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Effect of different thawing methods on quality properties of stuffed pasta (manti)

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RESEARCH ARTICLE

Abstract

Stuffed pasta or 'manti' is a traditional food consumed fondly in Turkey. For consumption, it is produced as fresh, frozen or dried manti. Frozen manti is cooked directly without thawing. The present study investigated the effects of different thawing processes on physicochemical properties and sensory qualities of frozen stuffed pasta (manti). The following five thawing processes were used individually: (1) infrared, (2) microwave (3) infrared-assisted microwave, (4) dry hot air and (5) running water thawing. The storing temperatures of manti found in the market were 10°C and 24.5°C. Consequently, manti samples were thawed up to these temperatures. It was determined that the shortest thawing period (20 sec) was that of infrared-assisted microwave process. The longest process was dry hot-air thawing (420 sec) in manti samples that were thawed until refrigerator (+4°C) and room temperatures (24.5°C). Thawing methods did not change pH, moisture values and weight gain ($p > 0.05$). It was found that sensory qualities and amount of dry matter passing into the water of samples were different ($p < 0.05$). It was concluded that thawing was necessary for frozen manti, and the best method was microwave thawing.

Keywords: manti, qualitative properties, stuffed pasta, thawing methods

Introduction

Some foods are susceptible to spoilage, because the microorganisms that cause spoilage are found in the foods. These foods are generally of animal origin. One of such foods produced is stuffed pasta (manti) with minced meat, which is fondly consumed in Turkey. Manti with minced meat is defined as a traditional food prepared by making a mixture of different types of spices and minced beef, putting it in small pieces of dough, and boiling it in water prior to consumption. The industrial production scheme of manti is shown in Figure 1 (Gökmen et al., 2015; Sitti *et al.*, 2009). Its shelf life is short because of high moisture content and presence of beef. In the thawing process, compared to the freezing process, more damage could occur in the textural properties of products (Zhu *et al.*, 2004). Hence, it is important to keep manti with minced meat under suitable conditions, for which different studies are found out in literature. Manti is dried for this purpose, consumed wet or stored by freezing. Traditional methods (dry hot air), and infrared and microwave methods are employed for drying manti. In addition, vacuum and modified atmosphere packing applications are also carried out after pasteurization of fresh manti. However, the shelf life of manti could not be significantly extended except for drying applications. Both sensory and nutritional losses are observed in dried manti compared to fresh manti. Freezing is another method that could be employed to consume fresh foods. Thanks to the freezing process, shelf life of manti could be extended to store it for about 4–6 months at a storage temperature of –18°C (having international validity) (Günşen and Büyükyörük, 2005). Freezing process is used to extend the shelf life of foods and to slow down and/or stop the activities of microorganisms and enzymes in the structure of foods. During the thawing of frozen

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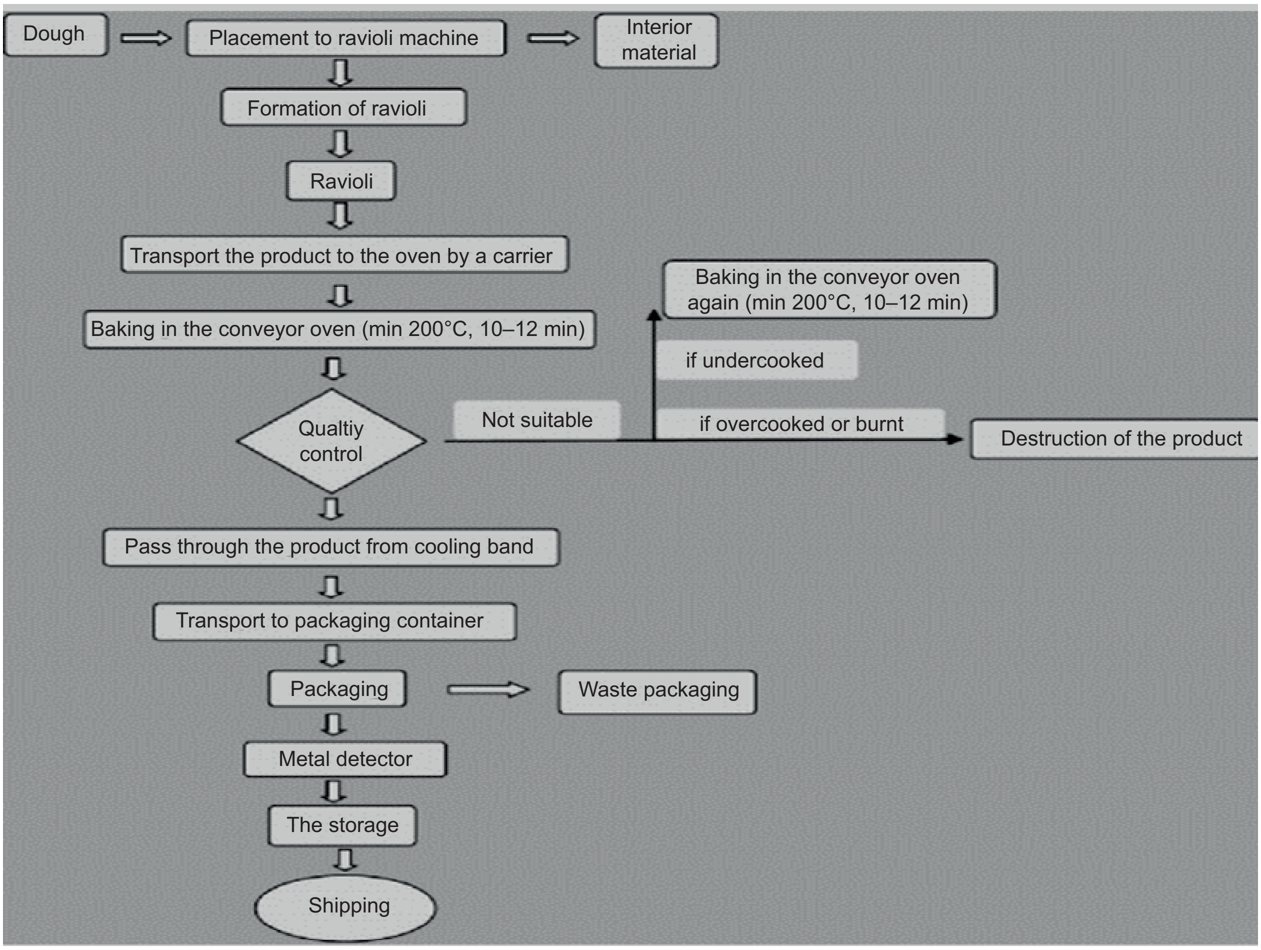


Figure 1. The industrial production scheme of manti.

foods, many physicochemical, sensory and microbiological changes occur depending on the freezing method and time (Atasever and Çubukçı, 2018; Azevedo *et al.*, 2005).

Different freezing methods are used during the thawing of frozen foods. However, after freezing of manti, no other method used for thawing is applied and the frozen manti is cooked directly. Freezing is an important process that protects the quality of food to extend its shelf life. Thawing is a very important stage of frozen foods prior to consumption or processing (Durmaz *et al.*, 2018). Hence, thawing process could determine the most appropriate quality of food. Different thawing processes are available, such as hot-air thawing, high-pressure thawing, low-temperature thawing, running water thawing, vacuum thawing, ultrasonic thawing, microwave thawing, infrared-assisted microwave thawing etc. (Cai *et al.*, 2019; Liu *et al.*, 2020; Xu *et al.*, 2020).

Today, traditional methods based on heat transfer on an industrial scale (based on the use of air or water heat transfer) are applied for thawing. These methods cause water loss, textural defects and negative changes in proteins during the process. In the traditional methods of thawing, product's quality is lost due to temperature differences in the product. Temperature inside the product must be uniform and the process time must be shortened. For these reasons, interest in the dielectric dissolution methods for thawing has increased (Uyar et al., 2015). No study has determined the thawing of frozen noodles and frozen filled pasta (Anonymous 2021a, 2021b, 2021c). Thawing processes determine the final quality of frozen manti; hence, improper thawing process causes irreversible degradation in the quality of frozen manti.

Frozen manti is cooked directly without thawing. Therefore, it is necessary to determine an appropriate process for thawing of frozen manti to preserve the quality of product. Studies are conducted about the effects of thawing methods on the physical, chemical and microbiological properties of meat and meat products. Therefore, in this study, we investigated the effects of hot-air, running water, microwave, and infrared-assisted microwave thawing processes on physical, chemical, and sensory properties of frozen manti.

Material and Method

Frozen stuffed pasta (manti) (with 50.6% carbohydrate, 3.6% sugar, 8.5% protein, 5% fat, and 2% salt) was purchased from ANEDA GIDA Industry and Trade Limited Company (Guven Mantı), Istanbul, Turkey. Manti samples were packed in polyethylene bags (20 × 22 cm, 450 g per bag) and stored at -18°C.

Equipments and reagents

Following equipments and reagents were used: microwave oven (NN-GD568, Panasonic Appliances Microwave Oven Co. Ltd, Shanghai, China), tap water, pure water, kitchen oven (Bosh Oven Co. Ltd, Shanghai, China), pH meter (Inolab-pH 7110, GER), precision balance, sample containers, frozen raw manti samples, portable thermohygrometer (sauna type) and thermocouple.

Features of raw manti

Ground beef features: it was double-pulled, obtained from leg meat; it contained about 25% fat. Manti shape: bundle type; manti dimensions: 1.5 × 1.5 × 1.5 cm; spices used in manti mixture: salt, black pepper, and mint; manti weight: average 2 g; and starting temperature for manti mortar: -3°C.

Storage conditions

Produced manti samples were stored in nylon nonvacuum bags (brand: Eco Pazar; 40-micron thick; oxygen, carbon dioxide and transparent nylon food bags with high air permeability and 20 × 30 cm in size) at -18 °C.

Thawing methods and time

It was determined that the temperatures at which manti was stored in the market were the best thaw temperatures. In addition, inside temperatures of manti were measured with a thermocouple. The storing temperatures of manti in the market were 10°C and 24.5°C. Manti samples were frozen for 24–48 h. Control samples were not defrosted, and cooked directly. After freezing of manti samples, these were thawed by the following five different thawing processes: in oven (hot-air thawing) at 40°C; running water process—the samples were thawed under 40°C running water; microwave and infrared-assisted microwave thawing processes—the samples were thawed in a microwave oven (NN-GD568, Panasonic). The power and frequency were 1,200 W and 2,450 Hz, respectively.The process was finished when the center temperature of the sample reached 10°C and 24.5°C (Cai *et al.*, 2019; Liu *et al.*, 2020; Xu *et al.*, 2020).

Features of infrared lamp: 60% power, 1,000 watt, bar-type, short wavelength. Features of microwave: 40% power, 240 V supply voltage, and 50 Hz frequency.

Manti features: Distance between the ray source and the product: 25 cm. Amount of manti taken: 10 kg.

Ambient conditions

Ambient conditions included room temperature and 47% relative humidity. In microwave and infrared-assisted microwave processes, the experiment was carried out at room temperature and under atmospheric conditions. The temperature value was determined as 24.2°C under atmospheric conditions.

pH analysis

The pH values of homogenized samples were read with a pre-calibrated pH meter (Inolab-pH 7110, GER) (Gökmen *et al.*, 2019).

Weight gain

Cooking efficiency was measured by the ratio of cooking weight to initial weight. Results were expressed as percentage values (Murphy *et al.*, 1975).

Moisture loss

It was calculated by taking into consideration the initial weights of samples (Murphy *et al.*, 1975).

Dry matter passing into water (DMPW)

It was based on the principle of gravimetric determination of the amount of substance passing into the cooking water during cooking of manti (Gökmen *et al.*, 2019).

Sensory analysis

Sensory analysis of manti samples was performed by a panel of seven trained and experienced sensory analysts.

The following parameters were considered for analysis (Gökmen *et al.*, 2019): 500 g of manti sample was taken into 2 L of drinking water and boiled; the samples were analyzed as shown in Table 1. Manti was cooked when it was on the surface of cooking water. In sensory analysis, the age group was 25–40 years.

Statistical analysis

Three measurements were conducted to test the effects of each thawing process on the physicochemical properties and sensory qualities of frozen manti samples. The analysis was performed with the JMP statistical software, and significant difference ($p < 0.05$) was determined by Tukey's test. Analysis with each thawing process was performed in triplicate. Independent variables were as follows: manti shape, manti weight, microwave power, infrared power, distance between product and ray source, thawing, running water, and oven temperature.

Results

The effects of different tempering methods on the physicochemical properties and sensory qualities (appearance, taste, smell, aroma, mouth feeling, and general evaluation) of manti samples were investigated prior to consumption.

Results of thawing time

Among thawing processes, the shortest dissolution time was observed in the infrared-assisted microwave process, and the longest time was determined in dry hot-air process at 40°C (Table 2).

Results of physicochemical analysis

The weight gain, moisture and pH values of the samples were not found statistically significant ($p > 0.05$). However, a statistical difference ($p < 0.05$) was determined in terms of the amount of dry matter passing into the water (Figure 3). Effects of thawing process and tempering time on weight gain, moisture% and pH values of thawed manti samples were not found. Maximum amount of dry matter passing into water was found in control samples, and minimum amount was found in dielectric processes (microwave, infrared, and infrared-assisted microwave). If the thawing time was extended in dielectric methods, then decrease in the amount of dry substance passing into water in manti was observed. Moreover, no significant relationship was established in other processes.

Results of sensory analysis

Results of sensory analysis demonstrated differences in the sensory parameters (appearance, taste, smell, aroma, mouth feeling, and general evaluation) of samples. Among the sensory parameters, the highest appearance value was found in the microwave process dissolved at 10°C ($p < 0.05$), and no significant difference was found among other processes. In terms of taste and odor parameters, the highest values were obtained in the microwave dissolution processes (at 10°C and 24.5°C). The highest values were established in aroma and mouth feeling parameter analysis of samples that were thawed at room temperature with microwave process. All the values obtained through different processes with the lowest general evaluation parameters in control samples, infrared-assisted microwave, and infrared dissolution (at room temperature and refrigerator temperature) samples were found to be statistically significant ($p < 0.05$) (Figures 4 and 5).

Besides this, the microwave process got the highest scores in the taste parameter of sensory analysis. Thawing time had no effect on taste and aroma parameters. Infrared thawing process got the lowest scores for odor parameter. The effect of thawing time on odor parameter could not be determined. Infrared application got the lowest scores for aroma parameter of sensory analysis. The

Table 1. Sensory analysis form.

Product: Manti with minced meat					
Quality criteria	**Codes**				
Taste					
Odor					
Flavor					
Appearance					
Mouth feeling					
General taste					
Values	1–3 = Very bad	4–5 = Bad	5–6 = Medium	7–8 = Good	9–10 = Very good

microwave thawing process got the highest scores for mouth feeling parameter. The effect of annealing time on mouth feeling and appearance parameters could not be determined. Microwave process received the highest scores for general evaluation parameter of sensory analyses. The annealing time had no effect on aroma parameter. Microwave thawing process got the highest scores for appearance parameter.

Table 2. Thawing processes, temperatures, and time.

Thawing processes	Thawing temperatures and time	
	10°C (sec)	24.5°C (sec)
Microwave medium level	23	33
Infrared	60	155
Infrared-assisted microwave (50–50%)	20	30
40°C Running water	150	420
40°C Dry hot air	240	420

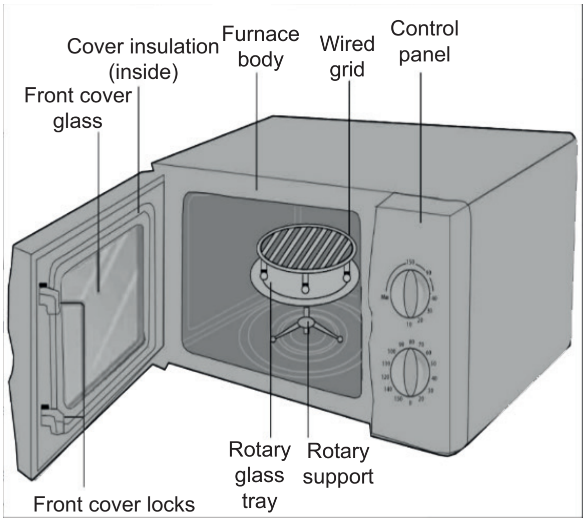
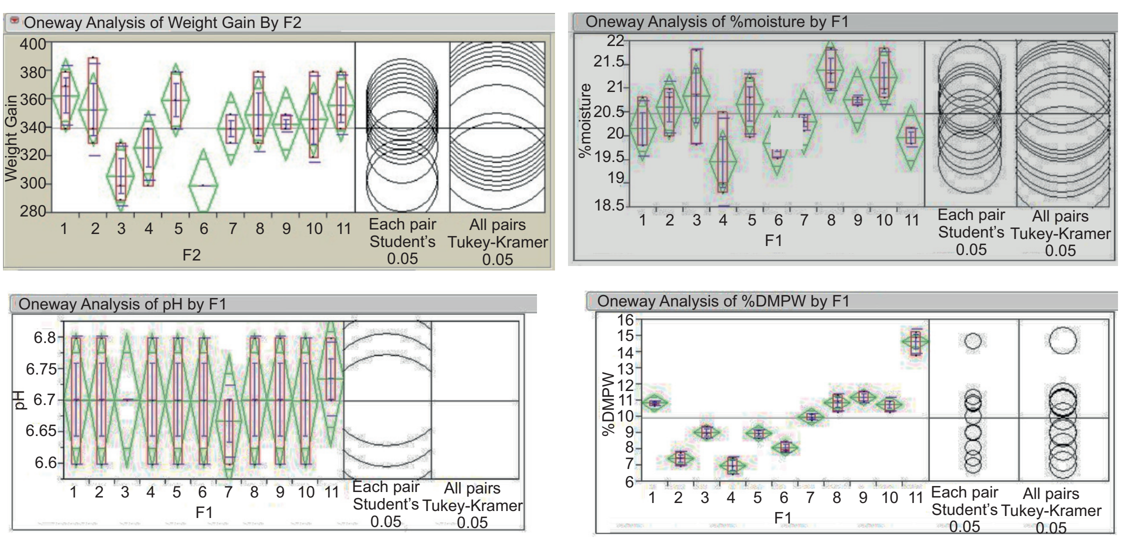


Figure 2. Far infrared (FIR)-assisted microwave oven.

Discussion

In the study, the maximum thawing time was determined for infrared-assisted microwave process whereas the minimum thawing time was obtained for running water process. In a study conducted by Álvarez *et al.* (2005), the shortest dissolution time was determined for an infrared–microwave combination process used to defrost frozen mashed potatoes, compared to infrared and microwave processes used separately. In another study, microwave process had a shorter thawing time compared to the conventional method used for thawing strawberries (Holzwarth *et al.*, 2012). In a study conducted on thawing frozen anchovies and blue fish, it was reported that the dissolution time was minimum in case of microwave thawing and maximum for running water thawing (Alberio *et al.*, 2012). It was determined that the obtained results were compatible with the results obtained in literature. No significant differences ($p > 0.05$) were observed between samples for weight gain, pH values and moisture content. The most effective factor for weight increase was starch gelatinization and the water-holding capacity of dough. It was assumed that the annealing processes performed had no effect on the rheological properties of manti dough. It was reported that pH values of fresh manti were close to neutral depending on the processing method applied (Sitti, 2011).



1. Microwave medium-level, 23 sec, 2. microwave medium-level, 33 sec, 3. Infrared, 60 sec, 4. infrared, 155 sec, 5. infrared-assisted microwave (%50–50), 20 sec, 6. infrared-assisted microwave (%50–50), 30 sec, 7. 40°C running water, 150 sec, 8. 40°C running water, 420 sec, 9. 40°C dry hot air, 240 sec, 10. 40°C dry hot air, 420 sec, 11. control.

Figure 3. Results of physicochemical analysis.

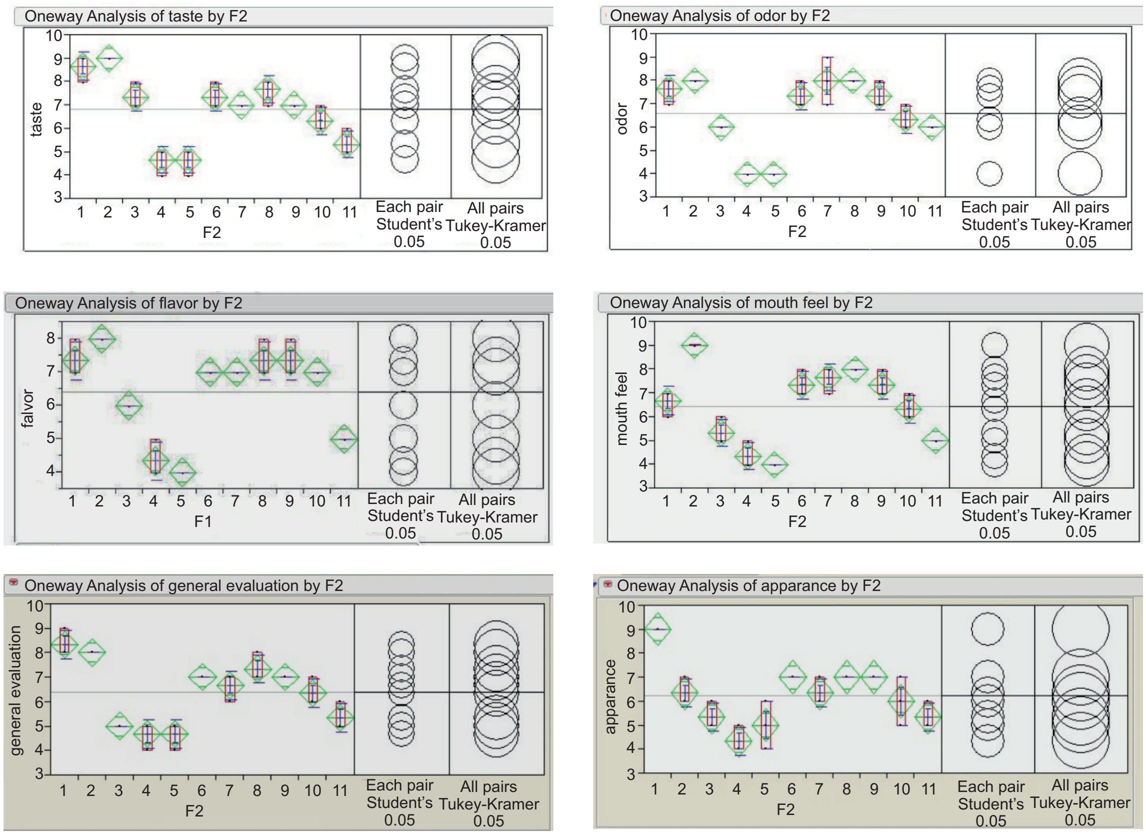


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Figure 4. Results of sensory analysis.

Thawing processes in case of frozen manti did not cause any significant change ($p > 0.05$) in its pH value. A study has reported that the pH values of manti samples stored at refrigerator temperature and packed in vacuum and modified atmosphere increased with increase in storage time, but initially there was no significant change in the pH values of samples (Sitti, 2011). In this study, since manti samples were stored for a short duration at -18°C, the probability of biochemical reactions was very low, and their pH values depicted no change. In addition, a very short duration of thawing processes reduced the possibility of biochemical reactions. Therefore, there was no significant change in pH values, and the values obtained were compatible with those found out in literature.

An important parameter for the quality of manti is the amount of dry matter allowed into water. As this value increases, the quality of manti decreases (Sitti, 2011). According to the results, the DMPW values of control samples were found to be high as well as statistically significant ($p < 0.05$). Therefore, it was concluded that the short-term thawing of manti instead of cooking it directly would decrease the amount of dry matter transferred into water, and thus its cooking quality would be preserved. After thawing of frozen manti, its cooking improved the sensory quality of samples. The obtained results were found to be statistically significant ($p < 0.05$). Direct cooking the frozen manti caused sudden changes in the temperature of manti, and therefore, the amount of starch passing to the cooking water increase and the manti dough sticks This happened because the sudden change in temperature caused excessive gelatinization of starch, and the lattice structure of starch particles embedded in proteins was damaged, resulting in the emergence of starch particles (Gökmen *et al.*, 2015).

It was estimated that thawing frozen manti with dielectric processes caused less damage to the protein–starch matrix of manti. Thus, starch granules played an important role in preserving the sensory quality of manti by less allowing of dry matter into cooking water. On the other hand, other processes (hot air and running water thawing) decreased the quality of manti in terms of both shape and texture. Hence, dielectric processes are preferred for thawing of manti. A study reported that heating at high frequency (0.1–2.5 GHz) is required for thawing of meat in a microwave. Accordingly, high-frequency microwaves were used in this study.

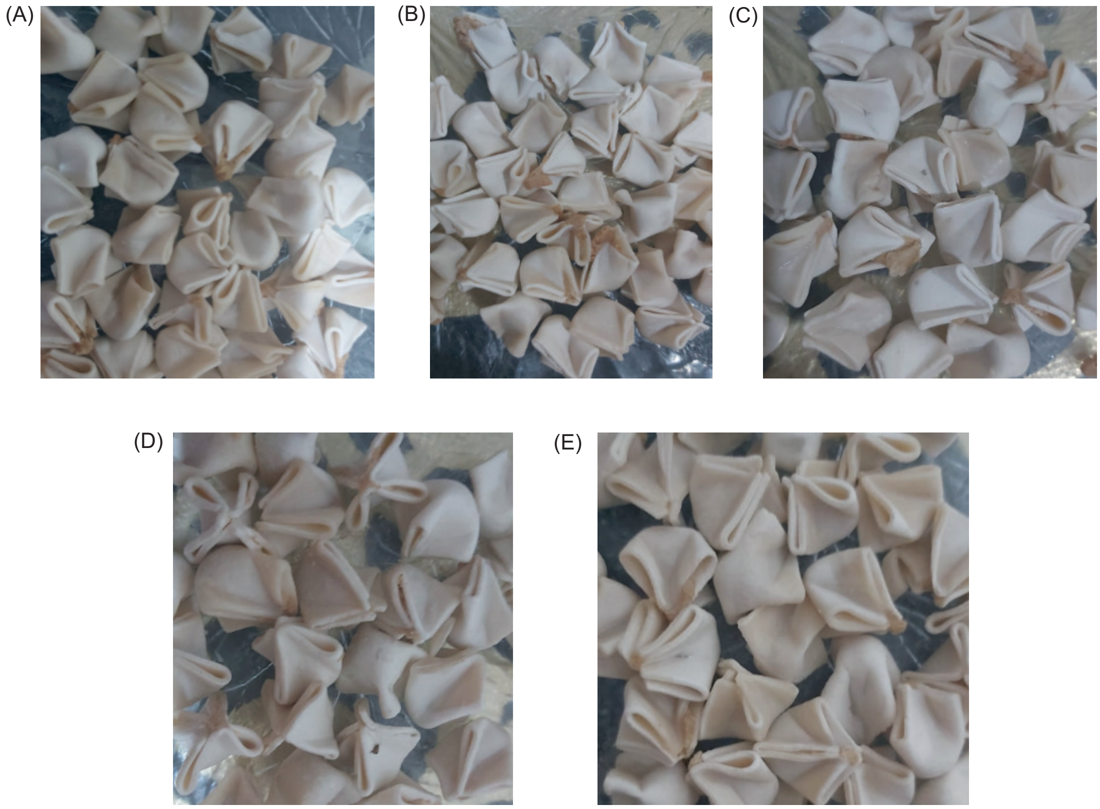

Figure 5. Mantı samples produced with (A) microwave, (B) ınfrared-assisted microwave, (C) ınfrared, (D) running water, and (E) dry hot air thawing processes.

Especially in control samples, it was estimated that the reason for the change in the amount of dry matter passing into the water was due to this. Presence of amylose and amylopectin fractions in the starch structure was another parameter that directly affected the cooking quality of manti. The starch particles embedded in flour protein were passed into water depending on the thawing process used for production. In addition, this condition caused the surface of manti grains to soften and their appearance to become worse. The passing of starch into water negatively affected the taste and aroma of manti. Likewise, while it is cooking manti, does not stick of the dough and does not come out of the mortar affects the mouth feeling parameter of manti. For this reason, it was estimated that mouth feeling values were high in tempered samples and low in control samples (Gallegos-Infante *et al.*, 2010).

Accordingly, it was determined that dissolving of frozen manti with thawing processes prior to cooking preserved the sensory quality of manti, and decreased the amount of dry matter passing into water. Besides, annealing processes had no effect on the pH and moisture content of manti. It was also determined that the thawing time of frozen manti was short and the most effective process was infrared thawing. More studies are required on this subject.

One of the parameters that determined the quality of cooking of manti was the amount of dry matter that passed into water. The higher the amount of dry matter passing into water, the more turbid would be the cooking water, thus decreasing the adhesion and visual quality of manti. There would also be a loss of mouth feeling and aroma of manti (Gökmen *et al.*, 2015). Owing to all these factors, it was estimated that the sensory quality of control samples was low compared to thawed manti samples. In order to increase the shelf life, fresh manti was stored and packed in vacuum and modified atmosphere. Although positive results were obtained in the studies conducted by Sitti *et al.* (2009) and Uzunlu and Var (2016), it was reported that the production cost of the product increased. Gökmen *et al.* (2015) reported that the sensory and chemical properties of various brands of manti available in the market were different. Ozturk *et al.* (2009) reported that the microbiological quality of manti samples available in Kayseri province was found to be quite low. One course to avoid all these negativities is to freeze manti on commercial level. Hence, it was concluded that different thawing processes must be used to preserve the quality of manti. In addition, it was determined that the sensory quality of manti decreased with increase in dry matter passing into the water during cooking of frozen manti. It was also determined that of all the dissolving processes, microwave dissolution was the best approach for preserving sensory parameters of manti

Studies conducted by Chipley (1980) and Emam *et al.* (1995) compared ultrasound-assisted vacuum thawing (UVT) or microwave vacuum thawing (MVT) of red sea bream fillets with fresh, cold storage thawing, vacuum thawing, microwave thawing, and ultrasound thawing. Results demonstrated that UVT and MVT caused limited damage to fillets compared to other thawing processes. Similar results were found in our study with the use of microwaves.

Conclusion

In this study, physicochemical properties and sensory qualities of manti samples were investigated due to different thawing processes employed prior to consuming frozen manti. It was concluded from the results of sensory and physicochemical analyses that freezing was necessary for manti.

Future directions

In recent years, industrial-microwave systems with band have been designed for microwave application, which is one of the dielectric methods. In these systems, the product is transported by conveyor belts and subjected to microwave application in a closed environment. It is estimated that these systems could be applied in the industrial thawing of frozen manti. The most important challenges in optimizing microwave applications with conveyor belts are that all products are thawed equally and their temperature distributions are homogeneous. For this, mathematical models could be used. Hence, these problems could be solved by making separate modeling for each machine in conveyor belts microwave applications.

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