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Production techniques and product characteristics of “kaymak” produced in Türkiye

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ABSTRACT

With its unique creamy structure, delicious consistency, slightly acidic taste and aroma, “kaymak” is a traditional dairy product that is consumed with honey and jam for breakfast, in the production of Turkish delight with cream and cream candy, or in Turkish desserts such as kadayif and baklava because of its many features that increase the ornamentation, flavor and nutritional value. In Türkiye, two types of “kaymak” are produced as “Afyon Kaymağı” and “Lüle Kaymağı”, especially in the Aegean region (Afyonkarahisar and its surroundings) and Central Anatolia, as well as in Ankara, Bursa, Edirne, Erzurum, Istanbul, Izmir, Kilis and Kocaeli provinces. It is also produced from buffalo milk in countries such as the Balkans, Middle East, Central Asia, Iran, Afghanistan and India. It is described by names such as “kajmak”, “kaimak”, “gemagh” or “geymar”. The fact that the “kaymak” produced by the traditional method has a very open production process to microbial contamination, is a product that does not undergo fermentation, has a high water content and is rich in usable nutrients, increases the importance of the risk of contamination after the pasteurization process. It is evaluated that “kaymak” can provide an extremely favorable environment for the development of pathogenic microorganisms that *Escherichia coli*, *E. coli* O157:H7, coliform bacteria, *Listeria* spp., *Listeria monocytogenes*, *Pseudomonas* spp., *Salmonella* spp., *Salmonella-Shigella, Staphylococcus, Staphylococcus aureus*, total aerobic mesophyll bacteria, total aerobic psychrophilic bacteria, yeast and mould, which cause foodborne infections and food intoxications in humans and this situation may pose a risk for public health.

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Introduction

Kaymak is an important dairy product in Türkiye, which is generally produced in small family businesses as well as in many enterprises, from small dairies to large modern facilities (Kurt and Özdemir, 1988; Hasdoğan, 2004). Cream-like dairy products are also produced in some European countries. There is a local type of cream called "clotted cream", produced especially in England. This traditional product is yellowish in color and has a granular structure, and is generally consumed by spreading it on products such as pastries, buns, or on fruits (Early, 1991).

According to the Turkish Food Codex Communique on Cream and Turkish Cream, Kaymak is defined as cream containing at least 60% milk fat by weight and also "Afyon Kaymağı" is described as the product obtained by boiling buffalo milk in accordance with the technique, keeping it at 92°C for at least 2 minutes and cooling it in accordance with the technique (TFC,

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2003). However, in recent years, since the number of buffaloes has been far below the desired level and sufficient amounts of buffalo milk cannot be produced, Kaymak produced from cow's milk or its mixtures is also produced and sold under the same name (Şenel, 2011). It is stated that the Kaymak must have a unique taste, smell and structure and must not contain any visible microorganism colonies. Kaymak to be offered for direct consumption must be put on the market after undergoing at least pasteurization or a heat treatment equivalent to pasteurization (TFC, 2003). In the Turkish Standards Institution (TSI) Cream and Kaymak Standard (TS 1864); it is stated that these oil-based products must have their own unique colour, taste, odor and consistency, and if they are to be offered for direct consumption, they must be put on sale after heat treatment at the lowest pasteurization norm (15-20 seconds at 72°C) (TSI, 2008).

Kaymak; being a dairy product rich in fat, it can easily spoil due to reasons such as not following adequate hygiene and sanitation rules in its production, not being able to prevent cross-contamination, and not paying enough attention to packaging and storage conditions (Bilir-Ormancı, 2020). For this reason, Kaymak and similar ready-to-eat dairy products; if it is to be consumed later, it must be cooled quickly and in a short time using other appropriate processes up to 5°C to kill bacterial cells or stop proliferation, and it should be known that heat treatments to be carried out after toxin formation will not be effective in preventing food-borne intoxications (Cretenet et al., 2011; Schelin et al., 2011; Ray and Bhunia, 2016). As a matter of fact, staphylococcal intoxications and related cases of staphylococcal gastroenteritis are frequently observed due to not paying due attention to Kaymak and similar protein-rich and ready-to-consume foods, especially during the production, preservation and marketing stages (Özcan-Yılsay and Akpınar-Bayizit, 2002; Erol and İşeri, 2004; Erol, 2007; Schelin et al., 2011; Ray and Bhunia, 2016).
In this study; it is aimed to reveal the importance of Kaymak, which has the potential to pose risks in terms of both consumer health and product quality, in terms of public health, with its microbiological, chemical and sensory properties that determine the quality of Kaymak, which is generally produced, sold and marketed as a traditional dairy product in small family businesses in our country.

The importance of kaymak in nutrition

Milk and dairy products are rich in phosphorus and calcium, important amino acids (lysine) that cannot be synthesized by the body and that the body needs to perform its normal functions, high quality protein, fat, carbohydrates, sugar, minerals, riboflavin and vitamin B12 (Galvano et al., 1998; Tekinşen, 2000; Tekinşen and Nizamlıoğlu, 2004; Fagundes et al., 2011; Üçüncü, 2018).

Kaymak has a very important place in nutritional physiology thanks to its unique sensory properties derived from milk fat (Metin, 2005; Tekinşen, 2005). Because milk fat contains very high levels of essential unsaturated fatty acids such as medium-chain fatty acids linoleic, linolenic and arachidonic acids, and fat-soluble vitamins (vitamins A, D, E and K) (Tekinşen and Nizamlıoğlu, 2004; Bilir-Ormancı, 2020). Milk fat plays a major role in the physical properties, taste, aroma and nutritional value of Kaymak, as in milk and other dairy products (Tekinşen, 2005; Bilir-Ormancı, 2020). Kaymak is also a good source of energy and provides 5.90-6.13 g-1 calories of energy (Tekinşen, 2005).

Recent studies have reported that conjugated linoleic acid (CLA) contained in milk fat has beneficial qualities for human health (Seçkin et al., 2005). In addition, milk fat is easily digested due to the short and medium chain fatty acids in its structure (Tekinşen, 2000). In a study conducted by Akalın et al. (2005), the amount of CLA was found to be higher in animal products compared to plant products, and it was reported that the level of CLA in the tissues of ruminant animals was found to be higher among animal products. Therefore, dairy products such as milk and milk fat-based Kaymak, butter and cheese are considered the most basic source of CLA. Kaymak, along with foods such as butter and cheese with high milk fat content, are among the preferred dairy products because they are rich dietary sources of CLA intake (Akalın et al., 2005).

Formation of the kaymak layer

The Kaymak binding power of milk depends on the formation of a layer consisting mostly of fat on the surface of the milk left alone after a certain period of time (Bilir-Ormancı, 2020). Although the specific gravity of milk fat in the form of globules is 0.931 g/ml, the specific gravity of the plasma part of milk is 1.034 g/ml. The fat part with lower specific gravity gradually accumulates on the surface of the milk as the fat globules rise. Fat globules partially combine to form large masses. The layer collected on the surface of the milk gradually becomes richer in fat, thus forming a Kaymak layer (İnal, 1990; Bilir-Ormancı, 2020).

The quality of the milk used in the formation of the Kaymak layer is one of the most important factors. The high fat content of milk also increases the amount of Kaymak obtained. In addition, the taste, aroma and color of the resulting product vary depending on the type of animal from which the milk is obtained. Buffalo

milk is richer in fat-soluble vitamins than cow's milk and also contains high amounts of the glycoprotein lactoferrin. However, since buffaloes convert all of the β-carotene they take in feed into vitamin A, the color of the Kaymak obtained from buffalo milk is white (Bilir-Ormancı, 2020). Due to its high Kaymak binding ability, the Kaymak produced from buffalo milk is thick, viscous and white in color, while the Kaymak produced from cow milk is thin and yellowish in color (Çon et al.,2000; Bilir-Ormancı, 2020).

Kaymak production technology

When the historical background of Kaymak making is examined, the first technological initiative took place in 1864 and the milk was separated from the Kaymak by rotating the milk placed in the containers. However, due to the low capacity of the first technological machines, it was reported that the Kaymak obtained was not of the desired quality. It is noted that Ledfeld, who discovered the hood centrifuge in 1877, managed to separate the milk Kaymak from the milk in a short time and completely, and later, with the advancement of technology, today's machines were developed by making some changes to this first discovered device (such as adding a disc device) (İnal, 1990).

"**Afyon Kaymağı" production with traditional method**

Kaymak production with the traditional method is generally carried out in small family businesses in Afyon, where modern tools and equipment are not available, with production lasting approximately 36 hours (Eralp, 1969; Hamzaçebi, 1973; Korkmaz, 1990; Yılmaz, 1998). "Afyon Kaymağı" is a geographically indicated dairy product (TURKISH PATENT, 2009). In the production of this Kaymak, respectively; preparation of milk, filtering of milk, thermal treatments applied to milk (first heating process, cooling and resting, second heating process, cooling and resting), cutting and packaging of Kaymak and final product storage processes are applied (Tekinşen, 2005).

"**Lüle Kaymağı" production with traditional method**

Although there are processes similar to the production of "Afyon Kaymağı" in the production of "Lüle Kaymağı" with the traditional method, there are some differences. In our country, "Lüle Kaymağı" production is mostly done in large cities such as Istanbul, Ankara, Izmir and Bursa (Erkmen and İzmen, 1942; İzmen and Eralp, 1967; Yöney, 1970). In the production of this Kaymak, respectively; preparation of milk, thermal treatments applied to milk (first heating process, cooling and resting, second heating process, cooling and resting), binding and packaging of Kaymak and storage of Kaymak are applied (Tekinşen, 2005).

Kaymak production with industrial method

It is a method applied using separators, based on the principle of separating milk fat by centrifugal force. In this method, the milk is heated to 60°C and the cream part is separated with a separator. After the cream obtained following the separation process is standardized to contain 60% fat, heat treatment is applied at 90-95°C for 3-5 minutes. After the heat treatment, it is cooled to 25-30°C. After the cream is filled into suitable containers for sale, it is kept at 4-6° C for 12 hours and rested (Bilir-Ormancı, 2020).

Features that determine quality in kaymak

Microbiological properties of kaymak: Kaymak differs from milk fat-based butter and other local products known as ghee, sanma, meshho, samin and samuli in terms of its composition and shelf life. Kaymak has a higher moisture content and lower milk fat content (Eralp, 1969; Bilir-Ormancı, 2020). For this reason, Kaymak creates an extremely favorable environment for the development of pathogenic microorganisms due to its high water content and rich content of usable nutrients. Additionally, the fermentation process is not used in Kaymak production. These differences affect the shelf life of Kaymak (Bilir-Ormancı, 2020). Although the shelf life of other products is 6-8 months, the shelf life of Kaymak is at least 3-4 days in summer and 6-7 days in winter at 4°C, since it is a product that does not undergo fermentation (Tekinşen, 2005; Bilir-Ormancı, 2020).

According to the Turkish Food Codex Communique on Cream and Turkish Cream; Kaymak that will be offered for direct consumption must be put on the market after undergoing at least pasteurization or a heat treatment equivalent to pasteurization (TFC, 2003). The possibility of Kaymak being exposed to microbial contamination after pasteurization is considered to be one of the factors that shorten its shelf life (Bilir-Ormancı, 2020).

One of the effective factors in controlling microbial growth and extending shelf life is storage temperature. In order to preserve its quality, it is recommended to store Kaymak at temperatures close to 0°C. If the storage temperature exceeds 6°C, bacteria develop faster, quality values in the product decrease and the rate of deterioration increases (Bilir-Ormancı, 2020). The microbiological criteria specified for Kaymak according to the Turkish Food Codex Regulation on Microbiological Criteria are shown in Table 1 (TFC, 2011).

Although the most important factor determining the quality and storage time of Kaymak is its microbiological properties, there are very few studies

Table 1. Microbiological criteria specified for Kaymak (TFC, 2011).

Microorganisms	Sampling plan (1)		Limits (2)	
	n	c	m	M
Coagulase positive *Staphylococci*	5	2	10^2	10^3
Salmonella spp.	5	0	0/25 g-mL	
L. monocytogenes	5	0	0/25 g-mL	

(1) n: Number of samples, c: Number of samples allowed to have values between m and M limit, (2) Unless stated otherwise, the limit is evaluated as cfu/g-mL. cfu: Colony forming unit (in solid medium)

Table 2. Microbiological properties of Kaymak determined in some studies (Pamuk, 2017).

Microorganisms	Hamzaçebi, 1973	Kurt and Özdemir, 1988	Çon et al., 2000	Öksüz et al., 2000	Özcan-Yılsay and Akpınar-Bayizit, 2002	Akalın et al., 2006
Coliform (log_{10} cfu/g^{-1})	0.70-7.97	1.48-3.34	1.30-5.90	2.69-3.90	-	-
Yeast-Mould (log_{10} cfu/g^{-1})	0-5.85	2.23-4.26	2.30-4.98	2.77-4.40	2.11-6.20	3.88-7.53
Total Aerobic Mesophilic Bacteria (log_{10} cfu/g^{-1})	3.78-10.48	3.68-6.52	3.51-7.77	3.23-4.74	2.71-6.35	-
Staphylococcus aureus (log_{10} cfu/g^{-1})	-	0-3.20	0.60-4.20	1.00-2.92	0.00-5.44	0-6.86
Coliform bacteria (log_{10} cfu/g^{-1})	-	-	-	2.69-3.90	-	0-3.38
Salmonella-Shigella (log_{10} cfu/g^{-1})	-	-	-	-	0.00-4.25	-

on this product (Özcan-Yılsay and Akpınar-Bayizit, 2002). The results obtained from the studies conducted to determine the microbiological properties of Kaymak are summarized in Table 2 (Pamuk, 2017).

In addition, studies have shown that Kaymak contains or has the potential to develop pathogenic microorganisms such as *Clostridium perfringens*, *Escherichia coli*, *E. coli* O157:H7, lactic acid bacteria, *Listeria* spp., *Listeria monocytogenes*, *Pseudomonas* spp., *Salmonella* spp., *Staphylococcus* and total aerobic psychrophilic bacteria (TAPB) that cause foodborne infections and food intoxications in humans (Akalın et al., 2006; Öncü, 2012; İpekçioğlu and Gürler, 2017; Tomar and Akarca, 2018).

Chemical properties of kaymak

Kaymak is very rich in milk fat and contains 56-69% fat in its composition. It also contains some of the protein, lactose and mineral substances in milk (Yılmaz, 1998; Öksüz et al., 2000). The chemical composition of milk used in Kaymak production may vary depending on animal species (Tekinşen, 2005). The chemical composition of milk according to animal species is shown in Table 3 (Tekinşen et al., 1997).

The results obtained from the studies carried out in Türkiye to determine the chemical composition of Kaymak are summarized in Table 4 (Öncü, 2012).

Table 3. Chemical composition of milk according to animal species (%) (Tekinşen et al., 1997).

Animal Species	Water	Protein	Fat	Mineral Substance
Buffalo	82.2	4.2	7.90	0.8
Cow	87.5	3.3	3.60	0.9
Sheep	81.6	5.2	7.50	0.9
Goat	87.0	3.6	4.2	0.9

As a result of the studies, the low dry matter and fat rates detected are attributed to the use of cow's milk during the Kaymak making process. In some of the studies, the amount of protein contained in Kaymak was also examined and it was reported that the differences in protein values depended on the dry matter. The detection of different acidity values is associated with the fact that the studies were carried out in different seasons (İzmen and Eralp, 1967; Hamzaçebi, 1973).

In recent years, there have been different studies conducted to determine the chemical properties of Kaymak samples (Kocaoğlu, 2009; Anlı and Gürsel, 2013; Albay and Şimşek, 2019; Kocatürk et al., 2019; Özbek et al., 2021).

Table 4. Average chemical composition of various types of Kaymak in Türkiye (%) (Öncü, 2012).

Sample		Dry Matter	Fat	Protein	Ash	Acidity (l.a.)	Reference
Type	Number						
Lüle Kaymağı	23	68.61	65.0	2.40	0.29	0.29	Adam, 1955
Lüle Kaymağı	42	68.57	63.4	3.58	0.45	0.20	İzmen and Eralp, 1967
Lüle Kaymağı	10	68.32	62.6	4.03	0.44	0.18	Eralp,1967
Lüle Kaymağı	25	-	65.0	2.40	-	0.29	Eralp,1969
Afyon Kaymağı	250	69.21	62.7	-	-	0.17	Hamzaçebi, 1973
Kaymak	10	55.02	29.1	8.40	2.13	0.44	Kurt and Özdemir, 1988
Afyon Kaymağı	4	66.19	60.0	-	-	0.13	Yılmaz, 1998
Kaymak	21	67.40	62.7	3.36	-	0.34	Öksüz et al., 2000
Afyon Kaymağı*	1	63.04	58.0	-	-	0.14	Çon et al., 2000

* : First day on sale, l.a.: Titratable acidity, as lactic acid.

Sensory properties of kaymak

The composition and qualities of the milk used in Kaymak production and the processes applied directly affect the sensory qualities of the final product by causing differences in its color and structure. For example; the flavor (taste and smell) and aroma of the Kaymak made from buffalo milk in accordance with the technique is unique, distinct and pleasant. However, its consistency is medium dark and its structure is granular (grained), white in color and thick, while the Kaymak produced by adding cow's milk has a yellowish color and non-homogeneous appearance, thin and brittle structure (Tekinşen, 2005; Bilir-Ormancı, 2020).

Exposing milk to high heat treatment during production also causes the product to develop a cooked taste. In addition, cooling the Kaymak quickly causes it to have a fine structure, and keeping it in the cold for a long time causes it to have a granular structure (Bilir-Ormancı, 2020). It is reported that the sticky, sandy and fluid structure, which are among the defects of Kaymak, may be related to the fatty acid composition of the cream (deterioration of the emulsion stability of the cream) and the feed fed to the dairy animal (for example; the relationship with alfalfa) (Bodyfelt, 1988). There should be no loose cream residue in the Kaymak package (Tekinşen, 2005).

As a result of the studies, it was found that in the Lüle Kaymağı samples stored at low temperatures (3-5°C), the acidity level increased from the third day onwards, the increase continued at temperatures above 0°C, and the acidity remained constant at temperatures between -5°C and 0°C. It was determined that in the Kaymak samples, a hard structure was formed at the degrees where the acidity remained constant, and fractures and cracks occurred on the surface. As a result, considering that the sensory and visual qualities of Lüle Kaymağı do not change, it was stated that a storage temperature of 3-5°C and consumption within 1-2 days after its production would be appropriate (Eralp, 1969).

Studies on kaymak

The diversity among the findings detected in some studies where Kaymak samples were examined; it is thought that this may be due to differences in the technology used in the production of Kaymak, the number of samples, the analyzes applied, the isolation methods, the isolate obtained, the time of collection of the samples and the geographical features (Muratoğlu, 2010; Tomar and Akarca, 2018).

Conclusion

Kaymak produced with traditional and unhygienic methods is exposed to microbial contamination during production, packaging and storage because the milk boilers, cream pans, cheesecloth, plastic containers and other equipment used in production are not cleaned or disinfected at the desired level. This situation causes microorganisms to multiply on the

equipment surfaces and causes the Kaymak to deteriorate or undesirable defects to appear during processing. Similarly, process tanks and all equipment within the facility to be used in Kaymak processes carried out in large capacity facilities should be placed in a way that ensures sanitation, maintenance and control in accordance with hygienic design principles, should be made of stainless steel and should be capable of preventing the development of microorganisms. Effective hygiene, sanitation and disinfection should be applied to the equipment used for Kaymak production after use. The shelf life of Kaymak is also shortened due to negative effects such as rancidity, mould, bitterness and putridity, which occur as a result of Kaymak being exposed to microbial contamination during production, packaging and storage. In addition, economic losses occur in milk and dairy products processing facilities that produce Kaymak. Studies have shown that Kaymak can provide an extremely favorable environment for the development of pathogenic microorganisms such as; "*Clostridium perfringens*, *Escherichia coli*, *E. coli* O157:H7, coliform bacteria, lactic acid bacteria, Listeria spp., *Listeria monocytogenes*, *Pseudomonas* spp., Salmonella spp., Salmonella-Shigella, *Staphylococcus*, *Staphylococcus aureus*, total aerobic mesophyll bacteria (TAMB), total aerobic psychrophilic bacteria (TAPB), yeast and mould" that cause foodborne infections and food intoxications in humans.

In order to protect public health; production and sales places must be inspected at appropriate intervals by official institutions, and manufacturing enterprises must take all measures to reduce the microbial load on products and fulfill the legal procedures and requirements. All personnel working in businesses that produce and sell food must receive training on hygiene and sanitation, apply hygiene rules, and effectively apply the HACCP (Hazard Analysis Critical Control Points) system with a proactive approach, especially in production activities.

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