Changes in the Gastronomic Characteristics Plain Tukish Delight (Lokum) During Production

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Abstract

Gastronomy is a new science in Turkey and it is difficult to find a study on Turkish delight (lokum) gastronomy. This research is an initial study conducted on the gastronomy values of lokum. In this study, the changes in the color, texture, acidity and pH content of lokum were determined during the cooking period. As a result of the research, the effect of the prolonging cooking period, it was shown that the hardness, gumminess, chewiness, springiness and cohesiveness of plain lokum decreased with increasing of cooking period. It was observed that while the CIE L* values decreased, a* and b* values increased with the extending of cooking period. The results of the research showed that it is appropriate to cook for 60 minutes in order to have a proper texture and aroma of plain Turkish delight.

Keywords: *Gastronomy, Turkish delight, lokum, starch, texture, color*

Sade Lokum Üretimi Süresince Gastronomik Özelliklerinde Oluşan Değişmeler

Öz

Gastronomi Türkiye'de yeni bir bilim olup lokum gastronomisi hakkında bir çalışma bulmak oldukça zordur. Bu araştırma, sade lokum gastronomik değerleri üzerine yapılan ilk çalışmadır. Bu çalışmada lokumun pişirme süresince renk, doku, asidite ve pH değerlerinde oluşan değişmeler incelenmiştir. Bu çalışmada pişirme süresi boyunca lokumun dokusu, rengi ve bazı kimyasal değerlerindeki değişiklikler belirlenmiştir. Araştırma sonucunda, pişirme süresinin uzamasıyla, sade lokumun sertlik, yapışkanlık, çiğnenebilirlik, esneklik ve sakızımsılık özelliklerinde azalma olduğu belirlenmiştir. Pişirme süresinin uzatılması ile CIE L* değerleri azalırken, a* ve b* değerlerinin pişirme süresinin uzamasıyla birlikte arttığı gözlenmiştir. Araştırma sonuçları, sade Türk lokumun uygun bir doku ve aromaya sahip olabilmesi içn 60 dakika pişirmenin uygun olduğunu göstermiştir.

Anahtar Kelimeler: *Gastronomi, lokum, nişasta, doku, renk*

INTRODUCTION

The world of food has rapidly evolved over the last few decades. Among many other developments, new and parallel approaches to the way chefs cook and food scientists do research have emerged in many restaurants and laboratories around the globe (**Vegaa and Ubbinkb, 2008**). Gastronomy is defined as the reasoned study of all that is related to man as he nourishes himself. Gastronomy is a new science in Turkey, only gaining prominence in the last 10 years. The field of gastronomy has a practical purpose, namely, "to keep humankind alive with the best possible food" (**Linden et al., 2008**). A new culinary trend called 'molecular cooking' has been touted as the most exciting development in haute cuisine. The term "molecular and physical gastronomy" was coined in 1988 by Hungarian physicist Nicholas Kurti and French physical chemist Hervé. Molecular gastronomy is a subdiscipline of food science that seeks to investigate the physical and chemical transformations of ingredients that occur in cooking (**This, 2006**).

Lokum is a food consisting essentially of sugar and starch raw material, has been known in the Ottoman territories in Anatolia for the soothing of the throat since the 15th century (**Anonymous, 2004; Batu, 2006**). It is a very favorite and delicious food consumed and has an elastic structure which can have different colors and flavors. However, it is difficult to find enough gastronomic studies about the color, viscosity, chemical composition of lokum and there has been little scientific gastronomological research about lokum. The most comprehensive study on lokum was carried out in Turkey at Ege University in the 1980s (**Batu and Kırmacı, 2006**). This is a very good work on the art of traditional lokum production. The work, titled "Research on the Construction Technique of lokum," was extensive. In this study, the general nature of technical problems in Turkey and the experimental nature of industrial lokum production and its raw materials, formulation, cooking temperature and time, candy molding, as well as quality criteria such as surface cracking, and scaling were investigated (**Gönül, 1985; Batu et al., 2014**). **Dogan (2008)** focused on the problems of lokum in terms of production and raw material problems, as well as on the marketing of lokum. Another study gives information about the production of Afyon cream lokum, and the packaging of creamy lokum in MAP to extend its shelf life (**Dereli and Şevik. 2011**). Lastly, a new study conducted on the production of black grape and sour cherry lokum (**Batu and Arslan, 2014; Batu et al., 2014**). However, today it is necessary to make more advanced studies of lokum gastronomy (**Batu and Batu, 2016**). To do this, this article is especially important in terms of lokum gastronomy and production of healthier lokum.

Texture evaluation is an important factor in developing a new food product. Both sensory evaluation techniques and instrumental measurements are used in food texture research to assess texture parameters. Correlations are generally used to assess the relationship between the instrumental measurement and sensory perception in order to predict consumer responses or to evaluate quality control tools or parameters (**Saldamlı, 2007**). The most popular instrumental imitative test, Texture Profile Analysis (TPA) was first developed for the General Foods Texturometer. Our objectives were to assess the relationships between the primary textural characteristics of hardness, gumminess, chewiness and cohesiveness when evaluated simultaneously in lokum representing the lokum texture spectrum (**Batu et al., 2014**). So, physical (color, texture) and chemical (pH, acidity) values of lokum are also important to lokum gastronomy. Additionally, the total antioxidant activity and total phenolic content are also very important values in assessing the impact of lokum on human health. That is why this is a simple initial research which can be conducted in terms of a gastronomy of lokum that includes the color, textures, acidity and pH values of plain lokum.

MATERIALS AND METHODS

Materials

The lokum used in the research was produced on-site at a pilot plant at Tunceli University. In lokum production, an electrically driven and the stirrer speed boiler with a double-walled oil heater is used. The boiler is temperature adjustable. The granulated sugar, corn starch and citric acid used in lokum production were obtained from a supermarket in Tunceli. The Tunceli city tap water was used in the lokum production.

Production of plain lokum

Lokum is a sugar based jelly-like confection containing starch with the gel former (**Batu and Arslan, 2014**). The formula of this production is 20 kg sucrose + 25 kg water + 3, 5 kg corn starch + 25 g citric acid. Before adding raw materials into the boiler, the 3.5 kg corn starch to be used in lokum production was dissolved in an approximately 7-8 kg of water. This is called the starch milk. Then the rest of the water and 18 kg of granulated sugar were poured into the boiler and then the mixer of the boiler was operated. After dissolving the sugar in water and adding the starch milk, a temperature of about 40°C was set, then 25 g citric acid was added and finally the cooking begun. After the mixture started to boil (about 20 minutes), the steam fan of the boiler was operated. Samples were taken from the boiler by opening the top cover during production at 40, 50, 60, and 70 minutes. At 70 minutes excessive hardening of lokum was observed. It was determined that a desirable consistency and sufficient cooking time occurred by cooking the lokum mass for 60 minutes. To make a homogeneous mixture, 4-5 kg of lokum mass was taken out of the drain valve of the boiler, and it was poured back into the boiler. All of the lokum was poured from the bottom drain valve into wooden framed or made of steel trays manually. The lokum was left to ripen and cooled for 24 hours at room temperature. Then lokums were cut by mechanically and then the required analyses were carried out (**Batu et al., 2014**).

Methods

Instrumental Texture Analysis

Texture values were evaluated instrumentally at room temperature (20-25ºC) applying the Instrumental Texture Profile Analysis (TPA) instrument (TA-XT Plus, Stable Microsystems, Godalming, Surrey, UK) by slightly modifying the methods of Uslu et al. (**Uslu et al., 2010; Batu and Thompson, 1993**). TPA was carried out using a flat ended pressure plate and then three-time compressions of the consecutive samples of Turkish Delight were made (Figure 1).

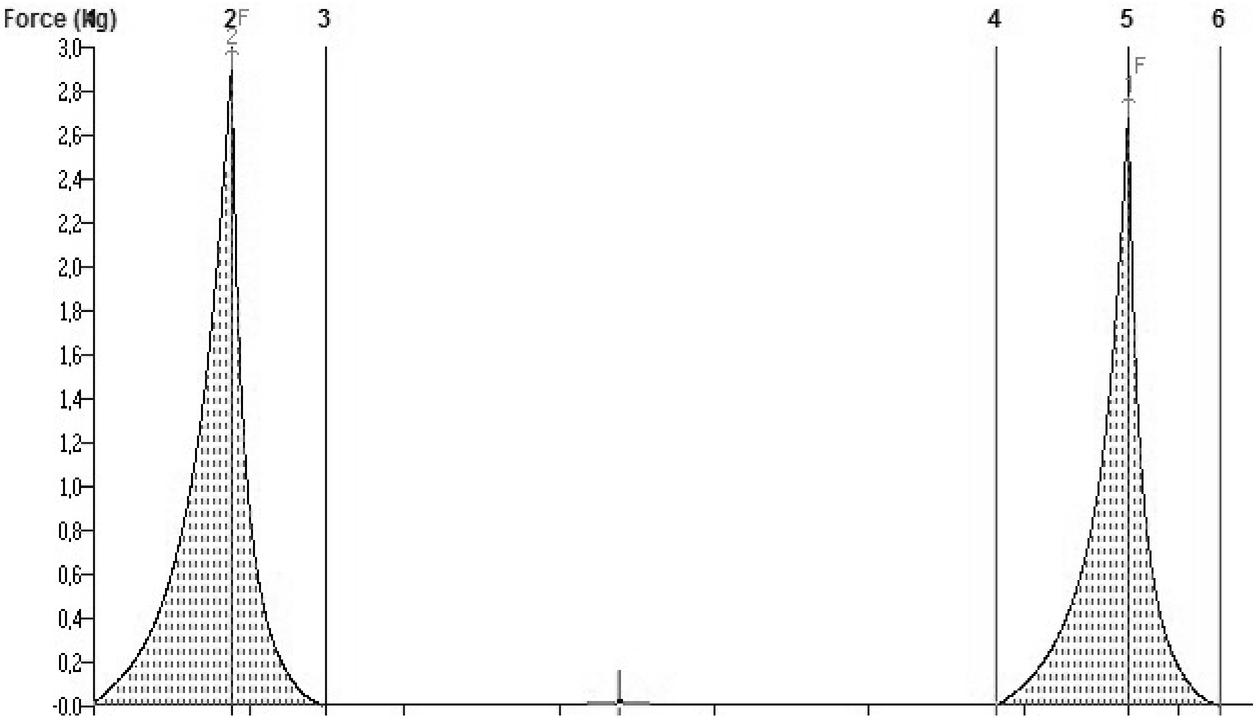

Figure 1. Aspects of a Texture Profile Analysis Curve (**Batu et al., 2014**).

Color measurement

The methods described by CIE-LAB (1992) and **Batu et al. (1997**) were used to determine the color values of the Turkish delight. CIE L*a*b* color parameters were recorded as L* (lightness), a* (redness), and b* (yellowness) with a color difference meter (CRN300, Kangguang Instrument Co., China) using the transmission mode. Samples were put into a 5-cm^3 glass cell and then color measurements were taken. The results were expressed as follows: L*, a*, and b*, indicating lightness, redness, and yellowness, respectively (**Batu and Arslan, 2014**).

Titratable acidity and pH

To extract the samples, 10 g of Turkish Delight was mixed with 90 mL of distilled water in a beaker. At the end of this time, the mixture was homogenized using a homogenizer. The mixture was then stirred with the help of a glass stick, and then at 20°C the pH measurement was carried out (Orion 3-Star pH meter, USA) (10). At 20°C, the total acidity of each mixture was monitored using the pH meter until pH 8.1 was reached after titration with 0.1 N NaOH. The calculation was done as % anhydrous citric acid in the sample (**Altan, 2002**).

Statistical Analysis

Physical and chemical analysis of plain lokum samples was carried out to determine the difference1s between the groups in order to interpret the results of the analysis of variance (one-way MANOVA). The differences between the two groups were observed in order to determine which Duncan Multiple Comparison Test would be used. Means and standard deviations were calculated for both sensory (n=11) and instrumental (n=7) data using the SPSS (18.0) computer program (**Norusis, 1993**).

RESULTS

Instrumental Texture Profile Analysis (TPA)

In this section, the effects of cooking time for the plain Turkish Delight on TPA features of Turkish Delight have been investigated. Texture of the product is very important for gastronomic values of lokum. TPA values depending on cooking time for Turkish delight are given in Table 1. According to the results of variance analysis, the differences between the values of hardness, gumminess, chewiness, cohesiveness, springiness and resilience in Turkish Delight depending on cooking time have been found statistically significant($p<0,05$).

Table 1: The Hardness, Gumminess, Chewiness, Cohesiveness, Springiness and Resillience values of simple lokum depending on 70 minutes cooking time (n = 7)

Cooking Time	**Hardness (g)**	**Gumminess**	**Chewiness (g.mm)**
40 min.	2242.36±14.6d	1000.09±10.6d	884.715±8.7d
50 min.	3090.40±18.5c	2104.56±6.7c	2021.56±7.7c
60 min.	3201.95±16.1b	2616.99±14.1b	2521.55±11.5b
70 min.	4617.84±68.7a	3786.63±59.6a	3345.39±47.1a
Cooking Time	**Cohesiveness**	**Springiness (mm)**	**Resilience**
40 min.	0.446±0.05 c	0.880±0,04b	0,265±0,03c
50 min.	0.681±0.03b	0.884±0.06a	0.375±0.05a
60 min.	0.817± 0.03a	0.960±0.08a	0.460±0.03a
70 min.	0.820± 0.01a	0.963±0.09b	0.465±0.02b

[a-d]Means within a column with different letters are significantly different ($p<0.05$)

Hardness: Force required to compress a food between the molars,

Cohesiveness: The strength of the internal bonds making up the food,

Chewiness: The energy required to chew a solid food until it is ready for swallowing, ***Gumminess***: Hardness x Cohesiveness.

Springiness**:** The spring back is measured at the down stroke of the second compression, so the wait time between two strokes can be relatively important.

Resilience**:** Resilience is measured on the withdrawal of the first penetration, before the waiting period is started. Resilience can be measured with a single compression, however, the withdrawal speed must be the same as the compression speed (**TTC, 2014; Batu et al., 2014**).

There was a significant difference ($p < 0.05$) between the TPA (hardness, gumminess, chewiness, cohesiveness, springiness and resilience) values of plain lokum. The lowest values of TPA values were obtained from the samples cooked for 40 minutes whereas the highest TPA values obtained the lokum cooked for 60-70 minutes. According to the research results, the hardness, gumminess, chewiness, cohesiveness, springiness and resilience values of lokum increased proportionally with increases of the cooking period. It was thought that the texture became harder because of water loss in lokum mass with the increasing of cooking period.

Changes in CIELAB Color values

Color is one of the most important quality attributes of gastronomy. The color values of the plain lokums are given in Table 2. The research results show that the differences between the L* (refers to darkness/lightness) values of the products were significantly ($p < 0.05$) decreased during cooking period. Thus, while the L* values of the lokum samples decreased during cooking because of caramelisation decreases continued with the extending of the amount of cooking period. Difference between lokum color values is significant ($p < 0.05$) depending on the cooking time of lokum. When the cooking time considered in terms of L* value having the highest value with 41.90 during 40 minutes cooking time, it was decreased during the 50 and 60 minutes cooking period, and it was reached to the lowest value when it cooked for 70 minutes. In other words, the cooking time of plain lokum increases the L* value. So; the color is determined to be darkened and its brightness decreases.

Tablo 2. The L*a*b* values of Turkish Delight during the 70 minutes cooking time (n = 7)

Cooking Time	L*	a*	b*
40 min.	41.90 ± 0.430 a	-4.32 ± 0.100 c	-1.73 ± 0.086 d
50 min.	41.54 ± 0.479 a	-4.18 ± 0.065 bc	0.13 ± 0.120 c
60 min.	40.07 ± 0.262 b	-4.08 ± 0.042 b	2.51 ± 0.085 b
70 min.	34.44 ± 0.511 c	-3.19 ± 0.047 a	5.61 ± 0.185 a

[a-d]In the same column with different letters are significant differences between means ($P < 0.05$)

The mean of the a* values (refers to redness) of the control lokum samples was the lowest, with a value of -4.32. In addition, the a* values increased significantly with the increasing of cooking period. The* value is good parameter for red color development and the degradation of the sugars being cartelization and at the end of the process for the formation of darkening of product color is occured. The a* values are negative (-) for all the cooking times (Table 2). Since a* represents a red color and –a* a green color, the products with a cooking time of 40 min. have a secret green shade with a value of -4,32 value. Similarly, the products with a cooking time of 70 min. have the lowest level of a green shade, which almost merges into an ashen color, with a value of -3, 19, and this is an indication of browning happening in the product.

Similarly, when b* values are evaluated, it is seen that while the color value of the products with a cooking time of 40 minutes. is 1, 73, and it is 5, 61 at the end of 70 minutes. While the b* parameter shows yellow discoloration (**Artes et al., 1999**). That is, while only 40 minutes. products have a relatively blue color, the characteristic color of plain Turkish Delight, gray-yellow, begins to appear after 40 minutes. While yellow coloration only just begins to appear, gray-yellow coloration periodically increases at 60 and 70 minutes.

Titratable acidity and pH

According to the results, pH values decrease as cooking time increases and total acidity values increase periodically (Table 3). Results have shown that pH values decreased significantly ($P < 0.05$) during the 60 minutes time of cooking, and no change was observed at 60-70 minutes. PH values were 0.040 between 40-50 minutes; 0,025 between 50-60 minutes, and 0,013 between 60-70 minutes, showing a decrease as cooking time is prolonged. Titratable acidity values depending on cooking time for plain Turkish delight achieved their highest degree at a cooking time of 70 minutes. Because the amount of water in the product decreases and the amount of sugar and acid increases during cooking. According to this formulation, proper cooking time for Turkish delight can be accepted as 60 min. At the end of this time, pH value was realized as 4.05 and acidity value 0.067 g/100g.

A significant difference was found in pH values obtained from cooking period. Naturally, there is a direct correlation between the increase in sugar concentration and the decrease in pH. The pH values of the Turkish delight produced are provided in Table 1. The results of the study show that there were significant ($P < 0.05$) differences between the pH and titratable acidity (TA) by the extending of cooking period. While the pH value was 4.10 at 40 minutes cooking time, it was decreased from 4.10 to 4.02 during cooking period. TA values increased significantly ($P < 0.05$) during the cooking period.

Tablo 3. The pH and total acidity values of simple lokum depending on 70 minutes cooking time (n = 7)

Cooking Time	pH	Titratable Acidity (%)
40 min.	4.09±0.05a	0.051±0.00d
50 min.	4.05±0.04b	0.062±0.01c
60 min.	4.025±0.03c	0.067±0.01b
70 min.	4.012±0.04c	0.073±0.04a

$^{a-d}$Means within a column with different letters are significant differences between means ($P < 0.05$)

DISCUSSIONS

Many food scientists and technologists use their understanding of fundamental scientific principles to design and fabricate novel structures within foods to provide functional properties, such as stability, taste, texture, appearance, or flavor (**Linden et al., 2008**). The reason of this is to produce a desirable product in terms of color and texture. The texture values of lokum should be determined as TPA values. The reason for effecting of cooking period in TPA values of lokum is that the dissolution of starch in aqueous starch solutions and water intake into starch causes the gelation of starch and an increase in the viscosity of the medium. The characteristics of water intake into starch and its dissolution show an increase depending on an increase in temperature (**Szczesniak, 1987**).

Starch type is effective on water binding feature. Corn starch is often preferred in the production of Turkish Delight. Such factors as the granular structure and form of starch, molecular structure of amylose and amylopectin, amylose-amylopectin ratio and amounts of lipid, protein and phosphate determine starch's functional features and hence, industrial use. Starch's functional features are important in the production of Turkish Delight. These features are specific viscosity, gel structure, freezing-dissolution stability, swelling and resistance against swelling. Starch granules undergo structural change under the influence of water and temperature. These granules swell and form gel with heating because of the fact that they absorb water. With an increase in temperature, amylose is separated from amylopectin as temperature increases and amylose passes from the granule into the solution (**Tako et al., 2014)**. With the ensuing cooling, amylose molecules form H^+ bonds with other amylose and amylopectin molecules. Therefore, as a result of water entrapment within this web formed with amylose and amylopectin, a gelatinous structure is formed. When this structure is frozen or cooled over a long period of time. Amylose molecules come closer to each other and form intense crystal clusters (retrogradation) and water molecules are released. Generally, amylose constitutes 17-30% of the total starch and amylopectin 70-83%. Normally, amylopectin in corn starch is relatively more than it is in wheat starch (**Ölçer and Akın, 2008**). Retrogradation is not desired in the production of high quality Turkish Delight. To achieve this, amylose molecules coming close to each other have to be prevented, and it is thought that this depends on the amount of amylopectin in corn starch and can be better achieved with corn starch (**Tako et al., 2014)**.

Corn starch, which has a low amylose content and high amylopectin content, is more easily cooked and maintains its stability during cooling and storing. Therefore, it is preferred in lokum production.

The water in the syrup plays two important roles: firstly, it reduces the chance of burning since most of the initial heat goes into the work of evaporation of water molecules. Secondly, the amount of water in the sugar syrup is important for the texture of the confection. Generally, the less water the sugar syrup contains, the harder the texture of the confection will be. For producing lokum makes very low concentration of water. That is why while the lokum cooking continues, the free water evaporarates and lokum mass become more concentrated and the texture also became harder. In non-crystalline confections the syrup is cooled fast enough so that the sugar molecules do not have time to arrange themselves into crystals and so form a liquid-like, or glassy structure. This gives a hard and brittle texture like that of boiled sweets (**Theguardian, 2010**). This study is important for the gastronomy of lokum when considering the textural structure of lokum and its color.

Molecular gastronomy is the scientific discipline that explores the mechanisms of culinary transformations from raw ingredients to eating the final dish (**This, 2005**). The Maillard reaction has a major role in explaining many of these changes because it is responsible for many of the flavor and color changes produced in food during culinary processing (**Yaylayan, 2006**).

The color of lokum also very important fort he consumers. Visual color in processed foods is largely due to colored products of Maillard or nonenzymic browning reactions. In spite of the longstanding aesthetic and practical interest in Maillard-derived food coloring materials, relatively little is known about the chemical structures responsible for visual color. A food's colour immensely affects how people perceive the food's flavour even before it is tasted. The influence of color on quality perception has long been known. How much thought has been given to food choices because of color, a food product must be suitable for the satisfaction of the customers. When this perception changes it often has a detrimental effect on the customer's perception of how that food should taste. The importance of color on taste perception is essential when customers decide whether or not to eat food that is prepared for them. This is why plate presentation is a key focus of top chef's nation wide. People associate different colors with different colors. The relevance of color sensory perception and how it relates to food selection is confirmed by various studies. Taste is actually the last step in sensory perception. The meal is first visualized and then placed in the mouth (**Magoulas, 2009**).

It is obvious that b* values (refers to yellowness and orange color) are also positive (+) and seem to increase in direct proportion to the cooking period. This situation is thought to cause the increase in the b* values of lokum. As the brightness decreases, the blue color is perceived instead of the red one. Thus, while the opposite position was expected, the red color in the lokum declined and the blue one increased. **Dirik (2009)** carried out a study on the production of a type of Turkish delight with pomegranate juice and found the a* and b* values to be 0.11 and 7.61, respectively (**Batu et al., 2014**).

In the light of the above observations, it can be concluded that gloss, and yellow and blue coloration decreases, but red and yellow coloration may increase as cooking time for plain Turkish delight increases. Heat treatment at high temperatures for long periods of time causes caramelization of sugar and carbohydrates in the products (**Cemeroğlu, 2011**). The increase of red and yellow coloration in plain Turkish Delight samples is thought to be related to caramelization reactions. It is also thought that the decrease of water within the product depending on cooking time causes a decrease in the gloss of the product.

A chemical group within the structure of such simple sugars as glucose and fructose reduces copper ions as a result of a chemical reaction. Such sugars are called reducing sugars. This chemical group in saccharose is not reducing because it is not free. However, since the chemical group in the other glucose unit in maltose is free, it is reducing. Because glucose, fructose and lactose (milk sugar) is reducing, color darkening in bakery products increases, but saccharose sugar must first be broken down into glucose and fructose (**Artık et al., 2011**). This is also true for starch. It causes the color to be partially darkened during lokum production. This is very important for lokum gastronomy.

The boiling point of sugar syrup is greater than that of pure water and increases with increasing concentration of sugar in the syrup in a predictable manner. Thus, once the syrup is boiling the temperature can be measured and the cooking stopped at the appropriate temperature. At 113°C (85% sugar) make fudge, at 132°C (90% sugar) make chewy toffee and at 149°C and above (nearly 100% sugar) make hard sweets. If the temperature goes too high the sugar can start to caramelise. Breaking the sugar molecules apart generating both appealing colours and an increasing complexity of aromas and flavours. Heat too much and these aromas become bitter and the syrup burns (**Theguardian. 2010; Gay, 2015**).

The relationship between sugar molecules and flavor is one of the basic principles of molecular gastronomy. The taste is one of the most important criteria in terms of gastronomy. The acid content and pH value of lokum are the two most effective factors on taste and for sucrose inversion. Acidification is generally used to improve lokum quality, texture, flavor and taste. The titratable acidity increased with the increasing from 0,051 g/100g for 40 minutes cooking to 0,073 g/100g for minutes cooking time (Table 3). It is thought that acidity increases as a result of sucrose inversion as the cooking time for Turkish Delight increases. In earlier studies, pH values for plain Turkish delight were determined as 4,30-3,99 g/100g by **Doyuran et al. (2004**), as 4.49 by İpek (2009), as 3,91-4,61 by **Uslu et al. (2010)**, and the total acidity values as 0,068-0,080 by **Doyuran et al. (2004**). These repots suppot our study results. The little difference is probably because of the difference in Turkish Delight formulations. Based on these results, it can be argued that acidity in plain Turkish Delight tends to increase depending on the increase in cooking time, but similarity can be observed between some cooking times in terms of acidity.

CONCLUSIONS

According to the study results; cooking time increase was seen as effective on acidity, hardness, gumminess and chewiness character of the plain lokum. The set of cooking time and temperature combination for plain lokum production will usefull to provide for amendments to be considered. Moreover, the cooking time of plain lokum was effective on lokum color are included in our survey results. Therefore, in order to obtain the desired color for lokum, and in order to determine the gastronomic values of lokum, it is necessary to optimize the cooking time of lokum.

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REFERENCES

Altan, A. (2002). Laboratuar Tekniği. Adana. Turkey. Çukurova Üniversitesi Ziraat Fakültesi Ders Kitabı.

Anonymous, (2004). Gıdaların üretimi, tüketimi ve denetlenmesine dair kanun hükmünde kararnamenin değiştirerek kabulü hakkında kanun. No:5179. http://www.tbmm.gov.tr/kanunlar/k5179.html.

Artes, F., Conesa, M. A., Hernandez, S. and Gil, M. I. (1999). Keeping quality of fresh cut tomato. Postharvest Biology and Technology, 17: 153-162.

Artık, N., Bayındırlı, L. and Mert, İ. (2011). Karbonhidratlar, Mısır şekeri ve Gıda Endüstrisinde Kullanımı. Türkiye Gıda ve İçecek Sanayi Dernekleri Federasyonu. Teknik Basım Matbaası, Ankara.

Batu, A., and Thompson, A. K. (1993). Effects of Cross-Head Speed and Probe Diameter on Instramental Meesurement of Tomoto Firmness. In proceedings of the international Conference for Agricultural Machinery and Process Engineering. October 19-22 Seoul, Korea. pp: 1340-1345.

Batu, A., Thompson, A. K., Ghafir, S. A. M. and Rahman, A. N. (1997). Minolta hunter renk ölçüm aletleri ile domates, elma ve muz'un renk değerlerinin karşılaştırılması. Gıda, 4: 301–307.

Batu, A. (2006). Türk lokumu üretim tekniği ve kalitesi. Tekn Araşt. GTED, 1: 35-46.

Batu, A. and Arslan, A. (2014). Biochemical and sensory evaluations of Turkish delight (lokum) enriched with black grape and sour cherry syrups. Turkish Journal of Agriculture and Forestry, 38(2014): 561-569. doi:10.3906/tar-1303-80.

Batu, A., Arslan, A. and Eroğlu, A. (2014). Effects of Black Grape Syrup on Texture, Colour and Sensory Qualies of Value Added Turkish Delight (Lokum). Nutrition and Food Science. pp:1-8. Open Access. http://dx.doi.org/10.4172/2155-9600.S8-005.

Batu, A. and Kırmacı, B. (2006). Lokum Üretimi ve Sorunları. Teknolojik Araştırmalar. GTED, (3): 37-49.

Batu, A. and Batu, H. S. (2016). Türk Tatlı Kültüründe Türk Lokumunun Yeri (The Place of Turkish Delight (Lokum) in Turkish Sweet Culture). Journal of Tourism and Gastronomy Studies, 4 (1): 42-52.

Cemeroğlu, B. (2011). Meyve ve sebzelerin bileşimi. Meyve ve sebze işleme teknolojisi 1., Nobel Yayın Dağıtım, Ankara.

CIE-LAB, (1992). Minolta Precise Colour Communication. Colour Control from Feeling to Instrumentation. Handbook. Minolta Camera Company, Osaka, Japan.

Dereli, Z., and Şevik, R. (2011). Modifiye Atmosferde Paketlenerek Depolanan Afyon Kaymağında Oluşan Kimyasal Değişimler. Gıda Teknolojisi Elektronik Dergisi, 2011(6): 1-8.

Dirik, A. (2009). Nar ve nar suyunun lokum üretiminde kullanım olanakları. Yüksek Lisans Tezi. Harran Üniversitesi, Şanlıurfa.

Doğan, İ. (2008). Hammadde ve sorunlarıyla Türk lokumu üretimi. Teknolojik Araştırmalar Gıda Teknolojisi Elektronik Dergisi, 1: 13-17.

Doyuran, S. D., *Gültekin*, M., Güven, S. (2004). Geleneksel gıdalardan lokum üretimi ve özellikleri. Geleneksel Gıdalar Sempozyumu. 23 - 24 Eylül 2004. Van. pp. 334 – 342.

Gay, J. (2015). The fly that sips treacle is lost in the sweets – John Gay. Guardian News and Media Limited or its affiliated companies. http://www.theguardian.com/-science/blog/2010/sep/24/sugar-honeycomb-cinder-toffee/print?.

Gönül, M. (1985). Türk lokumu yapım tekniği üzerine araştırmalar. Ders Kitapları 1. Baskı. Yayın No: 8. Bornova. Ege Üniversitesi Mühendislik Fakültesi, İzmir. .

İpek, D. (2009). Üretim aşamaları ve farklı ambalajlama tekniklerinin lokum kalitesine etkisi. Yüksek Lisans Tezi. Çanakkale Onsekiz Mart Üniversitesi, Çanakkale.

Linden, E. V. D., McClements, D. J. and Ubbink, J. (2008). Molecular Gastronomy: A Food Fad or an Interface for Science-based Cooking? Food Biophysics, 3(2): 246– 254.

Magoulas, C. (2009). How color affects food choices. UNLV Theses, Dissertations, Professional Papers, and Capstones. 552. Graduate College, University of Nevada, LasVegas. https://digitalscholarship.unlv.edu/cgi/viewcontent.cgi?article=-1553&context=thesesdissertations

Norusis, M. J. (1993). SPSS for Windows: Base System User's Guide. SPSS. Chicago.

Ölçer, H. and Akın, B. (2008). Starch: Biosynthesis, Granules Structure and Genetic Modifications. Dumlupınar Üniversitesi. Fen Bilimleri Dergisi, 16: 1-12.

Saldamlı, İ. (2007). Karbonhidratlar. Gıda Kimyası. Hacettepe Üniversitesi Yayınları, Ankara.

Szczesniak, A. (1987). Correlating sensory with instrumental texture measurements: An overview of recent developments. The Journal of Thermal Analysis, 18: 1-15.

Tako, M., Tamaki, Y., Teruya, T., Takeda, Y. (2014). The Principles of Starch Gelatinization and Retrogradation. Food and Nutrition Sciences, 5. 280-291.

This, H. (2005). Molecular gastronomy. Nature Materials, 4: 5-7.

This, H. (2006). "Food for tomorrow? How the scientific discipline of molecular gastronomy could change the way we eat". EMBO Reports. 7(11):1062–1066.

Theguardian. (2010). The science and magic of cinder toffee. http://www.theguardian.com/science/blog/2010/sep/24/sugar-honeycomb-cinder-toffee.

TTC, (2014). Texture Technologies. An Overview of Texture Profile Analysis (TPA). http://texturetechnologies.com/texture-profile-analysis/texture-profile-analysis.php

Uslu, M. K., Erbaş, M., Turhan, İ., Tetik, N. **(2010).** Nişasta miktarının ve çöven suyu ilavesinin lokumların bazı özellikleri üzerine etkileri. Gıda, (35/5): 331-337.

Vegaa, C. and Ubbinkb, J. (2008). Molecular gastronomy: a food fad or science supporting innovative cuisine?. Trends in Food Science and Technology, 19: 372-382.

Yaylayan, V. (2006). More acrylamide stories. A new look at an old reaction. IMARS Highlights, 1: 12-13.