product and pathogen microorganisms cannot develop in it (Say & Balli, 2012). Shalgam; It has high nutritional value, rich in vitamins A, C and B, and minerals such as calcium, iron, and potassium (Kabak & Dobson, 2011). Shalgam helps to remove toxins from the body, reduce kidney stones, and treat pubertal acne, eczema, abscesses, and hematomas. It is a diuretic. It is therefore considered a functional food. Due to the growing interest in functional foods, it has become more popular (Coşkun, 2017). Shalgam juice is beneficial for health because of its high vitamin and mineral content and antioxidant properties. One study has shown that shalgam juice has a protective effect against the development of colon cancer. Another study is showed that it has antioxidant, probiotic and anti-proliferative properties (Şanlier et al., 2019).

Pickle

The word pickle comes from the Persian word “torsh” which means “sour”. Pickle is one of the oldest fermentation products used by human beings in Anatolia. Pickled “It is formed by vegetables and fruits being fermented with certain salt concentrations in brine or their juices with lactic acid bacteria. It is expressed as a long-lasting product with the protective effect of lactic acid and salt in the environment”. Pickles can be made from a wide variety of vegetables and fruits. Vegetables and fruits fermented in the season when fruits and vegetables are abundant can be pickled and preserved until the season when they are not. These products can be consumed regardless of time. For this reason, pickles are one of the indispensable traditional products of our Turkish cuisine. Due to their structure, vegetables are more suitable for pickle production than fruits, and cucumber, cabbage, pepper, tomato,

bean, and carrot are the leading vegetables used in pickle production. Also, melon (unripe), okra, broccoli, celery leaf, cranberry, apple (raw green), plum (raw green), shalgam (raw green), apricot (raw green), peach (raw green), pear (ahlat), grapes (unripe), capers (large sizes), cherry and soul cherry are used in pickle production in some regions depending on consumer preference (Karagöz ve Güllü, 2017; Tokatlı, Dursun, Arslankoz, Şanlıbaba ve Özçelik, 2012). Garlic, parsley, fresh mint leaves, ginger, fresh dill leaves, and bay leaves are also used as aroma ingredients in pickle production (Kabak & Dobson, 2011).

Traditionally, there are microorganisms and lactic acid bacteria that cause spoilage in the natural microflora of vegetables and fruits, and the pickle is fermented with this microflora (Kabak & Dobson, 2011; Karagöz ve Güllü, 2017). The most common method among pickle production techniques is lactic acid fermentation. With lactic acid fermentation, resistance against nutrient deterioration and microorganisms causing toxin formation is prevented, the development of pathogenic microorganisms is prevented, the nutritional value of the product is increased (Tokatlı ve ark., 2012). The fermentation process begins within a few days after the vegetables and/or fruits are placed in brine (Karagöz ve Güllü, 2017). For a good fermentation, the brine must have a salt concentration of 10-15%. This is because at high salt concentration, lactic acid bacteria will not grow well (Kabak & Dobson, 2011). Among other lactic acid bacteria used in pickle production, *Enterococcus faecalis, Leuconostoc mesenteroides* are not resistant to high salt (more than 5%) and acid concentration, but *L. plantarum* is the most resistant to acid (Tokatlı ve ark., 2012). Other active lactic acid bacteria are *L. brevis, Pediococcus cerevisiae* (Evren ve ark., 2011). Visible changes occur during fermentation, and these changes are important in assessing the progress of the process. For example, the color of the cucumber surface varies from bright green to dark olive green, and the produced acids interact with chlorophyll. The specific gravity of cucumbers also increases as a result of the gradual absorption of salt, and instead of swimming on the surface, they begin to sink in saltwater (Kabak & Dobson, 2011).

Hardaliye

Hardaliye is a fruit-based alcohol-free fermented beverage (Baschali et al., 2017). It is classified as a non-dairy probiotic beverage due to the flora of hardaliye lactic acid bacteria (Altay et al., 2013). Hardaliye, although none of the day by day, Turkey's Thrace region is considered as local drinks. Although other ingredients like Prina and cherry leaves have been used for centuries, they are made from red grape juice and crushed black mustard seeds. Benzoic acid (on an industrial scale) is sometimes added as a preservative. Its color varies according to the grape varieties used and production methods. Hardaliye is produced mostly by the traditional method and grape juice, raw mustard seeds and/or benzoic acid are mixed, pressed and left to fermentation for 5-10 days at room temperature. The hardaliye microbial population has been reported to consist mainly of *Lactobacillus*

and unknown fungal species (Baschali et al., 2017; Pehlivanoğlu et al., 2015). Natural fermentation of hardaliye in *L. paracasei* subsp. paracasei, *L. casei* subsp. *pseudoplantarum, L. brevis, L. pontis, L. acetotolerant, L. sanfransisco* and *L. vaccinostercus* provide lactic acid bacteria and thanks to these lactic acid bacteria it has an acidic taste (Altay et al., 2013; Kabak & Dobson, 2011). The etheric oils in black mustard seeds inhibit yeast growth, prevent alcohol formation, and these compounds help create a special mustard flavor. Also, black mustard grains have an anti-carcinogenic effect (Baschali et al., 2017). This effect of hardaliye has increased the interest in the drink. Hardaliye helps nutritional value as well as coronary heart disease and digestive system (Pehlivanoğlu et al., 2015). With its antioxidant properties, Hardaliye has been shown to reduce plasma malondialdehyde, dienoconjugate and homocysteine levels (Şanlier et al., 2019)

Meat-Based Fermented Products

Although there are still negative thoughts among consumers about meat and meat products, meat and meat products are important in terms of essential nutritional components they contain in terms of human nutrition (Palamutoğlu ve Kasnak, 2014). The fermentation of meat is the oldest and most widely used form of fermentation. Fermented meat production involves many biochemical, microbiological, and chemical changes, and these changes provide the unique structure of fermented meat products with taste and flavoring agents (Tiske İnan, Palamutoğlu ve Karakaya, 2010). Lactic acid bacteria, which play an important role in the fermentation of meat, lower pH and produce organic acids and bacteriocins that prevent the growth of pathogenic and spoilage microorganisms, thereby improving the safety of fermented meat products, improving their stability and shelf life (Evren ve ark., 2011; Palamutoğlu ve Kasnak, 2014).

Sucuk

Sucuk is a semi-dry Turkish style fermented sausage and traditional fermented meat product and widely produced and consumed in many regions of Turkey (Palamutoğlu, Fidan, & Kasnak, 2018). After the beef, sheep, buffalo or goat meat is kneaded with a certain amount of sheep's tail fat, sugar, salt, nitrite/nitrate, flavoring spices, it is filled into the beef intestine and the steps of fermentation and drying take place under climatic or natural conditions (Gürbüz ve Çelikel Güngör, 2018; Palamutoğlu et al., 2018). S in the Turkish food codex; Bovine and /or ovine carcass meat and fat are minced and mixed with flavoring, then filled in natural or artificial cases, and fermentation and drying processes are applied under certain conditions, and it is defined as a non-heat-treated fermented meat product with a mosaic appearance (TGK, 2018). In our country, Fermented sucuk produced in homes and small businesses is also produced industrially. Sucuk produced by the traditional method is preferred by consumers because of its sensory properties. The production of fermented sucuk takes place in three stages: preparation of the dough, fermentation, and maturation/drying. Numerous

microbiological and biochemical changes occur during the ripening phase and these changes show the quality of the sucuk (Gürbüz ve Çelikel Güngör, 2018). Due to its antioxidant and antibacterial properties, nitrite/nitrate used in the production of sucuk functions as a substrate for fermentation of sucrose or glucose lactic acid bacteria and has a long shelf life due to salt and spice components. Also, lactic acid bacteria contribute to the aroma formation by reducing carbohydrates, with the pH-lowering effect, they allow the product to dry faster. Accelerates nitrite breakdown and color formation (Evren ve ark., 2011; Şanlier et al., 2019).

Traditionally, starter cultures are not used in sucuk production, and fermentation takes place spontaneously by the sucuk microflora, mainly composed of lactic acid bacteria. This causes major changes in both the quality and stability of the end product. Therefore, it is necessary to use starter cultures to prevent these differences in the quality of the product (Kabak & Dobson, 2011). Microorganisms that play the most important role in sucuk fermentation and ripening are members of *Lactobacillus*, *Staphylococcus* and *Micrococcus* genus (Palamutoğlu ve Kasnak, 2014). *L. plantarum*, *L. sake*, and *L. curvatus* species are the most abundant of lactic acid bacteria. Also lactic acid bacteria such as *L. pentosus*, *L. fermentum*, *L. brevis*, *Pediococcus pentosaceus*, *P. acidilactici*, *Lc. lactis* subsp. *lactis*, *Leuc. mesenteroides* subsp. *mesenteroides/dextranicum*, *Leuc. lactis*, *Lactobacillus* spp, *L. viridescens*, *L. agilis*, *L. carnis*, *L. casei* subsp. rhamnosus have been reported in various concentrates of sucuk, depending on the production techniques or the specific flora and type used (Evren ve ark., 2011; Kabak & Dobson, 2011).

The use of different combinations of microorganisms in sucuk production provides a variety of useful biochemical, physicochemical, and microbiological properties in addition to the desired taste, texture, and color. Although consumers enjoy sucuk due to sensory properties and are considered safe food, they are criticized by nutritionists for their high fat, salt, and biogenic amine content. For this reason, interest in the use of fermented meat products as probiotic starter culture carriers has increased recently (Şanlier et al., 2019). Lactic acid bacteria with probiotic properties used in sucuk fermentation have a positive effect on the product's functional and physiological properties as well as its effects on taste, flavor, and aroma. Since probiotics have positive effects on human health and have no negative effects on product properties, various cultures have started to be used in the production of probiotic fermented meat products. The dough mixture prepared in the production of these products creates a suitable environment for probiotic cells thanks to its meat and fat matrix (Palamutoğlu ve Kasnak, 2014). Probiotic starter cultures added during fermentation of meat have been shown to produce beneficial bioactive peptides such as the ACE (Angiotensin converting enzyme) inhibitory peptide, inhibit proteolytic action and fatty acid oxidation, and inhibit the growth of pathogenic microorganisms that produce biogenic amines. However, one study found that microbial starter cultures added during fermentation increase the microbial safety of naturally fermented sucuk by

reducing the level of biogenic amines (Palamutoğlu & Sariçoban, 2016; Şanlier et al., 2019).

CONCLUSION

Many traditional fermented food and beverages are produced by fermentation containing lactic acid bacteria, yeasts, or mixtures of both. In Turkey particularly, lactic acid fermentation, Turkey plays an important and dominant role in the production of traditional fermented products. Fermented products have long been an integral part of people's diet, and the health benefits of these nutrients are related to bioactive compounds that are formed during fermentation. Health benefits include prevention of obesity, diabetes, hypertension, constipation, and diarrhea, etc. Lactic acid bacteria in fermented foods have antimicrobial effects due to the production of organic acids.

It has many health benefits due to fermented products, biologically active peptides, vitamins, and compounds produced by fermentation bacteria. More studies are needed on the amount of consumption required to see the health benefits more clearly.

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