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DETERMINATION AND COMPARISON OF QUALITY CHANGES DURING STORAGE OF TURKISH PEPPER PASTE PRODUCED BY DIFFERENT METHODS

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ABSTRACT

The quality and microbiological criteria of pepper pastes produced by many different methods, especially domestic and fabrication, can often be overlooked in spite of regulating certain standards. Quality problems in domestic/traditional production are at a very high rate. Thus, it was aimed to determine and compare the criteria of pepper paste produced by various methods. For this purpose, physical, chemical and microbiological analyses were conducted and results were examined. Values of pH, dry matter, titration-acidity, and color changed significantly during storage. While their brightness decreased, pastes became redder and more yellow. Microbiological analysis showed that D had the highest microbiological load due to the lack of boiling. On the other hand, A had the lowest microbiological load owing to heat treatment and aseptic-filling applications. A was followed by E, which includes both drying and boiling applications. Thus, using these two production methods in paste production can be recommended.

Keywords: Turkish Pepper paste, traditional, commercial, microbial quality, storage

FARKLI YÖNTEMLERLE ÜRETİLEN TÜRK BİBER SALÇALARININ DEPOLAMA SIRASINDAKİ KALİTE DEĞİŞİMLERİNİN BELİRLENMESİ VE KARŞILAŞTIRILMASI

ÖZ

Yerli ve fabrikasyon başta olmak üzere birçok farklı yöntemle üretilen biber salçalarının kalite ve mikrobiyolojik kriterleri, belirli standartlar düzenlenmesine rağmen çoğu zaman göz ardı edilebilmektedir. Yerli/geleneksel üretimde kalite sorunları çok yüksek oranda. Böylece çeşitli yöntemlerle üretilen biber salçası kriterlerinin belirlenmesi ve karşılaştırılması amaçlanmıştır. Bu amaçla fiziksel, kimyasal ve mikrobiyolojik analizler yapılmış ve sonuçlar incelenmiştir. Depolama sırasında pH, kuru madde, titrasyon asitliği ve renk değerleri önemli ölçüde değişmiştir. Parlaklıkları azalırken hamurlar daha kırmızı ve daha sarı oldu. Mikrobiyolojik analiz, D'nin kaynama olmaması

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nedeniyle en yüksek mikrobiyolojik yüke sahip olduğunu gösterdi. Öte yandan A, ısıl işlem ve aseptik dolum uygulamaları nedeniyle en düşük mikrobiyolojik yüke sahipti. A 'yı hem kurutma hem de kaynatma uygulamalarını içeren E izledi. Bu nedenle salça üretiminde bu iki üretim yönteminin kullanılması önerilebilir.
Anahtar kelimeler: Türk biber salçası, geleneksel, ticari, mikrobiyel kalite, depolama

INTRODUCTION

Red pepper is an important plant belonging to the Capsicum genus of the Solanaceae family, grown in temperate climates for a year, and grown in various regions of the world in terms of production, consumption and food processing industry (Akgül, 1993; Duman ve ark., 2002). The pepper type grown in the Eastern Mediterranean region is known as Capsicum annuum L. (Akgül, 1993).

Especially the ripe fruits of this species, fresh and processed forms are used as colorant, pepper paste, paprika (spice) and oleoresin; especially used in meat products, soups, bakery, spice mixes, sauces, condiments, confectionery, soft drinks, vegetables, ice cream, chewing gum and pickles (Yalçın, 2008). Apart from these, it has a wide usage area in the world with its dominant color, bitterness, essential and nutritional properties (provitamin A, vitamin C, E, B1, B2, B3) and its unique aromatic structure in cosmetics and pharmacology industry (Duman et al., 2004; Serrano et al. 2010).

According to the plant production data of the Turkish Statistical Institute (TUIK), the amount of fresh pepper produced in our country between the years 2011-2021; while the production of bell pepper increased by 15%, the production of chili pepper increased by 21%, the production of pepper for paste increased by 98% (from 730493 tons to 1445275 tons) (TUIK, 2022). Moreover, Türkiye has only a 2.6% share in pepper production in the world according to 2020 year data from the Food and Agricultural Organization of the United Nations (FAO, 2022). In recent years, the production of pepper for pepper paste has increased in our country due to the advancement of technology used in agriculture, the widespread consumption and the increase in export demand.

Red pepper is widely used in the world, especially in the form of chili pepper, to improve the taste and flavor of dishes, as well as in different sauces such as ketchup. Although the use of red pepper as a paste (paprika paste, pepper paste) is very limited (in Spain, Mexico and Korea), it has become quite widespread in our country and in countries where Turks live densely, such as Germany, Belgium, Netherlands, England and Australia (Bozkurt and Erkmen, 2004; Bozkurt and Erkmen, 2005). Paste products are among the most important product groups in our country's food exports. Paste production aims to make tomatoes and peppers easier to consume and to preserve them for a long time without spoiling until consumption (Ismail and Revathi, 2006).

Pepper paste is defined as “Pepper paste is produced with pepper pulp, which is obtained from fresh, ripe, robust, red-colored, hot, or sweet peppers by washing thoroughly and crushing, then heating and separation from their shells, seeds, and fibers according to the procedure or without separation; in which the brix is thickened until at least 18%, excluding additional salt, and made durable by physically” in Turkish Food Codex Communiqué (TFCC) No.: 2014/6 on Paste and Puree (Anonymous, 2020).

Red pepper paste has been produced at homes with traditional methods for many years in Southern and Southeastern cities of our country, such as Gaziantep, Adana, and Şanlıurfa. It has been produced in modern facilities in recent years and has become a rapidly growing sector in many regions (Kuleasan and Okur, 2012). Academic testing of various producing methods has also been conducted (Bozkurt and Erkmen, 2004; Gogus et al., 2012; Askin Uzel, 2018). The effects of starter culture and salt on pepper pastes were also investigated by producing them via traditional and vacuum techniques (Bozkurt and Erkmen, 2005).

Paste type consumption changes as pepper paste, tomato paste or tomato-pepper mixed paste. The consumption habit of paste varies according to the people's taste and the region where they grow up. In a study investigating paste consumption habits, it was determined that 85.5% of families in Adana used pepper paste in their meals. It has also been stated that 62% of those who consume pepper paste produce it themselves at home, and 31.2% buy it from the market (Gül et al., 2005). In another study, it was revealed that 99.25% of the families living in Tokat province consumed tomato paste and 41.85% of them consumed pepper paste (Büyükbay et al., 2009). Another similar type paste of Korea, Gochujang, was reported as a healtier product by reducing fat gain, adipocyte size, serum lipid levels, leptin-secretion, tumor necrosis factor mRNA level (Ahn et al. 2006; Kim et al. 2014).

The interest in healthy and nutritious products has increased due to the increasing prevalence of urban life, the increase in the number of working people, the change in lifestyle, and the increase in education levels. Traditionally produced paste needs to be made safer by being technologically produced.

However, microbiological spoilage is one of the serious problems of the red pepper paste production sector and it is known that it can occur at every stage from raw material supply to the final product. There has been only a few studies especially on the effects of various producing techniques carried out on so far (Bozkurt and Erkmen, 2004; Bozkurt and Erkmen, 2005; Kuleasan and Okur, 2012; Gogus et al. 2015; Gamli et al., 2018, Askin Uzel, 2018). Thus, the aim of the research was to determine the quality criteria changes of pepper paste produced by using different technological/commercial and traditional methods and to compare the results obtained.

MATERIAL AND METHOD

Material

In the research, Islahiye red pepper harvested in the Islahiye district of Gaziantep in 2018 was used as the material. The red peppers were made into pepper paste in a fruit and vegetable processing factory (Yalçınkaya Biber Baharat Limited Company) that makes commercial production in the region.

Method

Pepper Paste Production Stages

The harvested red peppers were brought to the paste processing factory in perforated sacks with the help of trailers. The red peppers in the sacks were poured onto the conveyor belts and blasted between the steel plates. The seeds of the popped peppers were washed in the drum with pressurized water. In addition to washing in the rotating drum, it was ensured that the core, stalk and garbage were separated. Washed peppers were continuously transported to the sorting band with the help of an elevator. In the sorting band, rotten, dented, defective, or green peppers and stem and leaf parts that were not suitable for paste production were separated manually. At the end of the sorting band, the red peppers were passed through crushers with an average diameter of 6-8 mm and converted into must. In order to reduce the microbial content of the wort, a preheating process (3 mins at 85 ºC) was done. Then the brix was brought to 22.5 by evaporation for production A and by drying and boiling applications for productions B, C, D, and E. Afterwards, 1.5 kg salt was added and then brix values were adjusted to 28-31.5 levels by evaporating (A production) or boiling (B and E productions) or drying (C and D productions). Brix values were varied according to the method of evaporating the water in the pastes. After evaporation, pastes were made stable by tube pasteurization. In the last stage, it was packed in half-kg glass jars.

Storage Experiments

In the study, pepper paste samples produced by 5 different methods were used. The figural representation of the productions is basically as given in Figure 1. After being subjected to blasting, washing, sorting and pulping processes, the red peppers were processed into the final product in a way suitable for commercial mechanical processing (A) or home-type paste productions (B, C, D and E), which might vary

according to the regions. The methods to be applied for this purpose were carried out in the following order and procedure:
-A type paste: mechanically fabricated evaporative paste,
-B type paste: paste obtained by boiling the pulp in flat boilers,
-C type paste: paste obtained by laying and drying the pulp in the sun,
-D type paste: paste obtained by reducing the size of red pepper, which was made suitable for processing, by semi-drying in the sun and grinding,
-E type paste: paste obtained by reducing the size of the red pepper, which was made suitable for processing, by semi-drying in the sun, grinding and boiling.

Commercial red pepper paste production (hot filling)	Traditional (home-type) pepper paste production
Fresh Red Pepper	Fresh Red Pepper
↓	↓
Pepper Blast	Sorting And Washing
↓	↓
Washing	Removing The Core House
↓	↓
Extraction	Size Reduction With Meat Grinder
↓	↓
Crushers And Wort Vase	Drying in The Sun or Shade, Boiling
↓	↓
Preheater	Adding Salt
↓	↓
First Stage-Evaporation	Packaging
↓	
Second Stage-Evaporation	
↓	
Pasteurization	
↓	
Filling	
↓	
Lid Closing	
↓	
Labeling	
↓	
Outer Packaging	
↓	
Storage	
↓	
Shipping	

Figure 1. Commercial (left) and Traditional (right) pepper paste production stages

Brix of all paste obtained in the applied commercial and traditional production methods was adjusted to at least 28.

It has been reported that 15-46 days were enough to assess pepper pastes microbiologically for storage experiments (Bozkurt and Erkmen, 2005; Gamli et al. 2018). However, considering the case that paste produced at home is stored in the cellar for at least a few months, storage experiments were carried out for a period of 5 months in order to observe the quality changes and microbiological effects that may occur for a longer period of time. Paste samples were packed in half kg glass jars and stored in a sterile dark cabinet at 25 ^{o}C at room condition for 5 months.

While physical and chemical analyses were carried out by taking samples from pepper pastes at the beginning of each month; microbiological analyses were made at the beginning of production and the end of storage (at the end of the 5th month). The reason for this was to store the pastes in sterile packaging and to determine the total amount of microbial load that grew until the date they were opened and consumed (home-made pepper pastes are stored for an average of 5 months and only checked whether they deteriorate while being consumed.).

Physical and Chemical Analysis

A pH-meter (Orion Star A211, Thermo Fisher Scientific, Beverly, MA, USA) was used for the measurement by immersing the electrode of the pH meter into the resulting solution (AOAC, 1995). The color values of pastes were determined with a colorimeter (Minolta CR-400, Japan) by using the Hunter scale. Color measurements were made in triple and the average of the values was taken. In the scale, "*L*" refers to the brightness of the paste, "*a*" to the redness of the paste, and "*b*" to the yellowness of the paste (Francis, 1998). Dry matter and titration acidity (as citric acid) were determined (AOAC, 2003). Salinity were determined according to the Mohr method (AOAC, 1995). Water activity was measured with a Novasina LabStart brand (Lachen, Switzerland) water activity measuring device (Ranganna, 1999).

Microbiological Analysis

AOAC standart method was applied by modification for the microbiological analysis (AOAC, 1999). 10 g pepper paste sample was taken under sterile conditions and homogenized in 90 ml sterile solution containing 0.1% peptone (Merck, Germany). After the homogenization process, the samples were diluted 1/10 with 0.1% sterile peptone water, and the samples were inoculated on the appropriate medium by spreading method. In the experiments, all microbial inoculations were made in triple from each dilution. The average of the counting results was expressed as logcfu/g.

Total Mesophilic Aerobic Bacteria (TMAB) count was determined by spreading the dilutions prepared on petri dishes with PCA (Plate Count Agar, Merck) medium for inoculation and counting at the end of incubation at 30-32 ºC for 24 hours. Dilutions of mold and yeast were taken into petri dishes and cultivated in PDA (Potato Dextrose Agar, Merck) medium and incubated at 25 ºC for 3-4 days. Samples were seeded on Violet Red Bile Agar (VRBA, Merck) medium to determine the number of coliform bacteria in which the petri dishes were incubated at 37 ºC for one day to count (Çakır, 2000). For Total Lactic Acid Bacteria (LAB) count, 0.1 ml samples taken from the dilutions were spread on MRS Agar (Merck) medium and inoculated. Then the plates were incubated at 30-32 ºC for two days and be counted of colonies.

Statistical Analysis

All of the physical and chemical experiments were performed at least in triplicate, and the results were given as the mean ±standard deviation. In this study, firstly, the effects of the treatments (A, B, C, D and E productions) applied to pastes on the quality criteria were examined. Then, the effect of storage (5 months period) was examined by looking at the changes in the quality criteria of each paste during storage. The analysis results were compared One-way ANOVA and the DUNCAN multiple comparison tests.

RESULTS AND DISCUSSION

Evaluation of Physical and Chemical Analysis Results

Color, pH, titration acidity, salinity, dry matter and water activity analyses were performed on pepper paste samples used in the study. Since there were not many studies on Turkish pepper paste in the literature, the results of the analysis were also evaluated in terms of compliance with the TFCC. According to TFCC, the pH value of pepper paste should be 4.1-5.0; excluding added salt, it must have a brix value of at least 18%, a maximum of 10% acidity (in terms of citric acid) by mass, and a salt of at most 5% by mass in total dry matter (Anonymous, 2020).

The effect of different production methods on the physical and chemical properties of paste is given in Table 1. While lactic acid growth was not high with the effect of heat treatment processes and aseptic filling process used in fabricated production, it has been stated that lactic acid bacterial growth and with it the titration acidity increased and the pH value decreased in pastes produced with traditional methods, especially during drying and storage (Kuleasan and Okur, 2012; Askin Uzel, 2018). However, with the application of boiling and similar heat treatments in production, the growth and number of these bacteria was considerably reduced (Jasim et al. 2002). When compared with TFCC values, it was observed that acidity values were appropriate, but some of the pH values decreased to levels not suitable for TFCC during storage. On the other hand, salt values of pastes were found to be higher than TFCC. This was due to the high amount of salt added for preservative purposes in homemade pastes. Especially for the fabricated production method A, all values except salt were suitable for TFCC, on the other hand, all salt ratios for home-made production methods were higher than TFCC criteria (Table 1 and 2; Anonymous, 2020). As can be seen in Table 1, the effects of different production methods applied on pH, titration acidity, dry matter, water activity and salt values were found to be statistically significant (***P≤0.001).

Table 1. The effect of different production methods on the physical and chemical properties of paste

Production method	pH	Titration acidity (%)	Dry matter (%)	Water activity	Salt (%)
A	4.64±0.13^{c}	1.91±0.08^{b}	30.83±0.77^{a}	0.89±0.00^{c}	7.90±0.00^{a}
B	5.21±0.17^{e}	1.30±0.12^{a}	32.45±0.51^{b}	0.88±0.00^{b}	8.19±0.01^{d}
C	4.31±0.15^{b}	3.67±0.42^{c}	33.12±0.56^{c}	0.86±0.00^{a}	8.19±0.01^{d}
D	4.08±0.24^{a}	8.31±0.71^{d}	42.43±0.37^{e}	0.88±0.00^{b}	8.16±0.03^{b}
E	4.66±0.47^{d}	1.95±0.29^{b}	35.50±0.46^{d}	0.88±0.00^{b}	8.17±0.01^{c}
P	***	***	***	***	***

****P* ≤0.001. a-e Letters in the same column indicate statistical differences. Paste types: A: mechanically fabricated evaporative paste; B: paste obtained by boiling the pulp in flat boilers; C: paste obtained by laying and drying the pulp in the sun; D: paste obtained by reducing the size of red pepper, which is made suitable for processing, by semi-drying in the sun and grinding; E: paste obtained by reducing the size of the red pepper, which is made suitable for processing, by semi-drying in the sun, grinding and boiling.

Table 2. Changes in pH, Titration acidity, Dry matter, Water activity and Salt values during storage for each different productions applied

Production Method	Months	pH	Titration acidity (%)	Dry matter (%)	Water activity	Salt (%)
A	0	4.62±0.02^{b}	1.86±0.01^{b}	29.90±0.05^{a}	0.89±0.00	7.90±0.00
	1	4.78±0.01^{d}	2.02±0.01^{d}	30.73±0.01^{c}	0.89±0.00	7.90±0.00
	2	4.75±0.02^{c}	2.01±0.01^{d}	30.47±0.01^{b}	0.89±0.00	7.90±0.00
	3	4.73±0.03^{c}	1.80±0.01^{a}	30.84±0.02^{d}	0.89±0.00	7.90±0.00
	4	4.47±0.01^{a}	1.87±0.01^{b}	31.45±0.05^{e}	0.88±0.01	7.90±0.00
	5	4.44±0.13^{a}	1.89±0.01^{c}	32.26±0.03^{f}	0.89±0.00	7.90±0.00
P		***	***	***	NS	NS
B	0	5.26±0.02^{c}	1.19±0.01^{a}	32.27±0.07^{c}	0.88±0.00	8.19±0.01
	1	5.33±0.02^{e}	1.50±0.01^{e}	31.75±0.05^{a}	0.87±0.00	8.19±0.01
	2	5.42±0.04^{f}	1.21±0.01^{b}	33.26±0.03^{f}	0.87±0.00	8.19±0.01
	3	5.29±0.02^{d}	1.41±0.01^{d}	32.09±0.03^{b}	0.88±0.00	8.19±0.01
	4	5.06±0.01^{b}	1.26±0.01^{c}	32.55±0.01^{d}	0.87±0.00	8.19±0.01
	5	4.95±0.01^{a}	1.25±0.01^{c}	32.80±0.02^{e}	0.88±0.00	8.19±0.01
P		***	***	***	NS	NS

Production Method	Months	pH	Titration acidity (%)	Dry matter (%)	Water activity	Salt (%)
C	0	4.36±0.00[c]	3.67±0.02[c]	32.47±0.03[a]	0.86±0.00	8.20±0.02
	1	4.43±0.02[d]	3.81±0.01[d]	33.16±0.01[d]	0.86±0.00	8.20±0.02
	2	4.43±0.02[d]	3.24±0.01[b]	32.80±0.02[c]	0.86±0.00	8.20±0.02
	3	4.42±0.02[d]	3.04±0.01[a]	32.66±0.03[b]	0.86±0.00	8.20±0.02
	4	4.13±0.01[b]	4.12±0.01[e]	33.68±0.01[e]	0.86±0.00	8.20±0.02
	5	4.08±0.02[a]	4.13±0.02[e]	33.95±0.04[f]	0.86±0.00	8.20±0.02
P		***	***	***	NS	NS
D	0	4.16±0.00[c]	7.94±0.01[c]	42.95±0.02[f]	0.88±0.00	8.16±0.04
	1	4.25±0.01[d]	9.32±0.01[f]	42.76±0.04[e]	0.88±0.00	8.16±0.04
	2	4.25±0.01[d]	8.08±0.01[d]	41.87±0.02[a]	0.89±0.00	8.16±0.04
	3	4.28±0.01[e]	9.17±0.01[e]	42.18±0.03[b]	0.88±0.00	8.16±0.04
	4	3.96±0.01[b]	7.48±0.01[a]	42.35±0.02[c]	0.89±0.00	8.16±0.04
	5	3.71±0.01[a]	7.86±0.03[b]	42.45±0.02[d]	0.89±0.00	8.16±0.04
P		***	***	***	NS	NS
E	0	5.18±0.02[c]	1.91±0.01[d]	35.63±0.02[b]	0.89±0.00	8.18±0.02
	1	5.24±0.01[e]	2.36±0.01[f]	35.95±0.03[d]	0.89±0.00	8.18±0.02
	2	5.21±0.01[d]	2.31±0.01[e]	34.98±0.03[a]	0.89±0.00	8.18±0.02
	3	5.29±0.01[f]	1.71±0.01[b]	35.68±0.24[b]	0.89±0.00	8.18±0.02
	4	4.96±0.01[b]	1.67±0.01[a]	35.83±0.24[c]	0.89±0.00	8.18±0.02
	5	4.61±0.00[a]	1.76±0.04[c]	35.94±0.02[d]	0.89±0.00	8.18±0.02
P		***	***	***	NS	NS

****P* ≤0.001. a-f Letters in the same column indicate statistical differences. NS: Non Significant. Paste types: A: mechanically fabricated evaporative paste; B: paste obtained by boiling the pulp in flat boilers; C: paste obtained by laying and drying the pulp in the sun; D: paste obtained by reducing the size of red pepper, which is made suitable for processing, by semi-drying in the sun and grinding; E: paste obtained by reducing the size of the red pepper, which is made suitable for processing, by semi-drying in the sun, grinding and boiling.

In the research, the effects of storage period on the physical and chemical properties of paste during storage were compared the results were found statistically significant on pH, titration acidity and dry matter values of pastes, and insignificant on water activity and salt values (Table 2). It is seen that the pH decreased in all productions during storage (Table 2). LABs rapidly acidified the pastes by producing lactic acid by fermentation processes of carbohydrates in pastes, which inhibited the growth of other microorganisms by leading to the low pH 5.06±0.75 in our study (Li et al. 2016; Kaur and Kaur, 2020; Medina-Torres et al. 2020). On the other hand, moisture and pH of pastes are important parameters for microbial growth and product stability. It has been reported that pH values close to neutral values support bacterial growth during storage (Bozkurt and Erkmen, 2004; Medina-Torres et al. 2020). In addition, pH values of A and C pastes were in accordance with the TFCC No.:2014/6; however, it was observed that there was a decrease in pH values from 0 th to 5th months in all production methods. It was thought that this decrease was due to the heat treatments' affecting LAB growth applied in A, B and E productions, and the effect of drying treatments' reducing the water activity necessary for bacterial life for production type C (Orak and Demirci, 2005; Kuleasan and Okur, 2012; Gamli et al., 2018, Yassıhüyük, 2012).

Accordingly, all of the pastes were in compliance with the TFCC No.:2014/6 and more than previous study based on acidity values except production type D due to lack of heat treatment and drying to stop LABs activity and similarly production type C which as a method without heat treatment (Bozkurt and Erkmen, 2004; Orak and Demirci, 2005; Li et al. 2016; Anonymous, 2020; Askin Uzel, 2018). As can be seen from Table 2, dry matter values of pastes produced vary between 29.90-42.95 which complied with the minimum 18% standard specified in the TFCC No.:2014/6. Salt values detected in pepper pastes varied between 7.9-8.2 (Table 2). Although these values were in line with previous studies (Yassıhüyük, 2012; Gamli et al., 2018, Ryu et al. 2021; Ramalingam et al. 2022), they were outside the maximum 5% standard specified in the TFCC No.:2014/6 (Anonymous, 2020). The water activity values detected in pepper pastes ranged between 0.86-0.89 (Table 2) which were in line with previous literature of pepper pastes (Kaur and Kaur, 2020; Medina-Torres et al. 2020).

Color, which is one of the most important criteria in the product selection of consumers, is an important quality criterion in the selection of paste. The color of the pepper pastes produced by the traditional method is affected by variables such as heating process, evaporation in the sun, lactic acid formation as a result of fermentation, and ambient oxygen. In the literature, the resources on color analysis of Turkish pepper paste are very limited (Kuleasan and Okur, 2012; Yassıhüyük, 2012; Gamli et al., 2018). In this research, the effect of different production methods on the color of paste was compared with the DUNCAN multiple comparison test and the results are given in Table 3. As it can be seen from the Table (3); The effect of different production methods applied on *L, a, b, C* and *H* values was found to be statistically significant (***$P \leq 0.001$). It was thought that these significancies observed in color values were due to the effect of techniques such as heat treatment, drying, shredding, etc. applied in production and the effect of added salt which all were effective on the amount of growth of microbial life and enzymatic reactions (Orak and Demirci, 2005; Gamli et al. 2018). When the effects on the color changes during storage were compared; while the storage had no effect on the *L* value in all productions (Table 4), it was observed that method did (Table 3). Although the *L* values were the highest especially in the fabricated A production, *L* values decreased during storage in all productions (Kuleasan and Okur, 2012, Gamli et al. 2018). However, the change in *L* values during storage was found to be statistically insignificant (Table 4). For the pastes of C, D and E productions, *a* value increased during storage significantly. While the statistical effect of the storage for the pastes of A and D on the *b* value was found to be insignificant, it was observed that the b value increased during storage in all productions. It was observed that the red color intensity of pastes increased during storage, therefore an increase in *a* and *b* values was observed, which was compatible with the literature (Kuleasan and Okur, 2012; Gamli et al., 2018, Yassıhüyük, 2012). While the statistical effect of the storage for the pastes of A, B and D productions on the *C* value was found to be insignificant, it was observed that the *C* value increased during storage in all productions, however only C and E productions' increase were found to be significant. While the statistical effect of the storage for the pastes of A and D productions on the *H* value was insignificant, it is seen that the *H* value decreased during storage for A and D productions, while it increased in other productions.

Table 3. The effect of different production methods on the color of pastes

Production Method	L	a	b	*C*	*H*
A	35.58 ± 1.24^{c}	31.90 ± 1.78^{b}	24.80 ± 1.83^{b}	40.29 ± 2.38^{c}	37.75 ± 0.92^{c}
B	32.83 ± 0.83^{b}	29.44 ± 1.19^{a}	20.66 ± 1.63^{a}	35.92 ± 1.82^{a}	34.96 ± 1.39^{a}
C	30.97 ± 1.69^{a}	29.76 ± 2.90^{a}	21.65 ± 2.64^{a}	36.65 ± 3.72^{ab}	35.80 ± 1.40^{ab}
D	32.45 ± 2.33^{ab}	34.03 ± 1.14^{b}	26.05 ± 2.18^{b}	42.94 ± 1.52^{c}	37.30 ± 2.58^{bc}
E	31.26 ± 1.34^{ab}	32.22 ± 2.97^{b}	22.37 ± 2.83^{a}	39.16 ± 4.01^{bc}	34.72 ± 1.05^{a}
P	***	***	***	***	***

***$P \leq 0.001$. a-c Letters in the same column indicate statistical differences. Paste types: A: mechanically fabricated evaporative paste; B: paste obtained by boiling the pulp in flat boilers; C: paste obtained by laying and drying the pulp in the sun; D: paste obtained by reducing the size of red pepper, which is made suitable for processing, by semi-drying in the sun and grinding; E: paste obtained by reducing the size of the red pepper, which is made suitable for processing, by semi-drying in the sun, grinding and boiling.

Table 4. Color changes of paste produced by different method during storage

Production Method	Months	L	a	b	*C*	*H*
A	0	38.56±0.87	28.56±0.63	22.25±0.36	36.52±0.52	39.52±0.62
	1	37.81±0.98	29.23±0.56	23.12±0.25	38.65±0.02	38.75±0.52
	2	36.86±1.15	30.33±0.24	24.00±0.18	38.72±0.06	38.20±0.45
	3	35.17±0.11	31.95±2.16	25.09±2.95	40.07±3.32	37.51±1.25
	4	34.71±1.00	33.41±0.93	25.32±1.79	42.09±1.75	37.53±1.08
	5	33.85±0.85	34.06±0.84	26.12±1.29	42.15±1.08	36.78±1.20
P		NS	NS	NS	NS	NS
B	0	34.67±0.95	30.56±0.89	19.22±0.82[a]	33.65±0.85	30.85±2.14[a]
	1	33.92±1.05	29.97±0.62	19.48±0.95[a]	33.78±0.91	31.12±2.20[a]
	2	32.51±1.18	28.98±0.52	19.50±1.07[a]	34.89±1.02	33.71±0.99[b]
	3	33.53±0.42	28.97±0.12	19.97±0.02[a]	35.15±0.10	34.57±0.11[b]
	4	32.45±0.32	30.37±1.85	22.52±1.24[b]	37.72±2.21	36.62±0.15[c]
	5	31.82±0.65	31.25±2.01	24.01±1.22[c]	38.72±0.06	36.84±0.25[c]
P		NS	NS	*	NS	**
C	0	34.61±0.72	21.03±0.52[a]	18.01±0.98[a]	29.79±2.53[a]	33.98±0.85[a]
	1	33.45±0.63	24.12±0.30[b]	18.52±0.52[a]	31.55±0.55[b]	34.02±0.32[a]
	2	32.38±0.40	27.13±0.50[c]	18.67±0.60[a]	32.92±0.72[b]	34.29±0.36[a]
	3	31.05±0.05	28.66±0.51[d]	21.68±0.41[b]	35.76±0.70[c]	37.14±0.03[b]
	4	29.49±2.23	33.50±0.21[e]	24.59±1.02[c]	41.28±0.50[d]	35.90±1.28[b]
	5	28.74±1.64	35.92±0.25[f]	24.89±1.46[c]	43.77±0.48[e]	36.85±1.45[b]
P		NS	***	***	***	*
D	0	35.41±2.43	29.56±0.52[a]	25.21±2.81	40.45±0.48	37.75±2.14
	1	34.78±2.50	30.41±1.02[b]	25.62±2.25	41.67±0.58	38.02±2.51
	2	33.83±3.26	32.53±0.33[c]	25.83±3.97	41.84±2.24	38.49±4.54
	3	32.33±0.29	34.76±0.05[d]	26.34±0.82	43.67±0.48	36.94±0.93
	4	31.19±2.40	34.79±0.29[d]	25.98±1.57	43.30±1.11	36.47±1.34
	5	30.08±2.22	36.46±0.21[e]	26.85±0.92	43.47±0.52	36.12±1.25
P		NS	***	NS	NS	NS
E	0	33.63±2.13	26.78±0.84[a]	18.75±0.82[a]	33.82±1.93[a]	33.12±0.03[a]
	1	32.49±1.25	26.65±0.82[a]	19.15±0.41[a]	33.93±2.13[a]	33.29±0.05[a]
	2	31.50±1.12	28.97±0.79[b]	19.02±0.51[a]	34.68±0.93[a]	33.40±0.05[a]
	3	30.84±2.32	34.57±1.23[c]	24.57±1.38[b]	40.48±1.80[b]	35.20±0.60[b]
	4	31.43±0.33	33.11±2.80[c]	23.50±2.00[b]	40.32±3.41[b]	35.56±0.03[b]
	5	29.85±0.45	35.56±1.46[d]	24.51±2.15[b]	42.40±0.44[c]	36.65±0.01[b]
P		NS	*	**	*	***

$^*P<0.05$; $^{**}P<0.01$; $^{***}P\leq 0.001$; NS: Non Significant. a-f Letters in the same column indicate statistical differences. Paste types: A: mechanically fabricated evaporative paste; B: paste obtained by boiling the pulp in flat boilers; C: paste obtained by laying and drying the pulp in the sun; D: paste obtained by reducing the size of red pepper, which is made suitable for processing, by semi-drying in the sun and grinding; E: paste obtained by reducing the size of the red pepper, which is made suitable for processing, by semi-drying in the sun, grinding and boiling.

Evaluation of Microbiological Analysis Results

Pastes deteriorate due to physical, chemical and microbiological reasons (Şentürk, 1986). For this reason, total mesophilic aerobic bacteria (TMAB), yeast-mold, total lactic acid bacteria (LAB) and coliform counts were determined by microbiological analysis of paste samples. As the determination period, only the microbiological growths at the 0th day and 5th month when they were first produced were followed (Table 5).

Table 5. Logarithmic evolution of TMAB, Yeast and Mold, LAB and Coliform in Microbiological Analysis

	A	B	C	D	E
TMAB (logcfu/g)					
	A	B	C	D	E
0. day	<1	2.62±0.00	3.76±0.00	3.87±0.00	2.48±0.00
5. month	<1	3.33±0.00	3.89±0.00	4.02±0.00	3.02±0.00
Yeast and Mold (logcfu/g)					
	A	B	C	D	E
0. day	<1	2.60±0.00	3.20±0.00	4.20±0.00	2.62±0.00
5. month	<1	2.90±0.00	3.34±0.00	4.30±0.00	2.71±0.00
LAB (logcfu/g)					
	A	B	C	D	E
0. day	2.30±0.00	2.78±0.00	3.08±0.00	3.38±0.00	2.60±0.00
5. month	2.90±0.00	3.08±0.00	3.25±0.00	3.97±0.00	2.95±0.00
Coliform (logcfu/g)					
	A	B	C	D	E
0. day	<1	<1	<1	<1	<1
5. month	<1	<1	<1	<1	<1

*values set in logcfu/g. Paste types: A: mechanically fabricated evaporative paste; B: paste obtained by boiling the pulp in flat boilers; C: paste obtained by laying and drying the pulp in the sun; D: paste obtained by reducing the size of red pepper, which is made suitable for processing, by semi-drying in the sun and grinding; E: paste obtained by reducing the size of the red pepper, which is made suitable for processing, by semi-drying in the sun, grinding and boiling.

At the end of the incubation, while TMAB was not found any in A prodution, the number of which varied and increased during storage for B, C, D and E productions were determined (Table 5). When the TMAB numbers were examined, the highest value was observed in the form of D production, while the lowest value was in the form of A (mechanically fabricated) production. In addition, when the bacterial counts were examined in general, it was thought that there was no microbial load was found with the effect of heat treatment in the form of A production and filling under aseptic conditions. In other production methods, the numbers difference between the productions were caused by the inefficient heat treatment and drying applications during the process. Moreover, when homemade paste production techniques were compared, the microbial load was found the least in E production rather than the others was due to the use of more different processes in this production, while the advantage of the heat treatment effect in B production was seen. In addition, the highest microbial load was seen in D production, where the least processing was done. It was observed that the number of bacteria increased at the end of the 5th month in all production methods except A.

When the total mold-yeast numbers were examined, the highest value was observed in the form of D production, while the lowest value was in the form of A (mechanically fabricated) production. Similar to TMAB values, it was observed that the number of mold-yeast increased at the end of the 5th month in all production methods except A.

When the total lactic acid bacteria numbers were examined, the highest value was observed in the form of D production, while the lowest value was in the form of A (mechanically fabricated) production. However, as stated in previous studies, lactic acid growth might occur in the spaces between the paste despite the applied heat treatments (Kuleasan and Okur, 2012). It was observed that the total number of lactic acid bacteria increased in all production methods at the end of the 5th month.

After the incubation period of VRBA, the coliform bacteria were not found in all productions. As stated in previous studies, coliform group bacteria growth was not observed due to the effect of applied heat treatments and sterile production (Kuleasan and Okur, 2012). It was thought that this bacterial group was completely inhibited by the effect of heat in productions A, B and E, and by the effect of drying in productions of C and D, or due to the bitterness of pepper (Bozkurt and Erkmen, 2005).

In general, the findings obtained from this study were compatible with the bacterial and yeast count values made in different pepper paste products'studies (Askin Uzel, 2018; Gamli et al. 2018; Ramalingam et al. 2022). On the other hand, it was also stated that TMAB and mold-yeast numbers decreased during 21-46 days of storage in paste produced with different techniques. The reason for the decrease in that study was thought to be the decrease in the water in the environment due to the salt added in the productions (Bozkurt and Erkmen, 2004). In this study, in which the storage was extended up to 5 months, it is shown that the risk in terms of microbiology increased with long storage. Therefore, as in this study, it was thought that adding more salt may be beneficial in order to significantly reduce the amount of water in the pastes.

CONCLUSION

In this research, the effects of different production methods applied and their effects on the physical, chemical and microbiological properties of pastes during storage were examined. While significant changes were observed only in pH, titration acidity, and dry matter in pastes produced by different methods, their effects on water activity and salt values were found to be insignificant. It has been observed that the effect of different processes in production methods on the color of paste was varied during storage. While the highest microbiological load was found in the form of D production due to the lack of neither heat treatment nor complete drying during production; the best production method was found to be A as mechanically fabricated production owing to heat treatment and aseptic filling applications. Moreover, the E production method, in which the lowest microbiological load and growth was observed due to drying and boiling applications was chosen as the best home production method. Thus, if one of the homemade paste production methods is to be preferred, the E production method is recommended when compared to the other methods mentioned in the study. However, it has been seen once again that a healthier tomato paste can be produced more sterile by fabrication by mechanical methods, as in the production of A. In this way, it will be possible to support regional development economically and to contribute to public health by ensuring that the local people consume safer products.

CONFLICT OF 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 study.

CONTRIBUTIONS

MA: Data curation and data analysis, writing original draft; SD: Conceptualization, supervision, data curation and data analysis, writing, review and editing of manuscript; MD: Conceptualization, supervision, data analysis, project administration and methodology, writing, review and editing of manuscript.

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