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Review

Historical, Technological, Biochemical, and Microbiological Aspects of Pastırma, an Ethnic Meat Product from Asia to Anatolia

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Abstract: Meat drying is a traditional method of preserving meat that has a rich past in many cultures. Pastırma is an ethnic meat product defined as dry-curing, drying, pressing the whole muscles of cattle and buffalo, and coating them with a special paste. The most important ingredient that gives the product its characteristic features is in its content: a paste containing fenugreek seed flour, garlic, milled red capia pepper, and water. Among ethnic meat products, pastırma is familiar with dry-cured meat products such as jerky, kadid, cecina, and carne de sol. In this review, historical aspects of pastırma, its definition and classification, detailed production steps, composition and yield, chemical and microbiological properties, pastırma fraud and customer concerns are mentioned. The results of this review indicate that future studies on pastırma may focus on related cultural aspects, elimination of unpleasant odour from fenugreek, histological and chemical effects of pressing meat parts, kinetics of drying, osmotic dehydration, and developing new starter combinations.

Keywords: Pastirma; cemen; manufacture; dry cured meat; food fraud

1. Introduction

Meat and meat products are economic-interest foodstuffs, constituting valuable livestock products. From a nutritional perspective, meat's importance derives from its high biological value as a protein, which contains all the essential amino acids as well as highly bioavailable minerals, vitamins, and micronutrients like iron, selenium, and zinc. The consumption of meat has been of paramount importance in the development and sustenance of the human species, as it provides a wide array of essential nutrients that are vital for maintaining a healthy and balanced diet (Gagaoua & Boudechicha, 2018; Ledesma et al., 2016).

Traditionally, culturally, and commercially, ethnic meat products are precious foods in different nations worldwide. The meat products prepared by Eastern Mediterranean and Middle Easterners are typically cured or cooked and occasionally smoked or sun-dried (Gagaoua & Boudechicha, 2018). Many ethnic food products with animal origins are still in demand today and sold under various brands due to their customary, nutritional, and sensory properties. One example of these products is pastırma, which is commonly consumed in the Anatolian region. Also, it is consumed in the Middle East, Central Asia, the Mediterranean, and Europe (Aksu et al., 2020a; Ceylan & Aksu, 2011). At the same time, pastırma is a meat product produced without heating or smoking and consumed without cooking. So it is an ethnic meat product produced by dry-curing, drying, pressing the whole muscles of cattle and buffalo, and coating them with a paste called "Cemen" made with special spices (Aksu et al., 2020b; Kaban, 2013). Fenugreek (*Trigonella foenum-graecum* L.) seed flour, garlic (*Allium sativum* L.), milled red capia pepper (*Capsicum annuum* L.), and water are the primary ingredients used in the preparation of cemen (Figure 1).

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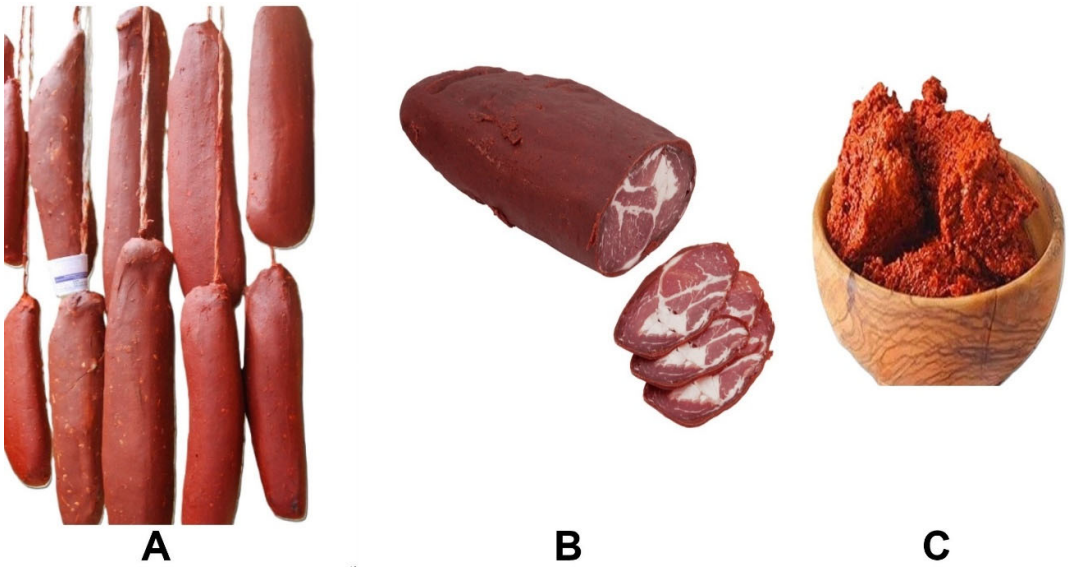

Figure 1. Appearance of pastırma (**A**), pastırma slice (**B**), and cemen paste (**C**).

Scientific research on ethnic food products is essential not only for those who create scientific knowledge but also for the sector, producers, and consumers. Although there have been a lot of research on pastırma, there needs to be literature in which all the aspects of pastırma are collected. In addition, researchers need to be shown new opinions, suggestions, and missing pieces. To this end, this comprehensive review aimed to address the definition of pastırma and its historical, technological, biochemical, and microbiological properties in all its parts.

2. Historical Aspects

Food consumption patterns are seen as a cultural attribute and, as such, vary in accordance with the societal culture. As it is known, food culture is a result of the accumulation of years of knowledge transferred from generation to generation. Nomads, who mostly salted, pressed, and dried their meat, tried alternative methods to make their food be consumed for a longer time in history. According to historians and archaeologists (Oboturova et al., 2022; Turner& Merwin, 2016; Merwin, 2015), Hun and Oghuz Turks, who led a nomadic and militant life in Central Asia, used to carry out their alimentation activities with salted meat and meat pieces of animals they hunted in order to advance on horseback without wasting time. They carried these pieces of meat in their saddles or saddlebags, which they placed on their mounts, and during the journeys that often lasted for weeks, the pieces of meat turned into pastırma by being stuck and pressed between horse and saddle (Çilginoğlu & Mutlu, 2022; Merwin, 2015). Pastırma, a Turkish name, is derived from the verb "*bastırmak*" which means to pressed (Özkan, 2013). The primary ancestral territory of Hun and Oghuz Turks was in Central Asia, with the Khingan Mountains in the east, the Caspian Sea in the west, Siberia in the north, and the Himalayas in the south. Hun and Oghuz Turks have been migrating for thousands of years and have spread out from the mainland to various parts of the world (Batu, 2018). Thus, pastırma culture has reshaped as a consequence of migration to different geographical areas and interaction with different cultures (Figure 2).

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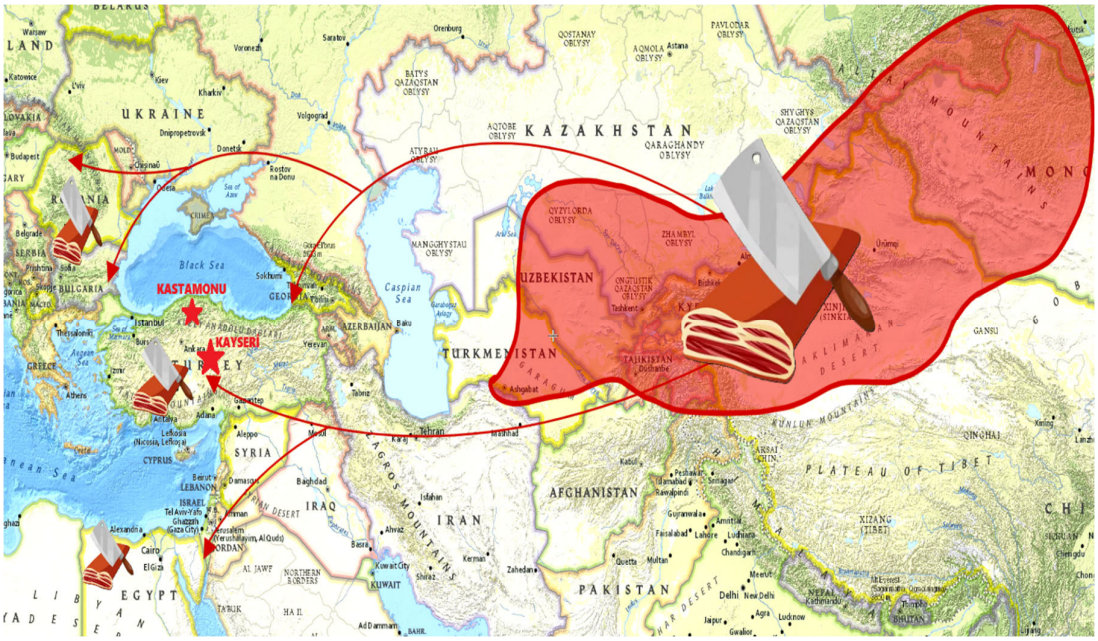

Figure 2. Migration map of pastırma via Turk tribes from east to west throughout history.

The fact that the cultural interaction of nomads with agricultural societies has affected pastırma to take its current form in time. To prevent the surface of the pastırma from becoming mouldy, ancient people covered meat with a thin spice paste called cemen, the main ingredient of which is fenugreek (*Trigonella foenum-graecum* L.). Greek hayseed, commonly known as fenugreek, was considered the best stabilizer and preservative by ancient people due to its easily obtainable and fibrous, sticky texture (Batu, 2018; Kaban, 2013; Visuvanathan et al., 2022).

Pastırma entered Anatolia from Central Asia during the Seljuk era in the 11-12th centuries. In the Seljuk era, "Divanü Lugati-t Türk" (1073): In a work that was prepared as a dictionary by Mahmut of Kashgar in order to teach the Turkish language to Arabs, we can find pastırma and a lot of ethnic product descriptions that still exist (Batu, 2018; Kaban, 2013).

In the era of the Ottoman Empire, pastırma had spread from Anatolia to North Africa (Egypt, Algeria, Libya, Tunisia), Rumelia, and the Balkans (Gagaoua & Boudechicha, 2018; Güney, 2023). The manuscripts that described social functions in the 16th century's Ottoman Empire mentioned that pastırma served as an appetizer in private bars at a point in time. On the other hand, it's estimated that commercial production of pastırma started in the 17th century (Türker et al., 2019).

Today, pastırma, known as *pasterma* or *basṭarma* in Egypt and consumed in great demand, especially by the Egyptians, is no different from Turkish-type pastırma. Unfortunately, pastırma is called *pastrami* in some publications from Turkey and Egypt (Abd-Elghany et al., 2020; El-Mougy et al., 2023; Yildirim et al., 2017; Akçay et al., 2015; Özkan, 2013). However, *pastrami*, which is considered a word of Jewish origin in America, refers to a different delicatessen product made by heat treatment, brining and smoking. The words pastırma and pastrami is cause conceptual confusion in some publication. This may perhaps be a straightforward case of a translation mistake into English.

The name seems to originate from closely related words in Romanian, Russian, Turkish, greek, and Armenian, namely *pastram*, *pastromá*, *pastırma*, *pastramás* and *basturma*, which all convey the meaning of "pressed." Also, an etymologist, identified a more extended version of the term, *pastramagiu*, in the Romanian language, which described meat that is salty, smoky, and reddish in color. Although it is basically a pressing process, it is understood that different cultures create different delicatessen products (Özkan, 2013; Cardoso et al., 2020; Merwin, 2015).

Traditional products mirroring the culture of a region are shaped according to the geographical and climatic circumstances of the area. Nowadays, pastırma manufacturing, mainly industrial production, is widely centralized in the province of Kayseri, located in the middle of the Anatolia

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region. Although it is not well known, Kastamonu, in the Black Sea region to the north of Turkey, is a unique and important place for consumers of traditional pastırma (Figure 2). The essential factor characterizing Kastamonu pastırma from other pastırma is that it is produced in small enterprises under natural conditions using traditional methods based on the experience and talents of the master chefs. Generally, conventional production occurs under natural conditions, depending on annual climate and weather conditions, in late September, October, and November. Also, these months are called pastırma summer by the local community in Anatolia (Kaban, 2013). The common eating practices of pastırma and the related sociocultural and historical aspects are still being investigated.

3. Definition and Classification

Dry-cured, pressed, washed, dried, coated with cemen paste, and re-dried beef or buffalo whole muscles are classified as a ready-to-eat (RTE) product without heat treatment, known as pastırma (Anar, 2017). The different parts of the carcass produce different grades of pastırma, and nearly 20 different types of pastırma may be made from a mature cattle or buffalo carcass. Pastırma can be divided into three grades according to quality (Figure 3). Grade 1 pastırma types have a highly marbled, low-fat, soft texture and pinky-red color. Again, grade 2 pastırma types have medium marbled, medium-fat, moderate texture, and red color. On the other hand, grade 3 pastırma types have a non-marbled, rich-fat, hard texture and a dark red color (Turkish Standards, 2002).

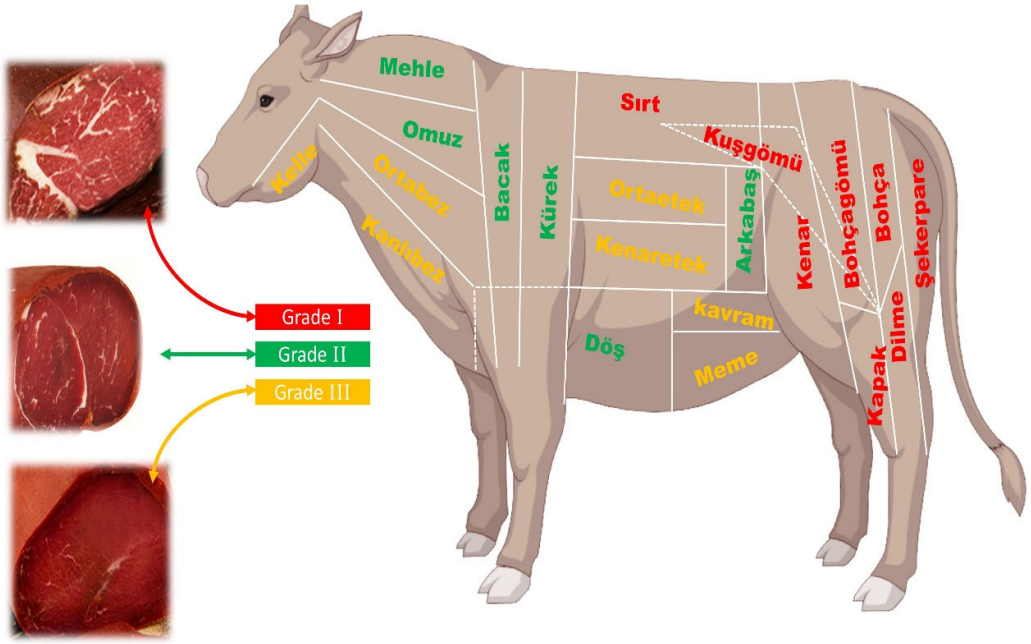

Figure 3. Infographic diagram of pastırma types and quality classification.

4. Manufacture of Pastırma

4.1. Animal Selection

Although horse, chicken and fish pastırma have been experimentally made, consumers are unfamiliar with it (Ren et al., 2015; Kök & Arslan, 2003; Anar, 2017). The animal chosen to produce pastırma is usually a cow, bull, or male buffalo between 3-6 years of age. The young animals' meat cannot be preferred because of its high juiciness. If the meat is too juicy, it causes problems with the drying and salting processes. In addition, heifers, oxen, and female buffaloes are not well preferred because of their meat quality (Anar, 2017).

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4.2. Definition and Preparation of Cemen Paste (Fenugreek Paste)

Cemen, the edible covering used for paste seasoning and cementing, is a tremendous source of nutrients, antioxidants, and flavors that are very important to the pastırma industry (Ahhmed et al., 2017). Fenugreek seeds are the main ingredient in cemen paste. Crude fenugreek seeds are brownish-yellow in color and rectangular-shaped, hard, pleasantly bitter, and have a maple flavour (Visuvanathan et al., 2022). Seeds are composed of carbohydrates, accounting for approximately 45 to 60% of their composition. These carbohydrates include mucilaginous fiber, specifically galactomannans. These galactomannans play an important role in making fenugreek paste an excellent coating material. The seeds also contain proteins, making up around 20 to 30% of their composition, which are notably high in tryptophan and lysine. Various flavonoids such as apigenin, orientin, luteolin, quercetin, vitexin, and isovitexin are present, as well as free amino acids including 4-hydroxyisoleucine (0.09%), arginine, lysine, and histidine (Singh & Garg, 2006; Visuvanathan et al., 2022; Wani & Kumar, 2018). In addition to consumption as food, *T. foenum-graecum* has a wide range of pharmacological uses and therapeutic effects. *T.foenum-graecum*, was used as a medicine in ancient Egypt. The Ebers papyrus, one of the earliest therapeutic manuscripts, contains reports on the advantages and medicinal applications that have been discovered (Visuvanathan et al., 2022). The effects of *T.foenum-graecum* on dealing with many health issues have been demonstrated by a multitude of in vitro, in vivo, and clinical research. *T.foenum-graecum* has been shown to have anti-hyperglycemic, hypocholesterolemic, immunomodulator, anticancer, anti-obesity, phytoestrogenic, neuroprotective, antimicrobial, and antioxidant effects (Achari & Jain, 2017; Akbari et al., 2019; Almalki & Naguib, 2022; Geberemeskel et al., 2019; Abdelwahab et al., 2021; Sevrin et al., 2019; Shesharao et al., 2020; N. Singh et al., 2022).

Fenugreek (*Trigonella foenum-graecum* L.) seed flour, garlic (*Allium sativum* L.), milled red capia pepper (*Capsicum annuum* L.) are used to produce a semi-solid paste that consists of some natural flavors known as cemen or fenugreek paste. Cemen is an ethnic food product in and of itself. And, it is used not only in the production of pastırma. It can also be consumed on toast for breakfast or as a fresh snack (Aksu et al., 2020b). There is no standard for the composition of cemen paste. Manufacturers use various formulations of paste provided with the main ingredients. The typical composition of cemen paste used for pastırma production is 22.5% fenugreek seed flour, 15% garlic, 3.75% paprika, 3.75% red pepper powder, and 55% water (Aksu et al., 2020b; Anar, 2017; Hastaoglu & Vural, 2018).

Applying a layer of cemen paste over the pastırma results in a distinctive appearance, color, flavor, and aroma. Also, it prevents oxidation, microbial contamination, and supports the prevention of over-drying of the pastırma. Despite their benefits, many customers enjoy the unique and strong odor of cemen paste, as well as those who don't. In pastirma, the activity of organosulphur compounds, mainly solotone in fenugreek and allicin in garlic, causes an unpleasant odor in human sweat, breath, and urine (Ahhmed et al., 2017; Mebazaa et al., 2009). Notwithstanding this unpleasant odor, pastırma continues to be enjoyed with great satisfaction, particularly among those residing in the Anatolian region. For customers bothered by the odor, cemen paste scraped pastırma has also been sold in recent years.

4.3. Production Steps

Pastırma masters have their own terminology. The terminology used for production pastırma has been passed down from masters to apprentices from past to present. Even customers or suppliers may never have heard of the terms used in production. Production can use a different range of temperature and time combinations. Below is an example.

Selecting and slaughtering the animals used for processing is the first step in the production of pastırma. After rigor mortis and carcass aging occur, meat is unboned and cut off as muscle blocks. This process is called "*söküm*," which means dissection (Anar, 2017). Chuck and neck (*Mehle, omuz, ortabez, kanlıbez*), shank (*bacak, kürek*), rib, short plate, short loin, sirloin and flank (*sırt, kuşgömü, ortaetek, kenaretek, arkabaş, döş, kavram*), round and part of sirloin (*şekerpare, dilme, bohça, bohçagömü, kapak, kenar*) prepared to make different kinds of pastırma (Figure 3). After that, excess parts are

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trimmed, like lymph nodes, fascia, tendons, and ligaments. Furthermore, muscles are given a rectangular shape. This process is called "*açım*," which means trimming. Then, a rope is tied to one end of the meat blocks and prepared for salting. For this purpose, a process called "*şaklama*", which means gashing, is performed (Anar, 2017; Arslan, 2013). Sometimes, punctures are created in meat using the sharp point of a knife, while at other times, slices are formed. The meat is sliced into sections from its vast surface, often ranging from 5 to 8 sections. These sections are cut at an angle of 45 degrees, ensuring that they do not exceed half of the overall thickness of the meat itself (Arslan, 2013). Each section is called "*şak*." After *şaklama*, the first salting process is performed at 6±1°C for 20–24 hours. Generally, rock salt with sodium nitrite ($NaNO_2$) or rock salt with potassium nitrate (KNO_3) are used. Rock salt with a size of 2.0–2.8 mm is used for dry salting. The large particle size of rock salt leads to salt burns in meat. On the contrary, tiny salt particles can cause oxidation, darkening, and overly salty products. Relatively cold environments that do not receive sunlight are preferred in the salting process. Dry-salted meat blocks are stacked to a height of 20–25 cm. After the first salting, the second salting process is performed at 6±1°C for 6–12 hours. At this stage, parts of the meat that have yet to be treated are salted and turned over. Meat stacked on top of each other is turned upside down. The recommended quantity of salt to be used in the first and second salting processes should be between 5 and 10% of the total meat weight. When the salt concentration exceeds 10%, it leads to yield loss in the final product. Then, salted meat is washed and rinsed to remove excess salt. This washing and rinsing process takes 1–3 minutes. The washed meat is taken to the first drying process called "*sergileme*," which means exhibition. Meats are hung on special hangers, so avoid touching something. This drying process can be performed in natural conditions or in air-conditioned rooms. The conventional method of natural drying takes place in late September, October, and November for 3-5 days on windy and sunny days when the weather is not too hot or 12–15 days in cloudy and mildly cold weather. On the other hand, the commercial drying method is carried out in climate rooms with 80–85% relative humidity at 15±1°C and 15–30 m/min airflow for 5 days. After that, the first pressure, called the "*soğuk denkleme*," which means cold pressure, is performed. At this stage, 0.9–1 kg/cm^2 pressure is applied to the dried meats at 7-8°C for 10–17 hours (Arslan, 2013). Meats that lose a little water at this time and show a flat form. Also, the sections called "*şak*" are closed. The next step is second drying. The surfaces of the pressed meats are moist. Therefore, a drying process is applied to the meats for 3 to 5 days, depending on the temperature and relative humidity. At the end of this process, the moisture in the meat can be below 34%. In addition, the fat on the surface of the meat melts and gives it a white appearance. This is referred to as "*ağarma*," which means bleaching, among manufacturers. After that, the second pressure, called "*sıcak denkleme*," which means hot pressure, is performed. Hot pressure is applied to 0.9–1 kg/cm^2 at 20–25 °C for 1–7 hours (Arslan, 2013). Finally, the meat coming out of the hot pressure process is covered with cemen paste and hung for 4 to 7 days to dry. Actually, the meats are kept in the cemen paste for 16–36 hours, and then the meats are covered with cemen paste with a maximum thickness of 4 mm and left to dry for 7–11 days (Aksu et al., 2022a; Aksu et al., 2023; Anar, 2017; Arslan, 2013; Kaya et al., 2022). It's crucial to remember that the cemen paste dough does not contain salt, and salt adsorbs from the meat into the cemen paste during the cemen paste process. Flow-sheet example for manufacture of pastırma is demonstrated in Figure 4.

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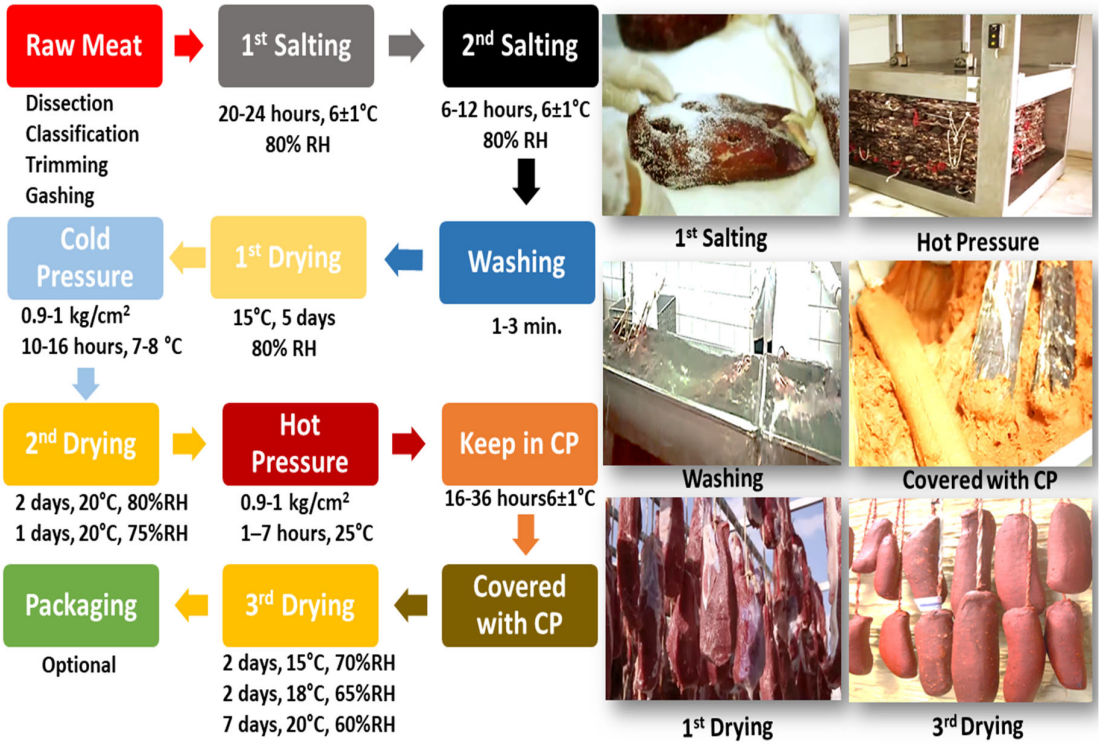

Figure 4. Flow-sheet example for manufacture of pastırma. (CP: cemen paste, RH: Relative humidity).

5. Composition and Yield of Pastırma

In general, meat is a rich source of macronutrients as well as micronutrients and provides essential amino acids, essential fatty acids, minerals, and vitamins essential for human growth. The quality of the final product is directly proportional to the quality of the raw meat. The meat used in the production of pastırma is sourced from carcasses that are in excellent condition, follow beef-cut standards, and are well maturated. Raw meat loses weight as a result of the pressing and drying processes used in accordance with pastırma technology. Raw meat used in producing pastırma generally loses 30–35% weight until it reaches the covered with cemen paste stage. After the cemen application and third drying, the wastage is between 20 and 35% (Anar, 2017). Akçay et al., (2015) indicated that, as the weight of the piece of meat used in producing pastırma increases, the total income also increases depending on the sales price, despite the rise in production costs such as the ripening time and yield decrease of the pastırma.

The reported chemical composition of pastırma differs considerably (Table 1). Anar (2017) stated that a 100-gram serving of pastırma contains 5–7 grams of fat, 2–3 grams of carbohydrates, and approximately 20–35 grams of protein. However, these rates vary depending on the specific manufacturing procedure used as well as the type of meat from which pastırma is made.

Table 1. The mean basic compositions of experimental pastırma as reported by different studies and commercially labeled pastırma (manufacturer's declaration).

Product	Grade	Parameters (g/100g)					
		Water	Fat	Saturated Fat	Carbohydrate	Protein	Salt
Commercial pastırma (Different labelled)	1 (*SIRT*)	NA	16.00	3.9	3.00	28.00	4.0
	NA*	NA	7.00	2.0	3.00	30.00	7.0
	NA	NA	8.00	4.0	5.00	31.00	5.0

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Pastırma produced by state-run company	NA	NA	3.30	0.9	1.00	34.50	6.0
Commercial Cemen scraped pastırma	NA	NA	7.00	4.0	2.00	30.00	5.0
	1 (*SIRT*)	NA	5.00	2.0	3.00	35.00	NA
(Biringen Löker et al., 2013)	NA	45.50	9.50	NA	9.02	28.60	NA
(Göğüş et al., 2016)	NA	40.00	3.4	NA	NA	42.9	8.50
(Gençcelep et al., 2022)	1 (*SIRT*)	44.44	15.12	NA	NA	34.91	4.85
	1 (*KUŞGÖMÜ*)	50.14	6.09	NA	NA	37.69	6.12
(Çakıcı et al., 2015)	1 (*SIRT*)	47.56	8.80	NA	NA	NA	6.32
	1 (*KUŞGÖMÜ*)	41.91	8.69	NA	NA	NA	8.07
	1 (*ŞEKERPARE*)	48.23	5.05	NA	NA	NA	7.92
	1 (*BOHÇA*)	45.11	6.42	NA	NA	NA	8.49
(Abdallah et al., 2017)	1 (*ŞEKERPARE*)	59.08	4.25	NA	NA	26.46	NA
(Ren et al., 2015)	1 (*KUŞGÖMÜ*)	42.60	3.50	NA	1.20	47.40	NA

*: Not available.

6. Chemical and Physico Chemical Properties of Pastırma

Pastırma is an ethnic dry-cured meat product, and upper limits except cemen for moisture, salt (in dry matter), and pH were specified at 50%, 10%, and 6.0 respectively, in Turkish Food Codex regulation. Also, the amount of cemen in the final product is allowed to reach a maximum of 10% of the total mass (Turkish Food Codex, 2019). The moisture content of pastırma has an important part in determining its qualitative characteristics The initial moisture content of the raw material, about 75%, undergoes a reduction of up to 50% via the processes of curing, first and second drying, and pressure processing, then increases again during the keeping and covering cemen paste process.

It is well recognized that salt has a crucial role in the composition of pastırma, effecting the degree of customer acceptance. The suggested amount of salt for the curing process of pastırma manufacture is 50–60 g of salt per kilogram of meat (Kaya et al., 2022). In production of pastırma, salt, nitrite, or nitrates are used together for curing stage. Firstly, salt gives meat a salty taste and brings out its own flavor by changing many biological reactions during the curing process, such as proteolysis, lipolysis, and lipid oxidation. The second thing that salt can do is to prevent the growth of pathogenic bacteria by reducing water activity (Aw) and suppressing the formation of biogenic amines. This can help ensure safety and enhance the stability of the product's shelf-life (Jia et al., 2024).

Nitrates and nitrites enhance the color quality of pastırma and provide additional benefits, including antioxidant and antibacterial properties. The visual aspect of pastırma, as influenced by the outer surface or sliced surface color, plays a significant role in shaping customers' preferences for this product. The color of pastırma is influenced not only by the quantity of salt and nitrite or nitrates included but also by the quality of the raw meat used, the muscle block type used, and the composition and thickness of the cemen paste utilized. (Aksu et al., 2020b; Aksu et al., 2022b).

A study has found that nitrate level had significant effects on pH and Thiobarbituric acid reactive substances (TBARS) level in final products (Akköse et al., 2017). On the other hand, another study shows that nitrite level had effect on composition and amount of Free amino acids in final product (Erdemir & Aksu, 2017). The pH of pastırma is an important quality criterion that is influenced by several factors, including the post-rigor degree of the meat used, the amount of salt, the degree of drying, the pH level at cemen paste, the usage of starter culture, and the degrees of fermentation (Çakıcı et al., 2015).

During the production of raw-consumed products and dry-cured meat products such as pastırma, the increase in the amount of lipid oxidation is a critical quality concern. The TBARS value is a lipid oxidation index that quantifies the amount of malondialdehyde (MDA). Hydroperoxides, the first products of polyunsaturated fatty acids interacting with oxygen, form MDA. As mentioned

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in the manufacturing steps, during the second drying stage of pastırma production, the fat drops form on the outer surface of the meat leach in the product with the effect of hot pressure, and the pastırma gains a sufficient flavor. Then, the oxidation of lipids is slowed down by taking advantage of the antioxidant properties of cemen paste (Aksu et al., 2020a, 2022b). Additionally, cemen paste cuts the meat block's contact with oxygen and acts as a barrier to prevent fat oxidation. Researchers have generally tried to prevent lipid oxidation in pastırma by making modifications to coating material or cemen paste (Abdallah et al., 2018; Abdallah et al., 2017; Aksu et al., 2023; Aksu et al., 2020a, 2020b, 2022b). In addition, Aksu & Erdemir (2022) reported that potassium lactate (PL, Potassium-L-2-hydroxy-propionate, Potassium-L-Lactate) usage in curing mixtures decreased lipid oxidation in pastırma. While the majority of salt balance occurs between the cemen paste and salted meat during the keep and covered cemen paste stage, additional chemical substances, including some amino acids and bioactive compounds, also permeate into the meat (Aksu et al., 2022a; Erdemir & Aksu, 2017). It can be said that there is definitely a negative correlation between the total antioxidant activity of the cemen paste and the lipid oxidation of pastırma during the storage period.

As is well known, lipolysis and proteolysis take place during the manufacturing process and shelf life of pastırma. There are many factors that affect proteolysis and lypolysis, such as raw meat quality and composition, proteolytic and lypolitic microorganisms' quantity and activity, production steps, curing agents, etc. Most of these reactions are known to be due to endo- or exo-peptidases and lipases (Erdemir & Aksu, 2017; Oz et al., 2021; Oz & Kaya, 2019; Soyer et al., 2011; Toldra, 1998). Deniz et al. (2016), indicated that pastırma represents a good source of natural bioactive peptides capable of reducing free radicals and inhibiting ACE activity. Also, cemen paste contributed to the high bioactivity of Pastırma.

7. Microbiological Properties of Pastırma

7.1. Natural Flora of Pastırma

The natural flora of pastırma consists of lactic acid bacteria (LAB), catalase-positive cocci, and halotolerant yeasts or molds. Researchers have shown that lactic acid bacteria dominate pastırma in some samples, whereas catalase-positive cocci take dominance flora in other samples (Çakıcı et al., 2015; Dişhan et al., 2021; Öz et al., 2017; Ozturk, 2015). Due to the use of traditional techniques in pastırma manufacturing, the microflora of pastırma may be different across manufacturers. In fabricated production, starter cultures (*Latilactobacillus sakei*+ *Staphylococcus xylosus, Lactobacillus pentosus* + *Staphylococcus carnosus* etc.) are may be used (Dişhan et al., 2021). Dincer & Kivanc, (2012) detected *Lactiplantibacillus plantarum* as the dominant species in pastırma samples and identified the dominant flora in the pastırma produced experimentally under controlled conditions as *Pediococcus pentosaceus*. Researchers also noted that *P. acidilactici*, *Latilactobacillus sakei*, and *Lactiplantibacillus plantarum* came after that microorganism (Çinar et al., 2019). Öz et al., (2017) identified lactic acid bacteria isolated from pastırma through 16S rDNA sequence analysis and found that main population of them consisted of *Latilactobacillus sakei*, *Weisella cibaria*, and *Weisella confusa*, respectively. It has been observed that LAB strains isolated from pastırma can be homofermentative, such as *Latilactobacillus sakei*, *Pediococcus pentosaceus*, or heterofermentative, such as *Weisella cibaria*. The primary function of lactic acid bacteria in pastırma is not to undergo lactic acid fermentation but to contribute to forming sensory characteristics. The pH of pastırma confirms this phenomenon. Briefly, the optimal pH level for pastırma is below 6.0. However, it often stands at 5.5 and does not decrease further below that point (Kaya et al., 2022).

It is known that, fermented meat products are suitable carriers for probiotics and can potentially induce health benefits (Munekata et al., 2022). Topçu et al., (2020) found that six strains (*P. pentosaceus* K7, K41, K44, K51, K81, and *P. acidilactici* K99) chosen from LAB strains taken from pastırma had probiotic properties.

In a study where they isolated and identified coagulase-negative staphylococci in pastırma samples, Fettahoğlu et al., (2019) genetically identified *Staphylococcus vitulinus*, *S. saprophyticus*, *S. equorum*, and *S. xylosus* in pastırma samples. Moreover, researchers stated that the dominant species

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in the samples was *S. vitulius*. On the other hand, Kaban, (2010) reported that *S. saprophyticus* and *S. xylosus* were the predominant species in pastırma.

Coagulase-negative staphylococci (CNS) are technologically important microorganisms for pastırma. Briefly, CNS are involved in the occurrence and stability of coloring through nitrate reductase activity, which causes the nitrosomyoglobin (NO-Mb) formation in pastırma. Nitrite, formed by reducing nitrate, can also limit lipid oxidation. Also, Nitrite in pastırma turns into nitric oxide and prevents the growth of pathogens such as *Clostridium botulinum*, *Listeria monocytogenes*, etc., providing microbial safety (Dişhan et al., 2021; Fettahoğlu et al., 2019, 2023; Huang et al., 2020; Sánchez Mainar et al., 2017). Moreover, CNS are essential in controlling lipid oxidation by breaking down hydrogen peroxide with catalase and superoxide dismutase activities. On the other hand, CNS plays a role in flavor development by forming low molecular weight compounds with their proteolytic and lipolytic activities (Fettahoğlu et al., 2019, 2023).

Due to the tolerance of yeasts to high-osmotic and low-pH conditions, they are capable of causing spoilage of cured meat products. At the same time, they may lead to economic losses throughout food manufacturing or storage stages (Güngören et al., 2023; Perrone et al., 2019). In different pastrma samples, Ozturk, (2015) 's study found a total of eight species from five different genera. These organisms include *Candida*, *Yarrowia*, *Trichosporon*, *Cryptococcus*, and *Debaryomyces*. According to the researcher's results, *Candida zeylanoides* (58% of all samples and, in all stages of pastirma processing) was the predominant yeast species, with *Candida deformans* (12%) and *Candida galli* (11%) following.

7.2. Pathogens in Pastırma

In pastırma production, dry-curing, drying, pressing, and coating the meat with a cemen paste significantly suppresses the development of foodborne pathogens. However, it has been indicated that pathogens such as *Listeria monocytogenes*, *Staphylococcus aureus*, *Bacillus cereus*, *Salmonella* spp., *Escherichia coli* O157:H7, and other enterohemorrhagic *E. coli*, *Clostridium perfringens*, and *Clostridium botulinum* can be found in dry-cured meat products such as pastırma due to unsuitable production or conservation (Büyükünal et al., 2016; Gök et al., 2019; Gungor et al., 2021; Kaban, 2013; Yildirim et al., 2017). As it is known, the reduction of pathogens cannot be wholly guaranteed if no thermal processing is applied. Therefore, in the production of pastırma, pH, water activity, or changes associated with other inhibiting factors such as salt concentration and the presence of nitrite are extremely important. Nitrite has an essential role in the inhibition of several pathogens, especially in *Clostridium botulinum* (Flores et al., 2021; Fraqueza et al., 2021; Majou & Christieans, 2018).

Parasites can also be present in pastırma. The presence of parasites in raw meat used in making pastırma, such as *Sarcocystis hominis*, *Sarcocystis heydorni*, *Cysticercus bovis*, *Toxoplasma gondii*, and *Echinococcus granulosus* should be considered a biological hazards (Dişhan et al., 2021; Majou & Christieans, 2018; Rosenthal, 2021; Yildirim et al., 2017). As is known, *Cysticercus bovis, which* occurs in the muscles of cattle, is the larval form of the cestode parasite *Taenia saginata*, which causes tapeworm infection in humans. If a small amount of *Cysticercus bovis* is detected on the carcass as a result of an inspection performed by the veterinarian in the slaughterhouse, the vet may decide to use these meats in making pastırma to prevent economic loss. It is reported that cysticerci lose their pathogenicity 14 days after making pastırma (Arslan, 2013; Gürbüz, 2009).

8. Food Fraud and Customer Concerns on Pastırma

One of the products that food fraudsters frequently abuse to endanger public health is pastırma. Examples of fraud in pastırma include the use of meat from unlicensed butchering and without veterinary inspection, adding malicious contamination chemicals to extend shelf life, dealing grade 3 or 2 pastırma under the name of grade 1, and labeling pastırma made from different animals as cattle pastırma (Anar, 2017; Arslan, 2013). Pastırma can be stored for nine months without refrigeration, depending on oxidation parameters (Öz et al., 2017). The stability and safety of pastırma are mainly due to low water activity. In addition, paste containing garlic has a protective effect on mold growth and excess drying of the final product. Again, the marketing of improperly stored and

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spoiled products is also a concern for consumers. Because cemen is an effective masker to disguise deterioration, reapplying cemen on spoiled pastırma may effectively mask unpleasant smells and evidence of deterioration. It is the industry's responsibility to introduce safe products into the market. This purpose is reached by correctly applying the Hazard Analysis and Critical Control Point (HACCP) procedure. El-Mougy et al., (2023) has introduced the HACCP procedure for pastırma produced in Egypt and determined four Critical control points (First pressing, second pressing, applying cemen paste and final drying). The research team observed that all parts of the HACCP procedure used in producing pastırma, including the pre-requisite programs (Good Manufacturing Practices, GMPs), were key to the HACCP plan succeeding. Codex Alimentarius states that a food hygiene system should be reviewed periodically, and legislation should be prescriptive and practicable. (Codex Alimentarus, 2020).

9. Conclusions and Future Aspects

Research focuses on increasing the health benefits, efficiency and quality properties of pastırma. Nevertheless, there are still unresolved questions. Firstly, the histological and histochemical impacts of pressing and cemen coating meat blocks are not well understood. Although several researchers have examined changes in myofibril proteins (Aksu et al., 2002; Aktaş et al., 2005), questions remain. The histological and histochemical effects of pressing and cemen coating on muscle fibers may guide the selection of meat to be used for making pastırma. Secondly, investigate the kinetics of drying and osmotic processing. The osmotic process, such as salt absorption and adsorption during production, is affected by several factors related to the product structure, shape, temperature, process duration, etc. Also, is affect several feature on final product. In recent years, strategies to reduce sodium in dry-cured meat products have been developed. The effects of novel salt reduction technologies and methods such as ultrasonic-assisted curing technology, basic electrolyzed water, sodium chloride with an altered physical structure, etc. on the quality and taste of pastırma are unknown. The third point pertains to the necessity of using a starter culture, the type of starter, and the ratio of microorganisms. As mentioned, lactic acid bacteria and some yeast contribute to forming sensory properties on pastırma, but their action is limited because of cemen paste and final product low water activity. It may be useful to develop new starter combinations based on microorganisms isolated from traditional pastırma which have been identified, their salt tolerance, and symbiosis with CNS established. Finally, no alternative has been provided for the unpleasant odor in people's sweat and urine coming from fenugreek paste. Preventing unpleasant odor without affecting the characteristic and sensory properties of the product could be a good research topic.

Examining the literature reveals that the terms pastrami and pastırma sometimes refer to the same product, while at other times they describe different ones. The words pastırma and pastrami is cause conceptual confusion in some publication. This may perhaps be a straightforward case of a translation mistake into English. More care needs to be taken when describing products.

This review may help pastırma producers improve the quality of pastırma and may encourage further research to evaluate the overall characteristics of the pastırma at all stages of production and storage.

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