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Some Chemical and Microbiological Properties of Homemade Capia Pepper Paste and Puree Samples

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Ev Yapımı Kapya Biber Salça ve Pürelerinin Bazı Kimyasal ve Mikrobiyolojik Özellikleri

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Abstract
Capia pepper (*Capsicum annuum L.* cv. Capia) is economically most well-known and critical essential species, widespread worldwide. People typically consume fresh, pickled pastes and purees in sauces, soups, canned foods, or powdered or flaked pepper. The food industry also uses it as an additive. In the Turkish Food Codex Communiqué on Paste and Similar Products, pepper paste and puree are defined according to the amount of water-soluble dry matter (brix). Their brix values ranged from 8.75% to 31.24%. The total acidity of paste and puree samples did not exceed 10% by mass (m/m), and the salt content of our samples varied between 0.93% and 3.34%. Therefore, these values were found to comply with the Turkish Food Codex Communiqué on Paste and Similar Products. Capia pepper paste and puree samples had pH values ranging from 3.60 to 4.96. The ash content of the 53.33% samples did not exceed the maximum 0.3% (m/m). Raw ingredients, process methods, microorganisms involved in the fermentation, and duration of the fermentation significantly influence the organoleptic properties of capia pepper paste and puree, including its aroma, taste, and texture. The mold and yeast count of the capia pepper paste and puree samples varied by approximately 1 log CFU/g and 6.99 log CFU/g. The aim of this study is to investigate the chemical and microbiological properties of capia pepper pastes and purees produced using traditional open pan techniques and to evaluate them according to the Turkish Food Codex Communiqué on Tomato Paste and Similar Products.

Keywords *Red pepper; Paste; Capia; Open-Pan Techniques*

Öz
Dünya çapında yaygın bir tür olan Kapya biberinin (*Capsicum annuum L. cv.* Capia) ekonomik değeri Türkiyede her yıl artmaktadır. Kapya biberi soslarda, çorbalarda, konserve gıdalarda, salça ve pürelerde toz veya pul biber formunda, salamura veya taze olarak kullanılmaktadır. Gıda endüstrisinde katkı maddesi olarak da kullanmaktadır. Türk Gıda Kodeksi Salça ve Benzeri Ürünler Tebliği'nde biber salçası ve püresi suda çözünebilir kuru madde (briks) miktarına göre tanımlanmıştır. Çalışmadaki örneklerin briks değerleri %8.75 ile %31.24 arasında değişmektedir. Salça ve püre örneklerinin toplam asitliği kütlece %10'u (m/m) geçmediği belirlenmiş olup, tuz içerikleri ise %0.93 ile %3.34 arasında değiştiği tepit edilmiştir. Dolayısıyla bu değerlerin Türk Gıda Kodeksi Salça ve Benzeri Ürünler Tebliği'ne uygun olduğu görülmüştür. Kapya biber salçası ve püresi örneklerinin pH değerleri 3.60 ile 4.96 arasında değişmektedir. Örneklerin %53.33'nün kül içeriği maksimum %0.3'ü (m/m) aşmamıştır. Ham maddeler, işleme yöntemleri, fermentasyona katılan mikroorganizmalar ve fermentasyon süresi kapya biber salçası ve püresinin aroma, tat ve doku gibi organoleptik özelliklerini önemli ölçüde etkilemektedir. Kapya biber salçaları ve pürelerinin küf ve maya sayısı yaklaşık 1 log CFU/g ve 6.99 log CFU/g arasında değişmiştir. Bu çalışmanın amacı, geleneksel açık tava teknikleri kullanılarak üretilen kapya biber salça ve pürelerinin kimyasal ve mikrobiyolojik özellikleri araştırmak ve Türk Gıda Kodeksi Salça ve Benzeri Ürünler Tebliği'ne göre değerlendirmektir.

Anahtar Kelimeler *Kırmızı Biber, Salça; Kapya; Açık Tava Tekniği*

1. Introduction

Capia pepper (*Capsicum annuum L.* cv. Capia) is a nutritional variety in the red sweet pepper group. Sweet pepper (*Capsicum annum L.*) belongs to the *Solanaceae* family, a widely cultivated and essential group of vegetables. Sweet pepper is the second most commonly cultivated important vegetable after tomatoes. Sweet peppers are harvested at the green ripeness stage or different coloring stages (yellow and red) (Kaur and Kaur 2021). It also contains aroma compounds such as alcohol, aldehyde, and ester. The Food and Agriculture Organization (FAO) reported that global fresh vegetable production has reached 1.1 billion tons. Turkey ranks fourth in the world with 38.1 million tons of vegetable production. Pepper production is increasing worldwide. Turkey, with 3.091.295 tons, is the second-largest producer after China. The Turkish Statistical Institute reports that capia pepper constitutes 46.8% of the total pepper production, amounting to 1.445.275 tons (Polat et al. 2024). Sweet peppers are essential to the food industry

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due to their widespread use as flavoring and coloring agents in sauces, soups, beverages, snacks, desserts, processed meats, and separated drinks (Kaur and Kaur 2021).

People typically consume fresh pickles, pastes, purees, sauces, soups, canned foods, powder, or flaked pepper, and the food industry uses it as a food additive (Askin Uzel 2018, Demirkaya and Gunes 2020, Kasım and Kasım 2018, Yilmaz 2020). Moreover, the ripe fruits of red pepper serve as a spice, a source of red pigment, and a vegetable in numerous countries (Demirkaya and Gunes 2020, Gogus et al. 2015). Capia peppers are very low in sodium, cholesterol, and saturated fat. They are also high in compounds like vitamins A and C, antioxidants, phenolics and flavonoids, carotenoids, tocopherols (vitamin E), folate, and capsaicinoids (González-Zamora et al. 2013, Kasım and Kasım 2018, Polat et al. 2024). Therefore, it is essential in human nutrition, particularly in developing countries (Bozkurt and Erkmen 2004, Demirkaya and Gunes 2020).

In 2023, capia pepper production in Turkey reached 1.6 million tons. The Mediterranean region is the most productive, producing 510 thousand tons of capia pepper. Çanakkale is the leader in Turkey, with a production of 344 thousand tons, meeting 21% of the total output in the country. Regions such as the Mediterranean, Western Marmara, Aegean, Southeastern Anatolia, and Western Black Sea are also essential production centers (Int. Ref-1, Int. Ref-2).

In general, the products in the Aegean and Mediterranean regions are table peppers, and those in the Marmara region are peppers produced for processing products such as pastes, purees, and pickles (Sermenli and Mavi 2010). Furthermore, Turkey's capia pepper exports have surged to 50 thousand tons in 2023, resulting in a revenue of 73 million dollars. Turkey plays a vital role in exporting capia pepper to many countries. European Union countries stand out among its main export markets. Germany, the Netherlands, Italy, France, and Belgium are the main export destinations for Turkey's capia pepper. Middle Eastern countries also receive its exports. These countries demand capia pepper for paste, spices, and pickles (Int. Ref-1, Int. Ref-2).

Pepper paste has been traditionally manufactured at home for many years in Turkey. In a survey conducted by Tapki and Sacmalıoğlu (2023), 81.9% of respondents reported that they produce pepper paste at home. Pepper paste is traditionally produced at home with different methods such as sun drying, open pan boiling, semi-drying and fermentation, although it varies by region of Turkey (Ayda et al. 2023). In this study, the traditional method of producing capia pepper paste and puree samples involves the following steps: The first step consists of collecting mature capia peppers from the field, washing them with water, and preparing them for production by separating the seeds and stems. The peppers are chopped finely, put in a large pot, enough water is added, and boiled over a wood fire. Once boiling achieves sufficient concentration, salt and oil is added 5 minutes before packing. The final step involves filling jars with concentrated capia pepper paste and puree, resting them, and covering them with a cloth. After they have rested, the packages are taken and stored in a suitable area. Production stages are given in Figure 1.

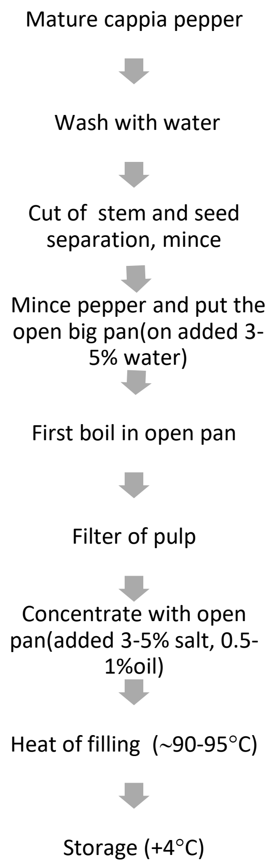

Figure 1. Production of traditional homemade capia pepper paste and puree with an open pan

The literature has limited information regarding the quality and stability of capia pepper paste, and puree produced using traditional methods. Specific aspects often not documented include dry matter content, salt levels, percentage of ash dissolved in 10% HCl, acidity, dry matter soluble in water, pH, invert sugar content, and counts of aerobic bacteria, molds, and yeasts. The "Turkish Food Codex Communiqué on Paste and Similar Products (Communiqué No: 2020/19)" specifies the physical-chemical and microbiological standards that must be followed in our country when producing pepper paste and puree on an industrial scale. This study assesses the chemical and microbial quality characteristics of capia pepper paste and puree samples made through traditional techniques.

2. Materials and Methods

This research collected homemade traditional capia pepper paste and puree samples from public markets in Çanakkale. Samples were stored in a refrigerator at +4 °C until analyses. The chemical and microbiological properties of these samples were determined.

2.1 Chemical analyses

About 50 grams were weighed. Each sample was then homogenized using a blender. The homogenized samples were used to measure pH, titratable acidity, dry matter, salt, and ash-soluble solution in 10% HCl and invert sugar and total soluble solids in water formation. Following filtration, titratable acidity (TA) was measured using 25 mL aliquots titrated at pH 8.1 (Hanna pH2211 ORP meter, Michigan, USA) with 0.1 N NaOH and three drops of 1% phenolphthalein. The results were expressed as grams of citric acid per 100 g of capia pepper paste and puree weight (Bozkurt and Erkmen 2005, Ilić et al. 2015). Total soluble solids (TSS) for each capia pepper paste and puree sample were calculated in two replicates using a refractometer at 20 °C. The results were expressed as a percentage of total soluble solids (Ilić et al. 2015). By measuring the pH of 10 g of the homogenized sample in distilled water, the ratio of the sample to water (w/v) was calculated.

Dry matter content was determined. A three-gram sample was dried at 105°C until it reached constant weight (Bozkurt and Erkmen 2005). Following the instructions, the amount of dry matter was determined by drying the homogenized sample at 105°C for approximately 3 h and then at 105°C for approximately h. The dried sample residue was then burned in a ceramic vessel at 525°C for 16 h. The soluble ash content in 10% HCl solution (Anonymous. 2000) was determined by weighing the residue. The copper-reduction method can identify the presence of added sucrose by specifying the amount of sugar before and after inversion. To invert at room temperature, a 50-mL clarified aliquot was transferred into a 100-mL volumetric flask, then added 10 mL of HCl (1:1), and left it at room temperature for 24 hours. The sample was heated with HCl at 70 °C for 1 hour to facilitate inversion. That saved time and shortened the whole process. Using phenolphthalein, neutralized the NaOH solution precisely to the concentration and diluted it to 100 mL. Titration against the mixed Felling A and B solution (25 mL of Felling's solution can be considered) revealed the total sugar as inverted sugar. The added sugar was calculated by subtracting the reduced sugar from the total (AOAC. 2000).

2.2 Microbiological analyses

For the enumeration of the microbial contamination levels of the selected capia pepper paste and puree samples, a representative sample of 10 g from each sample was aseptically taken, and the primary decimal dilution was prepared by adding an appropriate volume of peptone saline solution (PPS: 0.85% NaCl and 0.1% peptone in distilled water). Samples were homogenized for 60 min, at 22ºC with a stomacher (Bag Mixer 400SW Lab Blenders, USA). Subsequently, decimal dilution series were prepared with the primary dilution using PPS and made with the pour-plated technique in Plate Count Agar (PCA, Merck, Germany). PCA plates were formed as duplicates with incubation at 37°C for 3 days (Pothakos, 2012). Total yeast and mold counts were duplicated using the pour plate technique using potato dextrose agar (PDA, Merck, Germany). PDA petri dishes were incubated for up to 5 days at 25°C before counting (Brodsky 1982).

2.3. Statistical Analyses

The data was analyzed using the Sheskin (2003) method. The data were expressed as mean ± standard error (SE). The data were subjected to a non-parametric analysis of Kruskal Wallis and multiple comparison tests according to the statistical significance level on SPSS 25.0 statistical software.

3. Results and Discussions

3.1. Some chemical analyses of samples

3.1.1. pH values and titratable acidity

Since the traditional homemade capia pepper paste and puree samples were purchased from different public markets and people, the samples' pH values were between 3.60 and 4.96. The pH and titratable acidity values of traditional capia pepper paste and puree samples are given in Table 1. The capia pepper paste and puree samples showed no statistically significant differences in pH ($p > 0.05$). 20% of the samples in the study have a pH value between 4.1 and 5.0, as stated in the Turkish Food Codex Paste and Similar Products Communiqué. All capia pepper paste and puree samples regarding titratable acidity were statistically found to be insignificant ($p>0.05$). The percentage of citric acid determined the titratable acidity of capia pepper paste and puree. The titratable acidity of capia pepper paste and puree samples changed between 0.16% and 1.44%. The total acidity of the paste and puree samples did not exceed 10% (m/m) by mass. Thus, they were found to comply with the Turkish Food Codex Paste and Similar Products Communiqué.

Table 1. Values of pH and titratable acidity of capia pepper paste and puree samples (Average ± Std.Error).

Sample Nu.	pH	Acidity %
1	4.05 ± 0.02	0.83 ± 0.12
2	4.30 ± 0.02	0.32 ± 0.00
3	4.72 ± 0.02	0.26 ± 0.02
4	4.65 ± 0.00	0.29 ± 0.05
5	4.45 ± 0.02	1.16 ± 0.03
6	4.65 ± 0.00	0.70 ± 0.12
7	4.38 ± 0.02	1.07 ± 0.03
8	4.72 ± 0.02	0.30 ± 0.03
9	3.90 ± 0.00	0.62 ± 0.03
10	4.66 ± 003	0.19 ± 0.00
11	3.98 ± 0.00	1.44 ± 0.06
12	4.96 ± 0.00	0.16 ± 0.00
13	4.81 ± 0.01	0.25 ± 0.00
14	3.60 ± 0.01	0.91 ± 0.03
15	3.72 ± 0.01	0.49 ± 0.03

In work conducted by Guzel (2017), it was reported that the pH values of commercial pepper pastes were changed to be between 3.61 and 4.82%. Askin Uzel (2017) reported that the pH value of sweet red pepper changed between 4.35 and 4.44. Both the researcher's pH values were similar to those in our study. However, Erdogan (2013) conducted a study where the pH values ranged from 5.69 to 5.14. The pH values the researcher provided are higher than those in our study. This can occur because the researcher produced red pepper pastes and purees in a controlled environment. However, our homemade samples were made by housewives from the public market in an uncontrolled environment. Therefore, this study asserts that the pH values are lower than those of previous literature-based studies. Guloksuz Sahin (2021) determined that the pH value of tomato and capia pepper pastes were between 4.03 and 4.80. Askin Uzel (2017) reported that the temperature difference in the filling process did not alter the pH value in capia pepper paste and puree samples production. Still, the increase in the total sugar content of the final product caused higher titratable acidity, that is, a lower pH value. On the other hand, Bozkurt and Erkmen (2005) stated that the pH value of fresh hot pepper was around 5.20, and after the production of hot pepper pastes, pH values changed between 4.08 and 6.05. The production techniques significantly affect the pH values of pepper pastes. The pH values of the pepper pastes and purees produced using the traditional method may be lower than those using the vacuum technique. During the production of pepper pastes and purees using the traditional technique, lower pH values, fermentation, and acid production may occur at the beginning of the process (Bozkurt and Erkmen 2005).

In Erdogan's (Erdogan 2013) study, titratable acidities were found between 0.09% and 0.29%. For instance, Bozkurt and Erkmen (2005) found the acidity values of hot pepper pastes, produced with an open pan and without salt, were changed between 1.12% (in the storage process of 0. day) and 0.38% (in the storage process of 46. days). In research conducted by Askin Uzel (2017), it was reported that the total acidity of capia pepper pastes changed from 0.65% to 0.69%. Guloksuz Sahin (2021) determined that the titratable acidity value of tomato and capia pepper pastes were between 0.17% and 1.64%. It has been determined that there is a similarity between some acidity values obtained in our study and those found by these researchers. For instance, a work by Guzel (2017) reported that the total acidity values of commercial pepper pastes were changed to between 2.61% and 6.77%. Researchers determined that the processing technique significantly affected the acidity of pepper pastes and purees. They also specified that pepper pastes and purees produced with the traditional technique had higher acidity than those produced by the vacuum technique. Researchers have stated that fermentation occurs in the early days of the traditional production process, but this fermentation may not occur in the vacuum technique. They have noted that this may be due to the high temperature (at 70°C) applied in the vacuum technique, which inhibits some acid-producing microorganisms (Bozkurt and Erkmen 2005).

3.1.2. Basic chemical component

The chemical composition of the capia pepper paste and puree samples are given in Table 2. Among the capita pepper paste and puree samples, significant differences were observed statistically with regards to dry matter (%), salt (%), inverted sugar (%), soluble ash in 10% HCl solution (%), and soluble solids (Brix %) (p <0.05).

The highest dry matter value of capia pepper paste and puree samples was 36.08%, while the lowest dry matter was 11.34%. The samples' moisture content varied between 88.65% and 63.92%, and the ash content varied between 0.14% and 0.49%. The ash content of the 40% sample did not exceed the maximum 0.3% (m/m) value in the Turkish Food Codex Paste and Similar Products Communiqué. Moreover, the brix value of pepper puree must be at least 9% and at most 15%, and the brix of pepper paste, excluding added salt, must be at least 18% (Int. Ref- 3). Considering these definitions, some of the samples collected from public markets labeled paste are suitable for the definition of puree. The salt content should not exceed 5%. The salt content of our samples varied between 0.92% and 3.34%, and it was found to comply with the communiqué's criteria. The highest inverted sugar value of capia pepper paste and puree samples was 17.59%, while the lowest inverted sugar value was 1.51% in this study.

Table 2. Essential compounds of capia pepper paste and puree samples (% Average ± Std.Error)

S.Nu	Dry Matter	Salt	Inver Sugar	Ash	Brix
1	24.16 ± 0.10	1.81 ± 0.00	5.72 ± 0.25	0.34 ± 0.01	12.49 ± 1.24
2	17.54 ± 0.25	2.00 ± 0.01	4.76 ± 0.10	0.34 ± 0.00	10.13 ± 1.37
3	14.70 ± 0.31	1.41 ± 0.10	5.75 ± 0.00	0.25 ± 0.00	11.25 ± 0.00
4	18.36 ± 0.21	1.58 ± 0.01	8.48 ± 1.11	0.16 ± 0.00	15.00 ± 0.00
5	36.08 ± 0.01	2.29 ± 0.04	17.59 ± 0.00	0.49 ± 0.02	31.24 ± 0.00
6	22.16 ± 0.30	2.86 ± 0.11	5.52 ± 0.33	0.38 ± 0.06	17.50 ± 0.00
7	31.19 ±0.31	2.05 ± 0.03	16.25 ± 0.41	0.22 ± 0.02	27.50 ± 0.00
8	25.30 ± 0.13	2.62 ± 0.02	6.16 ± 0.29	0.36 ± 0.16	17.50 ± 0.00
9	16.45 ± 0.03	2.69 ± 0.02	12.29 ± 0.12	0.48 ± 0.00	13.75 ± 0.00
10	12.47 ± 0.08	0.92 ± 0.19	4.49 ± 1.16	0.25 ± 0.00	13.75 ± 0.00
11	25.50 ± 0.29	1.16 ± 0.04	11.52 ± 0.20	0.45 ± 0.00	21.24 ± 0.00
12	15.65 ± 0.15	2.11 ± 0.01	5.51 ± 0.04	0.36 ± 0.01	8.75 ± 0.00
13	15.41 ± 0.12	1.39 ± 0.01	6.66 ± 0.07	0.32 ± 0.00	8.75 ± 0.00
14	11.34 ± 0.38	1.00 ± 0.01	1.51 ± 0.00	0.14 ± 0.01	10.25 ± 0.00
15	15.81 ± 0.01	3.34 ± 0.00	1.70 ± 0.00	0.37 ± 0.00	30.00 ± 0.00

Erdogan (2013) reported that the values of dry matter and soluble solids of capia pepper paste and puree samples were between 9.69-34.58% and 7.63-34.00%, respectively. Guloksuz Sahin (2021) determined that the soluble dry matter contents of tomato and capia pepper pastes were between 10.50% and 29.00%. The Brix of capia pepper paste and puree samples ranged between 8.75% and 31.24%. Some of these values are similar to Sharoba's findings (2009), which stated that the difference was between 27.49% and 28.12%. Of the samples in the study, 26.67% met the definition of paste, and 46.67% met the definition of puree according to the amount of Brix in the Turkish Food Codex Paste and Similar Products Communiqué. Dimassi et al. (2019) reported that the total solids of capia pepper pastes were determined to be 15.87% (drying at 50°C) and 21.49% (drying at 70°C). Guloksuz Sahin (2021) determined that the total solids content of tomato and capia pepper pastes was between 12.10% and 29.72%. These results obtained by the researchers are similar to those obtained in our study. However, generally, our total solids and the values of other researchers were found to be lower than the values of studies conducted on commercial pepper paste. For instance, work performed by Guzel (2017) reported that commercial pepper paste' solids values were changed to between 20.05% and 37.45%.

Atwaa et al. (2020) reported that the moisture and ash values of capia pepper pastes were 90.04% (g/100g) and 0.86% (g/100g), respectively. Guloksuz Sahin (2021) determined that the ash of tomato and capia pepper pastes were between 1.13% and 7.53%, 0.00% and 0.64%, respectively. In work conducted by Güzel (2017), it was reported that the ash values of commercial pepper pastes were changed to be between 0.01% and 0.42%. For instance, a work performed by Guzel (2017) reported that the salt values of commercial pepper pastes were changed to be between 2.81% and 10.18%. The Turkish Food Codex Paste and Similar Products Communiqué states that inverted sugar in pepper paste and puree should be between 35% and 70%. However, the amount of inverted sugar in our samples varies greatly. Askin Uzel (2017) reported that inverted sugar values of red pepper pastes were found to change between 15.93% and 16.07% and in work conducted by Guzel (2017) reported that the invert sugar values of commercial pepper pastes were changed to be between 34.19% and 91.60%. During fermentation, yeasts and bacteria use glucose and fructose (components of inverted sugar) as energy sources. As inverted sugar breaks down, the amount of inverted sugar decreases at the end of the process. It is converted into by-products such as carbon dioxide and organic acids (e.g., lactic acid). Depending on the intensity of fermentation, sugar may be consumed entirely. The final product, paste and puree, should contain less sugar.

3.2. Microbiological properties

The microbiological properties of capia pepper paste and puree samples are given in Table 3. In the Regulation on Amendments to the Turkish Food Codex Microbiological Criteria Regulation (Int. Ref- 4), the amount of mold for purees under the title of fruits and vegetables and their processed products is 10^2-10^3 CFU/g. The mold amount exceeded this value in 40% of the capia pepper paste and puree samples. The total mesophilic bacteria count was 10^3 - 10^4 (3-4 log CFU/g) in the repealed Pepper Paste and Puree standard (TSE 7896). Interestingly, this value is not included in the current Turkish Food Codex Microbiological Criteria Regulation. The total mesophilic bacteria count provides a general overview of microbial contamination and is used across various food production processes to ensure safety and quality. Producers can ensure fermented products' safety, quality, and consistency by monitoring the total mesophilic bacteria count. The total mesophilic bacteria count of capia pepper paste and puree samples changed between <1 log

CFU/g and 6.26 log CFU/g. On the other hand, the total mold and yeast count of capia pepper paste and puree samples changed to <1 log CFU/g and 6.99 log CFU/g.

Table 3. Microbiological properties of pepper paste and puree samples

Sample Nu.	Total mesophilic bacteria log CFU/g	Total mold and yeast log CFU/g
1	3.77	3.65
2	1.85	<1
3	<1	<1
4	<1	<1
5	3.79	<1
6	3.62	3.89
7	5.34	<1
8	6.26	6.99
9	4.23	<1
10	<1	<1
11	<1	<1
12	5.23	6.71
13	5.23	5.32
14	5.81	6.21
15	2.65	<1

The results obtained in our study are supported by the findings of other researchers (Askin Uzey 2017, Kuleasan and Okur 2012). Kuleasan and Okur (2012) examined the microbial quality during the different stages of pepper paste production. After the washing process, the total mesophilic aerobic bacteria count in the peppers used as raw materials was found to be 6.22 log CFU/g. The final stage of pasteurization led to a decrease in this count to 2.78 log CFU/g. The application of boiling and similar heat treatments in the production process significantly reduced the growth and number of these bacteria (Ayda et al. 2023). In a study by Bozkurt and Erkmen (2004), the total bacterial count in traditionally produced unsalted pepper paste was measured at 8.60 log CFU/g. For instance, In a study, the mold-yeast count was found to be 6.60 log CFU/g in raw peppers and 2.77 log CFU/g in pepper paste after pasteurization (Kuleasan and Okur 2012). Guloksuz Sahin (2021) determined that the total mesophilic bacteria and mold-yeast value of tomato and capia pepper pastes were between <1 log CFU/mL and 5.30 log CFU/mL, <1 log CFU/mL and 4.47 log CFU/mL, respectively. The raw material used to make the pepper paste is susceptible to mold contamination, which raises the risk of aflatoxin production (Guloksuz Sahin, 2021). Mold growth and mycotoxin contamination can pose significant health risks. If high levels of mold are present in either the raw materials or the final product, the risk of aflatoxin increases.

Ayda et al. (2023) evaluated the microbiological characteristics of pepper pastes manufactured using various methods. Their research indicated that the semi-drying technique, prevalent in eastern Turkey, led to a significant microbial load due to the lack of boiling. On the other hand, pepper pastes produced through heat treatment and aseptic filling demonstrated a minimal microbial load. These study samples were heat-treated but not all of them were filled under aseptic conditions. For this reason, some samples had high microbial loads. Moreover, preparing homemade capia pepper paste relies on traditional fermentation techniques using simple equipment. Several elements influence microbial quality, including local microorganisms such as capia pepper microflora and surrounding environmental factors such as weather conditions. Furthermore, raw ingredients, process methods, microorganisms involved in the fermentation, and fermentation duration significantly influence capia pepper paste's organoleptic properties, including its aroma, taste, and texture (Ramalingam et al. 2022).

Considering the results of all the studies, applying heat treatment and hot filling in glass jars to produce homemade pepper paste is more reliable regarding microbial quality. However, traditional production methods often do not eliminate mycotoxins through heat treatment and time. Therefore, it is essential to select raw materials that are free from mold contamination for pepper paste production and to prevent potential contamination at subsequent stages.

4. Conclusion

Capia pepper is an essential product in domestic and international markets. It plays an important role in Turkey's agriculture, economy, and food industry. This study investigated the chemical and microbial qualities of capia pepper paste and puree samples produced by traditional production techniques. While there were statistically significant differences in the capia pepper paste and puree samples in terms of dry matter, salt, ash, inverted sugar, and soluble solids (Brix) contents, there were no differences in pH values and titratable acidity values. Upon evaluating the chemical properties of the study results, it was found that they failed to meet the criteria outlined in the Turkish Food Codex Communique on Pastes and Similar Products (Communiqué No. 2020/19). As a result, the public authority should take more responsibility for protecting consumer rights and producing healthy and reliable products by developing new standards to control traditional food production.

Declaration of Ethical Standards

The authors declare that they comply with all ethical standards. Preliminary versions of this research were presented as an abstract at

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Credit Authorship Contribution Statement

Author-1: Conceptualization, investigation, methodology, sampling and analyzing, validation, visualization, writing – original draft, and writing – review and editing.

Author-2: Conceptualization, investigation, methodology, sampling and analyzing, validation, visualization, writing – original draft, and writing – review and editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data Availability Statement

The authors declare that the primary data supporting the findings of this work are available within the article.

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