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Optimization of process parameters of manna bar, a kind of nougat, production

Bir tür nuga olan manna barın üretim parametrelerinin optimizasyonu

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ABSTRACT

Manna bar, a kind of nougat, is a typical Iraqi-Iranian confectionary that is made by manna, glucose syrup, table sugar, egg white, cardamom and nuts (pistachio, walnuts, or almond). Manna bar is a similar confectionary with French nougat, Italian torrone, and Spanish turrón, but produced from different raw materials and different process. The aim of this research was to determine influence of cooking temperature, cooking time and mixing time on the quality of manna bars during the production. The analyses made in this study were moisture content, pH value, color and textural properties. It was found that increasing cooking temperature from 100°C to 120°C, cooking time from 5 min. to 15 min., and mixing time from 10 min to 30 min. decreased moisture content from 15.58 to 8.50 %, but increased ($p<0.05$) hardness from 131.56 to 856.16 g. Browning index and pH value decreased ($p<0.05$) by increasing mixing time. Response surface analysis was carried out to optimize the production of manna bar. It's results showed that cooking at 120°C for 10.10 min and mixing of 21.26 min was the best condition as desirability = 0.682. This study showed that high temperature at 120°C and long cooking for 15 min., and mixing for 30 min. improved the physical and chemical properties of manna bars.

Key Words: Manna, Manna Bar, Response Surface Analysis, Optimization, Cooking And Mixing Times

ÖZ

Bir tür nuga olan manna bar, manna, glikoz şurubu, şeker, yumurta akı, kakule ve fıstık, ceviz veya badem ile yapılan tipik bir Irak-İran şekerlemesidir. Manna bar, Fransız nugası, İtalyan torrone ve İspanyol turrón ile benzer bir şekerlemedir, ancak farklı hammaddelerden ve farklı işlemlerden üretilir. Bu araştırmanın amacı, üretim sırasında manna barlarının kalitesine pişirme sıcaklığı, pişirme süresi ve karıştırma süresinin etkisini belirlemektir. Bu çalışmada yapılan analizler nem içeriği, pH değeri, renk ve dokusal özelliklerdir. Pişirme sıcaklığının 100 °C den 120 °C ye, pişirme süresinin 5 dakikadan 15 dakikaya ve karıştırma süresinin 10 dakikadan 30 dakikaya artmasının nem içeriğini % 15,58'den % 8,50'ye düşürdüğü, sertliği ise ($p<0,05$) 131,56 g'dan 856,16 g'a yükselttiği bulundu. Karıştırma süresi arttıkça esmerleşme indeksi ve pH değeri azalmıştır ($p<0.05$). Manna bar üretimini optimize etmek için tepki yüzeyi analizi yapıldı. Sonuçlar, 120°C'de 10.10 dakika pişirmenin ve 21.26 dakika karıştırmanın arzu edilirlik = 0.682 olarak en iyi koşul olduğunu göstermiştir. Bu çalışma, yüksek sıcaklık (120°C) ve uzun pişirme (15 dakika) ve karıştırmanın (30 dakika) manna barlarının fiziksel ve kimyasal özelliklerini iyileştirdiğini gösterdi.

Anahtar Kelimeler: Manna, Manna Bar, Tepki Yüzeyi Analizi, Optimizasyon, Pişirme e Karıştırma Süreleri

Introduction

The history of manna goes back to three thousand years ago. In the earliest time, manna has been known in Asia Minor (Harrison, 1950). Manna is mainly obtained in Penjween-Sulaymaniyah in Iraq; it is collected between June and July (Bodenheimer, 1947). Manna is a sugary compound which consists of white to brown small tears and soluble in water (Lanza, 2005). It chiefly appears on the leaves of gallnut and oak trees which mostly grown naturally in the mountains. Manna is a crystalline covered with a white crust, that is an exudate of tree probably wounds tree by insect. Manna is used for production of local sweets, delicious cakes mixed with nuts, bread and a medicine for treatment of minor disease since Noah flood in this region (Leibowitz, 1944; Sabry & Atallah, 1961; Erkan et al., 2014; Al Safi et al., 2022). Also, special confectionary produced by manna sold in Baghdad under the name of "man es-simma" means the manna from heaven (Bodenheimer, 1947).

Manna collected from Iran (Gaz of Khunsar) has a pH value of 5.5, rotates polarized light to the right and free of nitrogen, alkaloids, tannin, sulfur, and halogens (Br, Cl, and I) (Aeinechi et al., 1976; Sdiq & Saeed, 2019). It is originally white or cream-colored while it may appear greenish or brownish-yellow in bulk, depending on impurities. It is hydrophilic, very sticky, and soft under normal conditions, breakable when dry, and readily soluble in alcohol and water. Nicknejad (1976) analyzed gaz- alafi, it is (a type of manna), gathered from desert trees, and reported about a 10% fructose and 40% sucrose content. In Iran the word "Angabin" is used for manna, and it is used in the markets for traditional medicines. In Iranian medicine, different kinds of manna have been used as expectorant, antipyretics, laxatives and to treat hyperbilirubinemia (Ghasemi et al., 2003; Azadbakht & Alinejad, 2005; Al Safi et al., 2022).

Manna bar is a typical Iraqi-Iranian confectionary that is made up of manna, glucose syrup, sugar, egg white, cardamom and nuts (pistachio, walnuts, or almond). Manna bar produced in Al-Sulaymaniyah, Iraq, is very famous and this city has lots of famous firms. It is still produced in a traditional way. In firms, traditional manna bar production starts by dissolving of manna in water, and boiling until becoming a sauce or molasses. Then, it cooks with glucose syrup, after a certain time egg white is added during the mixing and then cardamom with or without pistachios/walnuts is added. After that, the mixture is put in a plate and left about 10 hours. Manna bar is ready for cutting. Finally, the produced Manna bar is packaged and is ready to sell.

Manna bar resembles to lots of product, such as Italian torrone, French or Spanish nougat, and Spanish turrón, which are generally manufactured during Christmas time. They are produced with honey, inverted sugar, sugar, egg albumin, and types of nuts such as pistachio or hazelnut, sometimes chocolate. Torrone is manufactured in some regions of Italy such as Lombardy, Abruzzo, Calabria, and Campania by traditional way (Speziale et al., 2010a). Manna bar has different sensory and textural attribute than those of products. Main quality attributes of manna bar its texture and flavor evaluated by the consumer (Hojjati et al., 2015a, b). Quality characteristics of manna bar are quite due to the different producer use different cooking time and temperature, mixing time and quantity of foam added, owing to the experience of masters.

In the literature, there is a lack of information about the process parameters on the quality during the production of manna bar. Process optimization is also needed for standard manna bar production. Therefore, the purpose of this study was to optimize the process parameters of manna bar during the production and to discover the effects of cooking temperature and cooking and mixing time on the physical and chemical properties of manna bars.

Materials and Methods

Materials

Glucose syrup, egg white, and cardamom were obtained from local market in Gaziantep, Türkiye. Manna was obtained from a grocery in Al-Sulaymaniyah, Iraq. Hand mixer (King, Model Deluxe, Türkiye) was used to prepare foam from egg white.

Purification of manna

Manna was taken from a grocery, which could have leaves and dust. For that reason, manna was soaked in hot water and stirred until completely dissolved. Then it was held for 36 hours without shaking in order to separate leaves and mud. The mud (precipitated at the bottom), and leaves (at the top) were removed by decantation and filtration, then clear syrup was obtained. After that, it was boiled till becomes a sauce or molasses (Figure 1).

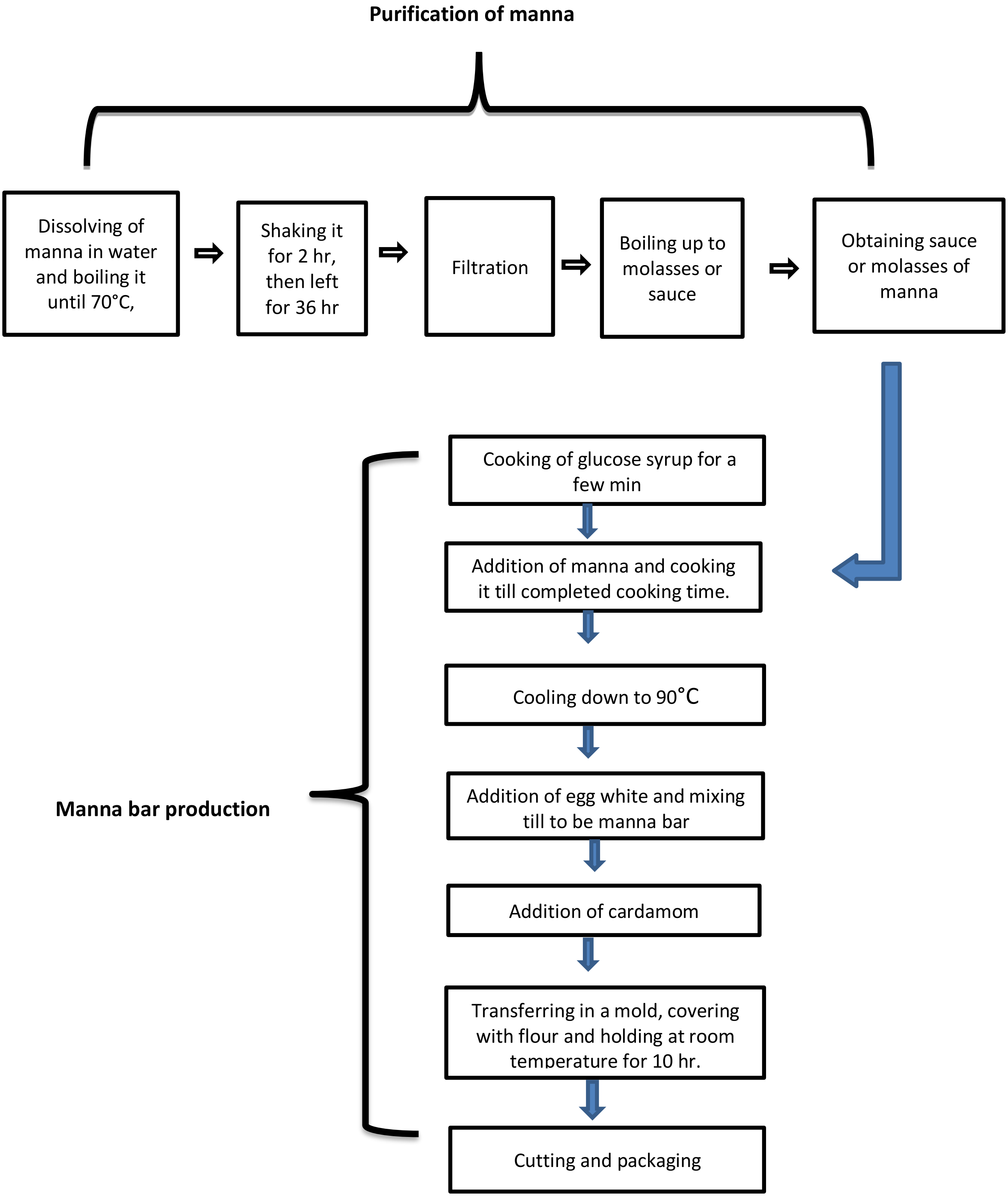

Figure 1. Flow diagram of manna bar manufacture process

Manna bar production

Glucose syrup was put into container and started to cook after that the clarified molasses was added. This mixture was cooked in hot plate (magnetics stirrer-heater; Isolab; Germany) according to experimental design given in Table 1. After cooking, it was cooled down for 5 minutes, and then foam was added into the mixture, which was prepared from egg white by shaking with at speed 2 hand mixer (Arçelik, Türkiye). After that cardamom was added to the mixture with mixing until obtaining homogenous mixture. At the end, it was transferred to a mold and covered by flour (Hojjati et al., 2015b).

Table 1. Process parameters used in manna bar production

Cooking temperature (°C)	Cooking time (min)	Mixing time (min)	Recipe for each sample it was consisted (%)
	5	10, 20, and 30	
100	10	10, 20, and 30	
	15	10, 20, and 30	
	5	10, 20, and 30	
110	10	10, 20, and 30	Manna: 26.0 Glucose syrup: 65.0 Egg white: 8.0 Cardamom: 1.0
	15	10, 20, and 30	
	5	10, 20, and 30	
120	10	10, 20, and 30	
	15	10, 20, and 30	

Experimental design

Fifty-four samples (two batches; each batch had 27 samples, so each recipe was made as 6 times) of manna bar were produced at different cooking temperature (100, 110 and 120°C), cooking time (5, 10 and 15 min), and mixing time (10, 20, and 30 min), but at constant recipe 26% manna, 65% glucose syrup, 8% egg white and 1% cardamom. The process condition and recipe are given in Table 1 as wet base.

Sampling and analysis

For all analysis, duplicate samples were taken. Molds were used for texture profile analysis (TPA analysis). The manna bar was put into molds, after producing; the dimensions of molds were 4×3×2 cm^3 (Hojjati et al., 2015b).

Determination of moisture content of manna bar

About 2 g of homogenized sample was taken for moisture content analysis. Moisture content was determined by use of oven method at 105°C until constant weight was reached (AOAC, 1990).

Determination of pH value of manna bar

The measurement of pH value was carried out on a 10 g of homogenized sample dissolved in 90 mL of distilled water (Hojjati et al., 2015b). The pH value of sample was determined by use of HANNA instruments Model 211 pH meter (Portugal).

Determination of color

Color measurements (L*, a*, b*, and YI values) were made using a Hunter Lab Color Flex (A60-1010-615 Model Colorimeter, Hunter Lab, Reston, VA). The instrument was standardized each time with a white and black ceramic plate

(L_0 = 93.01, a_0 = 11.11, and b_0 = 1.30). L* is the lightness coordinate. a* is the red/green coordinate, with +a* indicating red, and -a* indicating green. b* is the yellow/blue coordinate, with +b* indicating yellow, and -b* indicating blue (Bozkurt & Bayram, 2006). Browning index [BI] was calculated using Hunter L*, a*, and b* values as follows:

$$BI = ([100(x - 0.31)])/0.17$$

Where

$$x = ((a^* + 1.75L^*)) / ((5.645L^* + a^* - 3.012b^*))$$

Determination of texture attributes of manna bar

In this test, two compressions were made to find an instrumental texture profile analysis (TPA) (Texture Expert Exceed Version 2V3 (Stable Micro Systems, 1998) as described by Bozkurt and Bayram (2006), using a TA. TX2 Texture Analyzer (Texture Technologies Corp., Scarsdale, NY/ stable Microsystems, Godalmimg, UK). All instrumental texture analyses were conducted at room temperature 24 ± 2ºC equipped with a 50-kg load cell capacity. Molds were used to determine texture attributes of manna bars. Hardness, adhesiveness, springiness, cohesiveness, and chewiness values were obtained.

Statistical analysis

Statistical analysis was performed using the SPSS 19.0 (USA) software for Windows. The one-way analysis of variance, (ANOVA) was performed to determine significant differences at α =0.05 level. Duncan Post Hoc test was also carried out to determine homogenous group in the changes of moisture content, pH, color, and textural analysis. Optimization was done by using Response Surface Analysis (DesingExpert, version 12, Trial) as minimizing L*, a*, BI, adhesiveness, and springiness. Moreover, for optimization hardness and chewiness values were taken as 562 g and 129 g, respectively (this value was the average of 6 commercial manna bars; the data obtained from Mahmood, 2017).

Results and Discussion

Moisture Content

The moisture content of manna bar was followed at 100, 110 and 120°C for different cooking time (5, 10, and 15) and mixing time (10, 20, and 30 min). Their results are given in Table 2.

Table 2. Changes in moisture content and pH in manna bar at 100, 110 and 120°C for different cooking and mixing time.

Temperature (°C)	Cooking time (min)	Mixing time (min)	Moisture content (%)	pH
100	5	10	15.58 ±0.03[a]	5.84 ±0.09[a]
		20	15.45 ±0.15[a]	5.84 ±0.08[a]
		30	15.34 ±0.42[a]	5.84 ±0.08[a]
	10	10	15.26 ±0.11[A]	5.59 ±0.06[A]
		20	14.96 ±0.10[A]	6.24 ±0.00[B]
		30	13.25 ±0.12[B]	6.33 ±0.05[B]
	15	10	13.89 ±0.23[X]	5.92 ±0.08[X]
		20	13.56 ±0.16[XY]	6.17 ±0.03[Y]
		30	13.11 ±0.91[Y]	6.43 ±0.06[Z]
110	5	10	13.42 ±0.32[a]	5.65 ±0.06[a]
		20	13.07 ±0.53[a]	6.20 ± 0.07[b]
		30	12.46 ±0.42[a]	6.32 ±0.03[b]
	10	10	13.20 ±0.11[A]	6.02 ±0.00[A]
		20	12.60 ±0.09[B]	6.20 ±0.03[B]
		30	11.16 ±0.07[C]	6.40 ±0.03[C]
	15	10	11.64 ±0.43[X]	6.15 ±0.05[X]
		20	11.40 ±0.17[X]	6.30 ±0.04[Y]
		30	10.43 ±0.32[X]	6.51 ±0.03[Z]
120	5	10	11.06 ±0.18[a]	6.06 ±0.12[a]
		20	10.45 ±0.28[a]	6.16 ±0.05[a]
		30	9.41 ±0.16[b]	6.29 ±0.00[a]
	10	10	10.71 ±0.15[A]	6.05 ±0.02[A]
		20	10.04 ±0.09[B]	6.06 ±0.02[A]
		30	9.58 ±0.06[C]	6.30 ±0.00[B]
	15	10	9.21 ±0.04[X]	5.91 ±0.07[X]
		20	8.64 ±0.06[Y]	6.00 ±0.03[XY]
		30	8.50 ±0.07[Y]	6.10 ±0.00[Y]

Small letters (a,b,c) show significant difference mixing time at α = 0.05 for 5 min of cooking time for each parameter. Capital letters (A,B,C)show significant difference mixing time at α = 0.05 for 10 min of cooking time for each parameter. Capital letters (X,Y,Z) show significant difference mixing time at α = 0.05 for 15 min of cooking time for each parameter. ± Standard deviation obtained from 6 samples.

The moisture content of samples cooked at 100°C for 5 min decreased but not affected significantly (P>0.05) by different mixing time. At 10 min cooking time, the increase of mixing time from 10 to 20 min, moisture content was not significant (P>0.05). However, increasing mixing time to 30 min, moisture content decreased significantly (P<0.05). At 15 min cooking time, the moisture content decreased significantly (P<0.05) by increasing mixing time.

The moisture content of samples cooked at 110°C was not significant (P>0.05) at 5 and 10 min cooking time for different mixing time. However, it decreased and significantly (P<0.05) for different mixing time.

The manna bar cooked at 120°C for 5 min, the moisture content decreased but not significantly (P>0.05) between 10 and 20 min mixing time. However, it was significant (P<0.05) for 30 min mixing time. The reduction of moisture content was significant (P≤0.05) at 10 min cooking time by increasing mixing time. At 15 min cooking time, the moisture content of samples decreased significantly (P<0.05) among 10 with 20 and 30 min mixing time, but it was not significant (P>0.05) between 20 and 30 min mixing time.

Generally, high cooking temperature, long cooking time and mixing time affected the moisture content. The reduction of moisture content in manna bar could be due to the evaporation of water by high temperature and long time. Jeffery (2001) mentioned that moisture content ranges from 6% in hard nougats to 15–17% in soft nougats due to long cooking at high temperature.

Hojjati et al. (2015a) studied moisture content of two Spanish turrón cooked for one hour at 50-60°C, then cooked again for one more hour at 70-

80°C. They reported that moisture content was 5.02% and 4.28% for first and second cooking, respectively. Also, the moisture content of two French nougats was found which were cooked for 12 hours at 35°C as 4.83% and 5.90%. These results were consistent with our results.

pH Value

The pH value of manna bar was followed at 100, 110 and 120°C for different cooking times (5, 10, and 15) and mixing times (10, 20, and 30 min). Their results are given in Table 2. Cooking of manna bar at 100°C for 5 min, the pH value was not changed (P>0.05) with increasing mixing time. At 10 min cooking time at that temperature, the pH value increased (P<0.05) from 10 to 20 min mixing time, but not significantly affected (P>0.05) at 30 min mixing time. At 15 min cooking time, the pH value increased (P<0.05) by increasing mixing time. At 110°C for different cooking time, the pH value increased (P<0.05) by mixing time, except between 20 and 30 min of mixing. At 120°C, increasing mixing time, the pH value was not changed significantly (P>0.05) at 5 min cooking time. Moreover, at 10 min of cooking time for 10 and 20 min mixing, the pH value was not affected significantly (P>0.05), however, it was significant (P<0.05) at 30 min mixing time. At 15 min cooking time, pH value increased (P<0.05) from 10 to 20 min mixing time but not significant (P>0.05) at 30 min of mixing time. Vázquez et al. (2007) found similar results that pH of turrón decreased during the manufacturing. They noticed that reduction of pH value increased by increasing cooking time.

Generally, the pH value increased (P<0.05) during mixing time. The temperature of manna bar decreased during the mixing time, this would lead to decrease the ability of water to ionize, and so the concentration of H^+ or H_3O^+ in manna bars would increase, hence it could decrease the pH.

Color Measurement

The Hunter L*, a*, b* values of the manna bar were measured to determine the change in color of manna bar after producing at different processes and recipes. L* (lightness-darkness), a* (redness-greenness), b* (yellowness-blueness) have been previously proved valuable in describing deterioration of visual color (Garza et al., 1999; Gunawan & Barringer 2000; Tijskens et al., 2001). Browning index (BI) values were calculated by using of Hunter L*, a*, and b* values (Bayram & Bozkurt, 2007).

The color value of manna bar was followed at 100, 110 and 120°C for different cooking time (5, 10, and 15) and mixing time (10, 20, and 30 min). Their results are given in Table 3. The Hunter L* value increased significantly (P<0.05) at different cooking temperature, cooking time and mixing time, except at 30 min mixing time for 15 min cooking at 120°C. However, the Hunter a*, b*, YI and Browning index (BI) values decreased significantly (P<0.05) during the processes. Generally, during the mixing, manna bar was going to be white due to that manna bar took air during mixing. Color attributes of that type of confectionary depends on the process conditions and also added egg white. During the process, browning reactions, especially caramelization, leads darker color, however, egg white makes whitening of manna bar.

Vázquez et al. (2007) reported that in manufacturing turrón, the L* values decreased during heating, implying that samples got darker due to water evaporation. L* values of turrón found to be 34.94 for 15 min, and 82.74 for 20 min. The addition of ovalbumin L* increased by increasing heating time. They found also that a* and b* values increased by cooking time at same condition. These results were in agreement with the results of this study.

Texture Analysis Profile

Texture profile analysis (hardness, adhesiveness, springiness, cohesiveness, and chewiness values) of manna bar were followed during the production at 100, 110 and 120°C for different cooking times (5, 10, and 15) and mixing times (10, 20, and 30 min), and their results are given in Table 4. Through the parameters hardness and adhesiveness are more important than those of other parameters, as; hardness is important to give a good texture in the final product. Also, adhesiveness related to the stickness of manna bar, should not be stick to teeth during eating. Vázquez-Araujo et al. (2006) reported that oversaturation of syrup is mainly occurs in the production of *Xixona turron* which was influence the textural attributes. They also concluded that glass transition temperature is affected from the small variations in moisture content and sugar compositions.

The Hardness and adhesiveness values of the manna bar samples cooked at 100°C, increased significantly ($P<0.05$) at the different cooking times and mixing times, except from 10 to 20 min mixing at 10 min cooking which was not significantly affected ($P > 0.05$) in hardness. Hardness and especially adhesiveness values of the product linked to the moisture content. As decreasing of moisture content of the manna bar during the process increased hardness values and decreased adhesiveness value of the product. Vázquez-Araujo et al. (2006) found the similar results. They observed that increase in the mixing (homogenization) time would give harder product, because of the stronger consistency. It was also reported that less mixing leads softer products.

Table 3. Determination color in manna bar at 100, 110 and 120°C for different cooking time and mixing time

Temperature (°C)	Cooking time (min)	Mixing time (min)	CIE L*	CIE a*	CIE b*	CIE YI	BI
100	5	10	67.57 ±0.14^{a}	4.89 ±0.04^{a}	13.58 ±0.06^{a}	39.18 ±0.11^{a}	27.34 ±0.08^{a}
		20	70.04 ±0.00^{b}	3.76 ±0.00^{b}	10.95 ±0.04^{b}	29.09 ±0.07^{b}	20.60 ±0.07^{b}
		30	75.79 ±0.28^{c}	2.96 ±0.00^{c}	9.89 ±0.01^{c}	35.73 ±0.09^{c}	16.54 ±0.09^{c}
	10	10	65.53 ±0.10^{A}	4.88 ±0.01^{A}	13.27 ±0.15^{A}	37.16 ±0.01^{A}	27.69 ±0.31^{A}
		20	74.18 ±0.20^{B}	3.85 ±0.00^{B}	11.14 ±0.05^{B}	28.36 ±0.03^{B}	19.76 ±0.03^{B}
		30	84.42 ±0.60^{C}	2.80 ±0.05^{C}	8.79 ±0.02^{C}	20.32 ±0.01^{C}	13.18 ±0.02^{C}
	15	10	68.47 ±0.09^{X}	4.66 ±0.01^{X}	12.96 ±0.00^{X}	34.83 ±0.01^{X}	25.59 ±0.00^{X}
		20	75.14 ±0.04^{Y}	3.85 ±0.00^{Y}	11.15 ±0.00^{Y}	28.11 ±0.02^{Y}	19.50 ±0.01^{Y}
		30	78.77 ±0.29^{Z}	2.67 ±0.03^{Z}	8.30 ±0.02^{Z}	20.43 ±0.07^{Z}	13.37 ±0.01^{Z}
110	5	10	66.66 ±0.21^{a}	4.71 ±0.00^{a}	13.02 ±0.02^{a}	35.69 ±0.09^{a}	26.53 ±0.11^{a}
		20	75.83 ±0.00^{b}	3.92 ±0.00^{b}	11.72 ±0.04^{b}	29.06 ±0.09^{b}	20.25 ±0.07^{b}
		30	81.90 ±0.02^{c}	2.61 ±0.02^{c}	8.13 ±0.03^{c}	19.37 ±0.04^{c}	12.57 ±0.03^{c}
	10	10	68.88 ±0.10^{A}	4.39 ±0.00^{A}	12.83 ±0.01^{A}	34.06 ±0.06^{A}	24.90 ±0.05^{A}
		20	77.38 ±0.13^{B}	3.05 ±0.00^{B}	9.40 ±0.03^{B}	23.23 ±0.04^{B}	15.56 ±0.02^{B}
		30	79.32 ±0.26^{C}	2.31 ±0.04^{C}	7.44 ±0.03^{C}	18.20 ±0.05^{C}	11.76 ±0.04^{C}
	15	10	74.44 ±0.00^{X}	3.96 ±0.02^{X}	12.49 ±0.03^{X}	13.01 ±0.04^{X}	21.91 ±0.02^{X}
		20	77.66 ±0.02^{Y}	2.83 ±0.02^{Y}	9.32 ±0.01^{Y}	22.8 ±0.01^{Y}	15.18 ±0.00^{Y}
		30	83.17 ±0.25^{Z}	2.20 ±0.02^{Z}	7.76 ±0.02^{Z}	17.99 ±0.00^{Z}	11.50 ±0.01^{Z}
120	5	10	71.13 ±0.04^{a}	2.61 ±0.01^{a}	10.44 ±0.04^{a}	26.51 ±0.08^{a}	18.23 ±0.03^{a}
		20	82.92 ±0.00^{b}	2.26 ±0.00^{b}	9.57 ±0.02^{b}	21.57 ±0.05^{b}	13.99 ±0.04^{b}
		30	84.89 ±0.13^{c}	2.00 ±0.04^{c}	8.62 ±0.03^{c}	19.17 ±0.00^{c}	12.19 ±0.01^{c}
	10	10	76.00 ±0.10^{A}	2.59 ±0.04^{A}	11.65 ±0.02^{A}	27.51 ±0.02^{A}	18.79 ±0.03^{A}
		20	75.60 ±0.05^{A}	2.25 ±0.01^{B}	10.02 ±0.02^{B}	24.08 ±0.01^{B}	16.10 ±0.04^{B}
		30	78.21 ±0.28^{B}	1.93 ±0.00^{C}	8.96 ±0.06^{C}	21.05 ±0.04^{C}	13.70±0.03^{C}
	15	10	75.40 ±0.14^{X}	2.33 ±0.00^{X}	12.84 ±0.09^{X}	29.76 ±0.21^{X}	20.55 ±0.11^{X}
		20	78.14 ±0.25^{Y}	1.97 ±0.05^{Y}	11.45 ±0.04^{Y}	25.94 ±0.03^{Y}	17.36 ±0.04^{Y}
		30	76.92 ±0.10^{Z}	1.74 ±0.00^{Z}	10.72 ±0.02^{Z}	24.59 ±0.04^{Z}	16.35 ±0.03^{Z}

Small letters (a,b,c) show significant difference mixing time at α = 0.05 for 5 min of cooking time for each parameter. Capital letters (A,B,C)show significant difference mixing time at α = 0.05 for 10 min of cooking time for each parameter. Capital letters (X,Y,Z) show significant difference mixing time at α = 0.05 for 15 min of cooking time for each parameter. ± Standard deviation obtained from 6 samples.

The hardness values of the manna bar samples cooked at 110°C, hardness values of the samples increased with increasing mixing time at the different cooking times. Also, at 5 and 10 min cooking, they were significant (P<0.05), but not significantly affected (P>0.05) for 15 min cooking. Speziale et al. (2010b) reported that in the production of Italian torrone, cooking for a longer time leads to harder texture than desired. In an another study, Hojjati et al. (2015b) found that hardness of Gaz (Iranian type manna bar) changed between 31.6 Newton (N) to 257 N depending on the amount of almond and pistachio nuts. Adhesiveness values at 5 and 10 min cooking of the samples were not significant (P > 0.05) at different mixing times. However, adhesiveness values at 15 min cooking time increased between 10 and 20 min mixing, and then it decreased significantly (P≤0.05) at 30 min mixing. Hojjati et al. (2015b) found that adhesiveness values ranged between -21.1 N.sec. to -1.9 N.sec., and it was mainly related with the surface free oil comes from almond and pistachio.

The manna bar produced at 120°C, hardness value of the samples increased significantly (P<0.05) by increasing mixing times for 5, 10 and 15 min cooking times. Adhesiveness values of the samples at 5 min cooking time decreased significantly (P≤0.05) between 10 and 20 min mixing time, but it was not significant (P>0.05) between 20 and 30 min mixing. At 10 min cooking, adhesiveness values were significantly (P≤0.05) decreased, and then increased during the mixing time. At 15 min cooking time, adhesiveness values of the samples decreased not significantly (P>0.05) between 10 and 20 min mixing time, but at 30 min mixing time it increased significantly(P<0.05). Speziale et al. (2010) found similar results that lower and/or shorter cooking time caused more adhesive product.

Vázquez-Araujo et al. (2006) and Speziale et al. (2010a) concluded that process parameters such as cooking time and temperature and mixing time are the main factors affecting the textural attributes of *Xixona turron* and Italian turrone like manna bar. Higher temperatures used for cooking by reduced time cause softer products of Spanish *Xixona turron*. Therefore, during the production of manna bar cooking time and temperature with mixing time should be arranged to produce standard textural attributes.

Springiness value decreased for 100 and 110°C, however, it increased for 120°C. Cohesiveness and chewiness values increased by increasing cooking temperature and time with mixing time. Chewiness, related with hardness, is increased by increasing hardness. Generally, these samples produced at 100°C, did not give a good result due to the soft samples by producing at low temperature.

Hojjati et al. (2015a) studied different samples of Spanish Turrón, Italian Torrone and French Nougat. The hardness found 55.3, 36.9, 20.3, 104.0, 43.7 and 127 N, and for adhesiveness 3.39, 0.68, 7.72, 8.75, 1.24, and 3.49 N.s. The manual control over operational conditions (temperature and time) also leads to different final textures (Speziale et al., 2010a).

The importance of textural properties in the current study was effective to make better manna bar. Softness or hardness is closely related to the quality of the texture as the manna bar should be enough firms to be consumed. Process temperature and time are the main reason in developing of textural attributes of manna bar during production. Therefore, high temperature and long time had significant effect on the texture. By increasing temperature and time, it caused the formation of hard product by losing water. Also, after adding egg white, textural attributes were also affected by mixing time.

Table 4. Changes in texture in manna bar at 100, 110 and 120°C for different cooking time and mixing time

Cooking temperature (°C)	Cooking time (min)	Mixing time (min)	Hardness (g)	Adhesiveness (g.sec)	Springiness (%)	Cohesiveness (%)	Chewiness (g)
100	5	10	131.56 ±1.32^{a}	-1.05±0.02^{a}	0.70 ±0.01^{a}	0.30±0.01^{a}	28.18 ±1.26^{a}
		20	140.44 ±1.32^{b}	-0.98 ±0.01^{b}	0.51±0.00^{b}	0.33±0.00^{b}	24.31 ±0.38^{b}
		30	144.70 ± 0.41^{c}	-0.31 ±0.00^{c}	0.38±0.01^{c}	0.28 ±0.00^{a}	15.65 ±0.68^{c}
	10	10	156.68 ±2.31^{A}	-1.02 ±0.00^{A}	0.41 ±0.08^{A}	0.31 ±0.00^{A}	20.59 ±4.09^{A}
		20	164.15 ±0.82^{A}	-0.61 ±0.02^{B}	0.35 ±0.00^{A}	0.32 ±0.01^{A}	18.46 ±1.36^{A}
		30	243.08 ±12.97^{B}	-0.45 ±0.02^{C}	0.39 ±0.00^{A}	0.37 ±0.01^{B}	35.86 ±1.02^{B}
	15	10	181.39 ±1.40^{X}	-0.97 ±0.01^{X}	0.38 ±0.02^{X}	0.31 ±0.00^{X}	22.37 ±1.92^{X}
		20	199.15 ±1.81^{Y}	-0.60 ±0.02^{Y}	0.38 ±0.01^{X}	0.29 ±0.00^{X}	18.42 ±0.06^{X}
		30	279.88 ±0.74^{Z}	-0.44 ±0.02^{Z}	0.31 ±0.04^{X}	0.32 ±0.01^{X}	34.75 ±5.55^{Y}
110	5	10	215.04 ±7.51a	-0.06 ±0.01a	0.45 ±0.02a	0.28 ±0.02a	27.61 ±1.75a
		20	296.69 ±3.91b	-0.25 ±0.01a	0.32 ±0.02b	0.28 ±0.00a	27.97 ±2.69a
		30	317.21 ±0.66c	-0.00 ±0.43a	0.32 ±0.02b	0.33 ±0.01a	34.32 ±4.65a
	10	10	262.65 ±6.27A	0.01 ±0.39A	0.35 ±0.02A	0.30 ±0.02A	27.89 ±1.55A
		20	310.73 ±2.72B	-0.30 ±0.00A	0.34 ±0.00A	0.30 ±0.01A	32.66 ±2.58A
		30	370.73 ±7.73C	-0.32 ±0.01A	0.40 ±0.01B	0.42 ±0.01B	65.12 ±6.51B
	15	10	301.32 ±0.33X	-0.08 ±0.01X	0.32 ±0.02X	0.31 ±0.01X	31.35 ±0.79X
		20	413.61 ±73.36X	-0.02 ±0.00Y	0.35 ±0.01X	0.35 ±0.00Y	51.88 ±11.96X
		30	433.12 ±0.82X	-0.20 ±0.00Z	0.42 ±0.00Y	0.43 ±0.00Z	79.71 ±1.48Y
120	5	10	383.21 ±4.32a	-0.11 ±0.00a	0.39 ±0.00a	0.40 ±0.00a	61.10 ±0.36a
		20	424.94 ±0.99b	-0.26 ±0.00b	0.44 ±0.02ab	0.44 ±0.00b	84.47 ±5.79b
		30	609.55 ±5.94c	-0.28 ±0.00b	0.44 ±0.01b	0.48 ±0.00c	145.96 ±7.54c
	10	10	459.64 ±8.26A	-0.17 ±0.03A	0.36 ±0.03A	0.39 ±0.00A	66.16 ±6.65A
		20	488.97 ±3.30B	-0.81 ±0.02B	0.41 ±0.03AB	0.41 ±0.01AB	85.34 ±10.23A
		30	558.55 ±57.08C	-0.63 ±0.01C	0.45 ±0.00B	0.46 ±0.03B	118.49 ±2.82B
	15	10	656.16 ±43.29X	-0.42 ±0.05X	0.39 ±0.06X	0.45 ±0.01X	118.02 ±23.73X
		20	821.90 ±5.70Y	-0.47 ±0.00X	0.46 ±0.00X	0.46 ±0.00X	174.37 ±3.96 Y
		30	852.57 ±4.62Y	-0.05 ±0.04Y	0.50 ±0.00X	0.50 ±0.00Y	215.78 ±5.97Y

Small letters (a,b,c) show significant difference mixing time at α = 0.05 for 5 min of cooking time for each parameter. Capital letters (A,B,C)show significant difference mixing time at α = 0.05 for 10 min of cooking time for each parameter. Capital letters (X,Y,Z) show significant difference mixing time at α = 0.05 for 15 min of cooking time for each parameter. ± Standard deviation obtained from 6 samples

Optimization of Manna Production

Process optimization of manna bar was done by using Response Surface Analysis. Optimization of the manna bar processing was done as considering; minimize L*, a*, BI, adhesiveness, and springiness. Moreover, for optimization hardness and chewiness values were taken as 562 g and 129 g, respectively. The desirability value used for optimization of the manna bar processing was obtained by the use of Design Expert program. It's results showed that cooking at 120°C for 10.10 min and mixing of 21.26 min was the best condition for manna bar processing as desirability = 0.682 (Figure 2).

Process optimization reported in the literature for different food processing by Response Surface Methodology (Medina et al., 2021) or Artificial Neural Network (Sadhu et al. 2020). Medina et al. (2021) used RSM for rice cooking and they found that desirability was greater than 0.6. Marra et al. (2023) used D-optimal design, to plan the cocoa hazelnut spread formulations. They found that optimized formulation was identified in a spread characterized by a total replacement of palm oil with an oleogel made of 95% olive oil and 5% GMS.

Results indicated that manna bar production should be done at those optimum conditions to get high quality. Process optimization is an important issue to prevent over burning (causing a lot of health adverse effect compound formation from Maillard reaction and quality losses), to prevent very soft texture and to prevent sticky product formation.

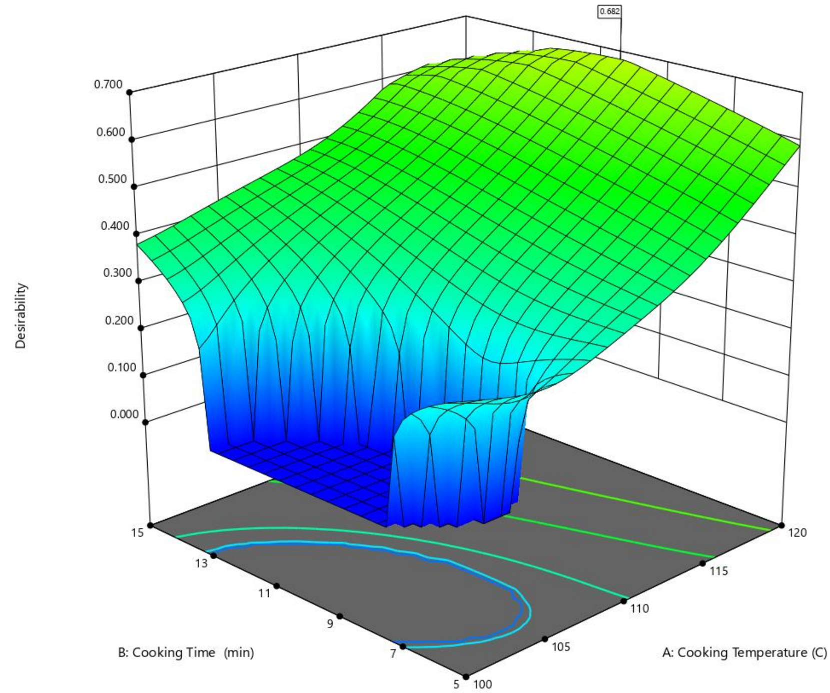

Figure 2. Optimization of manna bar processing

Conclusion

This study presents production of manna and investigating its properties by many of analysis. In this study, moisture content, pH value, color and textural properties were followed during mixing time (10, 20 and 30 min) at different cooking time (5, 10 and 15 min) and different cooking temperature at 100, 110 and 120°C. By increasing cooking temperature, cooking time and mixing time decreased moisture content but increased hardness and chewiness. Increasing mixing time increased pH and lightness values, but decreased redness, yellowness, CIE YI, and BI values. The best condition obtained from optimization for producing of manna bar was found as cooking at 120°C for 10.10 min and mixing 21.26 min. Therefore, that product was not so soft and hard, also it was suitable for eating with an acceptable color.

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