Preventing oil leakage with natural wax additions during the storage of tahini halva

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Tahini halva, a famous traditional Turkish dessert, is a food product with a high oil content and when stored an oil leakage may occur leading to unpleasant appearance. In this study, to restrict oil migration, sunflower, shellac and beeswax were used at 3% (w/w) in tahini halva and the effects of these natural waxes were comparatively investigated during a 6-month storage period at 25 and 35°C against control samples containing no additives and halva containing 3% hydrogenated palm stearine (HPS). The physico-chemical, textural, and sensorial characteristics were monitored and the results revealed that natural wax addition led not only to successful restriction of oil leakage, but also the samples, especially sunflower wax and HPS containing samples preserved their textural and sensory characteristics throughout storage. According to the samples XRD patterns, the crystal structure of the natural wax containing samples did not change during storage, but that of the tahini halva containing no additive extremely changed, mostly related with oil leakage during storage. The data on oxidative induction time, peroxide values, and free fatty acid contents of the samples, were within the legal limits during storage. It can be concluded that sunflower wax was more suitable in replacing commercially used HPS in terms of restricting oil leakage and preserving textural and sensory properties of traditional tahini halva than the other natural waxes.

Keywords: Natural waxes, oil leakage, organogelation, storage, sensory, shelf life.

INTRODUCTION

Due to the rapidly increasing world population, there is a need for the effective use of food raw materials that are rather limited. On the other hand, there is growing demand for ready-to-eat and packaged foods. Hence, one of the main issues in food industry is to protect food quality during storage as long as possible. In this process, additives, packaging materials, transportation and storage conditions as much as the processes applied to food are very important. It is known that any foodstuff with a quality production process cannot complete its shelf life due to improper packaging materials, as well as subsequent transportation and storage conditions. As an inevitable result of these conditions, food products may lose their attractiveness and nutritional quality hence, consumer preferences may be affected negatively. Additionally, the manufacturers of food products may experience economic and credibility losses also waste in already limited food resources may occur [1, 2].

One of the most important problems during the transportation and storage is oil migration in oil based food products. Oil migration is characterized with oil leakage from inner surface to outer surface of food products. The oil migration process is responsible for textural changes and loss of visual appeal and structural breakdown of food products [1]. The oil migration of composite confectionary products is affected by particle size and distribution, storage conditions and concentration types of the emulsifiers used. On the other hand, oil migration cannot be completely stopped, but it can be delayed.

Tahini halva is one of the oil-based food products that suffer from economic and brand-name losses caused by oil migration. Tahini halva, is obtained by mixing certain levels of sesame paste (tahini) and sugar syrup. Particularly, in the Balkan countries, sunflower paste is used to replace sesame paste (tahini) in halva production. Sesame paste, also called tahini, contains significant amounts of sesame oil that may vary between 40-50%. Additionally, tahini halva has a high lipid (32%), carbohydrate (47%, w/w) and protein content (13%, w/w) [3, 4]. Hence, oil migration takes place inevitably in tahini halva during the storage period. In the event of oil leakage, nutritional losses, textural and structural changes, sensorial losses, and economic losses in tahini halva may occur. In recent years, to restrict oil leakage of tahini halva and halva type products addition of palm oil [5], soapwort root extract and glycyrrhizin [6], sorbitan tristearate (STS), sorbitan monopalmitate (SMP) and their combinations (STS:SMP, 1:1) [4], lecithins and monoglycerides [3], sesame testae, date fibre [7], proteins, non-hydrogenated palm oil, emulsifiers, gum Arabic, sucrose, and calcium chloride [8] were reported.

Natural waxes such as beeswax, sunflower wax, and shellac wax have high oil binding capacity and they have been recently used to convert liquid oil to solid/semi-solid form. This processing is called organogelation and these products are known as oleogels. This technique has some advantages such as thermo-reversible structure, no *trans*-fat content, low saturated fats content, and there are no changes in the fatty acids composition of oils. In literature, there are many researches related to natural waxes used as gel agents for organogelation [9 - 11], but the oil migration studies are quite limited. Studies on restriction of oil leakage were reported by Patel et al. [12], who used shellac wax as a replacer for oil-binders in chocolate paste formulations. Stortz et al. [13] reported cream filling made with ethyl cellulose and 12-hydroxystearic acid, while Öğütcü et al. [14] investigated tahini halva made with beeswax, shellac wax and sunflower wax. However, the studies mentioned above included very limited information on the sensorial properties, consumer acceptance and shelf life of these types of products. A useful food additive should not disturb the taste of food and cause no sensory anomalies, while it should be easy to obtain, economical, healthy, and have the capacity of extending the product's shelf life. Otherwise, even if additives are sufficient to solve the problem in products, they cannot be used in food production. Hence, the main aim of this study was to determine the effect of wax additives on the consumer acceptance of fresh and stored tahini halva products. The other aim of this research was to monitor oil leakage level, structural changes of the tahini halva samples during the six-month storage period at 25 and 35°C.

MATERIALS AND METHODS

MATERIALS

Sesame paste, sugar, citric acid, hydrogenated palm stearine (HPS) and soapwort extract were supplied by a commercial halva manufacturer in Turkey (Sefa Akyüz Helva, Çanakkale, Turkey). Beeswax (BW), Shellac wax (SHW) and Sunflower wax (SW) used as organogelators were purchased from KahlWax (Kahl GmbH & Co., Trittau, Germany). The producer provided the following specifications of beeswax as 61-65°C melting point, 17-24 mg KOH/g acid value and 87-104 mg KOH/g saponification value; shellac wax as 78-84°C melting point, 5-15 mg KOH/g acid value and 45-70 mg KOH/g saponification value; sunflower wax as 74-80°C melting point range, 2-8 mg KOH/g acid value and 75-95 mg KOH/g saponification value. All other chemicals had an analytical grade and were purchased from Merck (Darmstadt, Germany) and Sigma-Aldrich (St. Louis, ABD).

TAHINI HALVA PRODUCTION

The tahini halva samples were produced by Sefa Akyüz Halva factory (Çanakkale, Turkey). The production of the tahini halva samples used in this study took place according to Figure 1. Five (5) different samples were prepared including 3% (w/w) additives such as beeswax, shellac wax, sunflower wax, HPS, and plain tahini halva with no wax or emulsifier. Moreover, the tahini halva samples that were produced were stored at 25 and 35°C during the six-month storage period. A temperature of 25°C was chosen for the winter-autumn period, while a temperature of 35°C was selected for the summer-spring period. In addition, the storage period was determined considering commercial shelf life. The tahini halva sample codes were arranged according to the food additives used. Thus, the first letter shows the food additive type, while the second letter shows the storage temperature. Sample codes are arranged as follows; Commercial (CH), tahini halva prepared with 3% HPS; Control (C), tahini halva sample do not containing any additive; SW, tahini halva prepared with 3% sunflower wax, BW, tahini halva prepared with 3% beeswax and SH, tahini halva prepared with 3% shellac wax.

EXTRACTION OF SESAME OIL AND ANTIOXIDANT DETERMINATION

For the oil extraction process, 40 g halva sample were weighed into an oil flask and then, 200 ml hex-

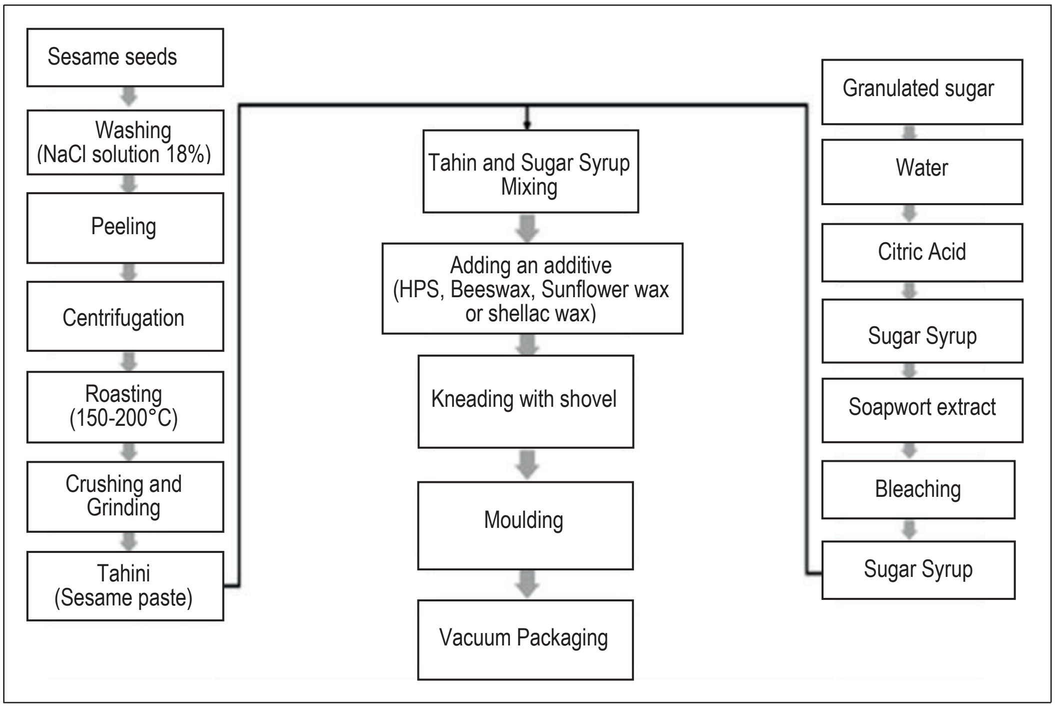

Figure 1 - The production scheme of the tahini halva

ane were added. The halva: hexane (1:5, w/v) mixture was stirred in a magnetic stirrer for 4 hours. After this, the mixture was centrifuged at 3500 rpm (1000 g) for 5 min at 20°C then, the liquid phase was transferred to a rotary evaporator flask, and the hexane portion was removed. These procedures were repeated twice and then the combined filtrates were concentrated in a rotary evaporator under vacuum at 60°C. The oil samples obtained according to these procedures were frozen (-18°C) until analysis.

For the total antioxidant content determination, the extraction process was performed according to Tokusoglu et al. [15]. 5 g defatted halva samples were weighed into a flask, mixed with ethanol (1:5, w/v) and stirred at 200 rpm for 4 hours. After this, the halva: ethanol mixture was centrifuged at 3500 rpm for 10 min at 4°C. Then, the liquid ethanol was filtered through filter paper and filled to 25 mL with ethanol. The extract was stored at -18°C until analysis.

PHYSICO-CHEMICAL ANALYSIS OF HALVA AND EXTRACTED OIL SAMPLES

The colour values of the tahini halva samples were measured using Minolta CR-400 colorimeter (Konica Minolta Sensing, Osaka, Japan) with CIE lab standards and delta E values were calculated. The oxidative induction time (OIT) values of the oil samples were measured via DSC 4000 (Perkin Elmer). The method adapted by Tan et al. [17] was applied. The peroxide and free fatty acid content of the halva samples was measured by the AOCS Ja 8-87 and Ac 5-41 technique, respectively [17]. The antioxidant activities of the halva samples were measured according to Re et al. [18]. The antioxidant activity of the halva samples was given as Trolox equivalents. All the above-mentioned analyses were carried out every two months during the 6-month storage period. The combustion energy values of the halva samples were determined with a Leco AC-350 bomb calorimeter (St. Joseph, USA) according to its manual. The energy values of the fresh and six-month stored samples were determined. The oil separation test of the halva samples was adapted from Ereifej et al. [8]. According to this method, 100 g halva samples were weighed into a beher-glass and then the beher-glass was closed with perforated aluminium foil. This beher-glass was inverted and placed on a petri dish (a) with five filter papers (Whatman #4) for the absorption of the released oil from the halva samples. Then, the petri dishes with the filter papers were stored at room temperature and weighed at the beginning and the end of the 2nd, 4th and 6th months of storage (b). The following formula calculated the amount of separated oil:

$$\text{Released Oil (\%)} = [(a-b)/(\text{sample weight})] \times 100$$

TEXTURAL ANALYSIS OF HALVA SAMPLES

A Texture Analyser TA-XT2i (Stable Microsystems, Surrey, UK) was used to determine the penetration test of tahini halva adapted by Pazır et al. [20]. The penetration test parameters were 2 mm cylinder probe, weight head 50 kg, samples size 30 × 30 × 30 (height, thickness, and length), probe inlet velocity

2 mm/s, outlet velocity 2 mm/s and penetration rate 50%. The penetration test results were calculated by TA-XT2i Software and the results were given as hardness values (N). The texture measurements of the halva samples were carried out every two months during the 6-month storage period.

The X-ray diffraction (XRD) patterns of the halva samples were determined by Rigaku D-Max Rint 2200 model X-Ray Diffractometer (Rigaku Int. Corp, Tokyo, Japan) at room temperature. The angular scans ($2\theta = 2.0$ -50° by 2°/min) were performed using a Cu Source X-ray tube ($\lambda = 1.54056$ Å) at 40 kV and 40 mA. The data were evaluated by MDI Jade 7 Materials Data Inc. software program (Livermore, USA).

The SEM photographs were taken by using SEM (JEOL JSM-7100F). First, 0.02 g halva samples were weighed on two-way carbon band and then, the samples were coated with gold-palladium using Quorum apparatus under 8×10^{-1} mbar/Pa vacuum and 10 mA voltages. The experimental conditions were indicated on each SEM photographs. The XRD and SEM analyses were performed on fresh samples and samples stored for 6 months.

SENSORY ANALYSIS OF TAHINI HALVA SAMPLES

The consumer tests were performed using 5- point hedonic scale (1- extremely dislike and 5- extremely like) that included four different features as appearance, texture, flavour/odour and acceptability. The halva samples were selected for consumer test according to their physico-chemical, textural, and sensorial features. As many as 120 volunteer consumers performed the Hedonic test of the halva samples and they willingly consumed halva or similar products. The consumer tests were performed on fresh samples and samples stored for 6 months.

STATISTICAL ANALYSIS

This study was replicated twice and all measurements within each replicate sample were done at least twice as well. The results were presented as means ± standard deviation (SD). The values were considered statistically different when $P \leq 0.05$. The results were evaluated using Minitab 16.1.0 statistical software [19]. The data were evaluated by using ANOVA with Tukey's multiple tests to detect the differences among the mean values.

RESULTS AND DISCUSSION

PHYSICO-CHEMICAL PROPERTIES

In our previous study [14] tahini halva samples were prepared using with 1, 3 and 5% addition levels of sunflower wax, shellac wax and beeswax. Additionally, the results of the previous study revealed that 1% addition level of the waxes were not enough to reduce oil leakage, while 5% addition level led to negative consumer perception. Hence, the tahini halva samples were prepared with 3% addition level of natural waxes, mainly because these halva samples not only restricted oil leakage but also had desirable and acceptable sensorial properties for the potential consumers [14]. Therefore, in this study 3% wax addition level was selected and the tahini halva samples were prepared. The colour of any food product is primarily effective on the consumer preferences. Therefore, it is expected that a quality product should maintain its colour throughout shelf life and should not cause any changes [21]. The ΔE value indicates the total colour differences occurring on any product during storage [22]. The ΔE values of the tahini halva samples are given in Figure 2. The beeswax added halva samples had lower ΔE values than the other samples at both storage temperatures. From Figure 2, it can be observed that the SW added halva sample stored at 25°C had lower ΔE values than the control samples (CH and C) though it had higher value at 35°C. Generally, the halva samples stored at 35°C had higher ΔE values than the halva samples stored at 25°C, except for the SH sample. The results revealed that storage temperature was fairly effective on the tahini halva colour. On the other hand, the colour differences among the halva samples may be explained by the different colours of the additives used. The physico-chemical features of the tahini halva samples and extracted oil samples are given in Table I. The oxidative induction time (OIT) values of the extracted sesame oil from the fresh halva samples ranged from 24.35 to 28.48 min.

Additionally, the OIT values of the extracted oil samples from the six-month stored tahini halva samples at 25 and 35°C, ranged between 25.43-31.48 and

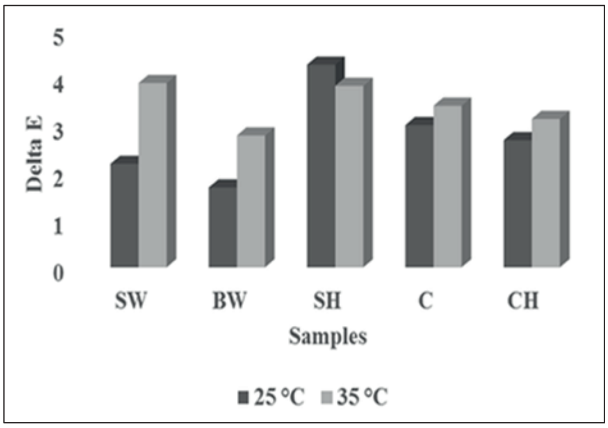

Figure 2 - Delta E values of the tahini halva samples stored at 25 and 35°C during the storage period. (SW: tahini halva prepared with sunflower wax, BW: tahini halva prepared with beeswax, C: tahini halva samples without additives, SH: tahini halva sample prepared with shellac wax and CH: tahini halva samples prepared with hydrogenated palm stearin)

Table I - Physico-chemical properties of the fresh and stored tahini halva samples (Mean ± Sd).

Sample	OIT (min)	TEAC (µmol TEAC/g)	PV (meqg O_2/kg)	FFA (%)	Calorie Value (cal/g)
Fresh Samples					
SW	28.23±1.70a*	0.80±0.02a	0.68±0.21b	0.76±0.17b	6933.3±5.02b
BW	26.52±0.02b	0.77±0.02a	0.96±0.19ab	1.74±0.03a	6849.4±47.0b
C	25.59±0.93a	0.78±0.01a	1.01±0.11ab	0.98±0.01b	7108.9±8.63a
SH	24.35±1.86ab	0.76±0.01a	1.33±0.08a	1.04±0.08b	6332.8±5.80c
CH	28.480±0.09a	0.77±0.03a	0.88±0.08ab	0.76±0.14b	6018.30±52.40d
Six Months Stored Samples (25°C)					
Sample	OIT (min)	TEAC (µmol TEAC/g)	PV (meqg O_2/kg)	FFA (%)	Calorie Value (cal/g)
SW	31.16±0.23a	0.50±0.01a	0.39±0.03b	0.84±0.01c	5698.40±5.80b
BW	27.02±0.04b	0.42±0.01bc	0.28±0.01c	1.66±0.01a	6076.60±31.30a
C	26.75±0.35b	0.47±0.02ab	0.79±0.05a	0.82±0.01d	5412.40±68.30c
SH	25.43±0.61b	0.51±0.02a	0.83±0.01a	0.84±0.01c	5995.60±17.70a
CH	31.48±0.68a	0.39±0.01c	0.20±0.01c	0.84±0.01b	5953.00±79.60a
Six Months Stored Samples (35°C)					
Sample	OIT (min)	TEAC (µmol TEAC/g)	PV (meqg O_2/kg)	FFA (%)	Calorie Value (cal/g)
SW	31.44±0.62a	0.44±0.01b	0.39±0.02b	0.83±0.01c	6395.70±38.90a
BW	30.08±0.11ab	0.47±0.01ab	0.20±0.01c	1.37±0.01a	6423.10±32.10a
C	29.40±0.57b	0.44±0.01b	0.54±0.01a	0.84±0.01b	6218.40±28.50ab
SH	28.21±0.30b	0.48±0.02ab	0.53±0.03a	0.80±0.01d	6005.80±124.50b
CH	31.45±0.64a	0.49±0.01a	0.28±0.01c	0.83±0.01bc	5538.1±14.3c

*The small letters show differences among the tahini halva samples in same column. OIT: oxidative induction time, TEAC: total antioxidant activity, PV: peroxide value and FFA: Free fatty acid value. SW: tahini halva prepared with sunflower wax, BW: tahini halva prepared with beeswax, C: tahini halva samples without additives, SH: tahini halva sample prepared with shellac wax and CH: tahini halva samples prepared with hydrogenated palm stearin.

28.21-31.45 min, respectively. Moreover, in terms of OIT values, there are no significant differences between storage temperatures ($p = 0.481$), while there are significant differences between storage days ($p = 0.015$). The free fatty acid (FFA) values show information on the freshness of oils and oil based food products. The FFA values increased depending on the inappropriate storage conditions. On the other hand, there is a synergistic effect between FFA and PV values [23]. The peroxide value (PV) indicates not only early stage oil oxidation, but also provides information on the storage conditions [24]. The FFA and PV values of the samples varied between 0.20-1.33% and 0.76-1.74 meqO_2g/kg at both storage temperatures during the storage period, respectively. The SH and C samples had higher PV values than the other samples, while the BW samples were higher in FFA values than the other samples. The higher PV and FFA values of the BW and SH samples were related to the characteristics of these waxes. According to the Turkish Food Codex (TFC), the PV and FFA limits for sesame oil extracted from tahini halva were 10 meqO_2g/kg and 2%, respectively. Both PV values and FFA values of the halva samples were within the legal limits at the end of the storage period. Kahraman et al. [23] reported that PV and FFA values of 120 tahini halva samples varied between 4.20-16.42 meqO_2g/kg and 0.14-1.20%, respectively. Our findings are close to literature findings. In terms of FFA values there were no significant differences between storage temperature ($p = 0.692$) and time ($p = 0.437$), while in terms of PV values there were significant differences between storage temperatures and time ($p <0.05$). The antioxidant values of the halva samples varied between 0.39 and 0.80 µmol TEAC/g. Similar to the PV results, in terms of total antioxidant values, there were significant differences between storage temperature and time ($p <0.05$). Shahidi et al. [25] reported that sesame oil is stable against oil oxidation due to the its natural antioxidants contents such as sesamol, sesaminol and tocopherols. Oil leakage is one of the common problems of oil based food products. The characteristic indications of oil leakage consist of oily packaging material, dry-hard product structure, and undesirable appearance, flavour, and colour changes. All these indications may lead to economic, quality, reputation, and nutritional losses to the manufacturer of these types of products. The oil leakage values of the tahini halva samples stored at 25 and 35°C are given in Figure 3. The SW and CH samples had lower oil leakage values, while the C sample had higher oil leakage values. These results clearly showed that all the additives were effective in restricting oil leakage in tahini halva more or less at both storage temperatures during the storage period. Especially, HPS is used as currently commer-

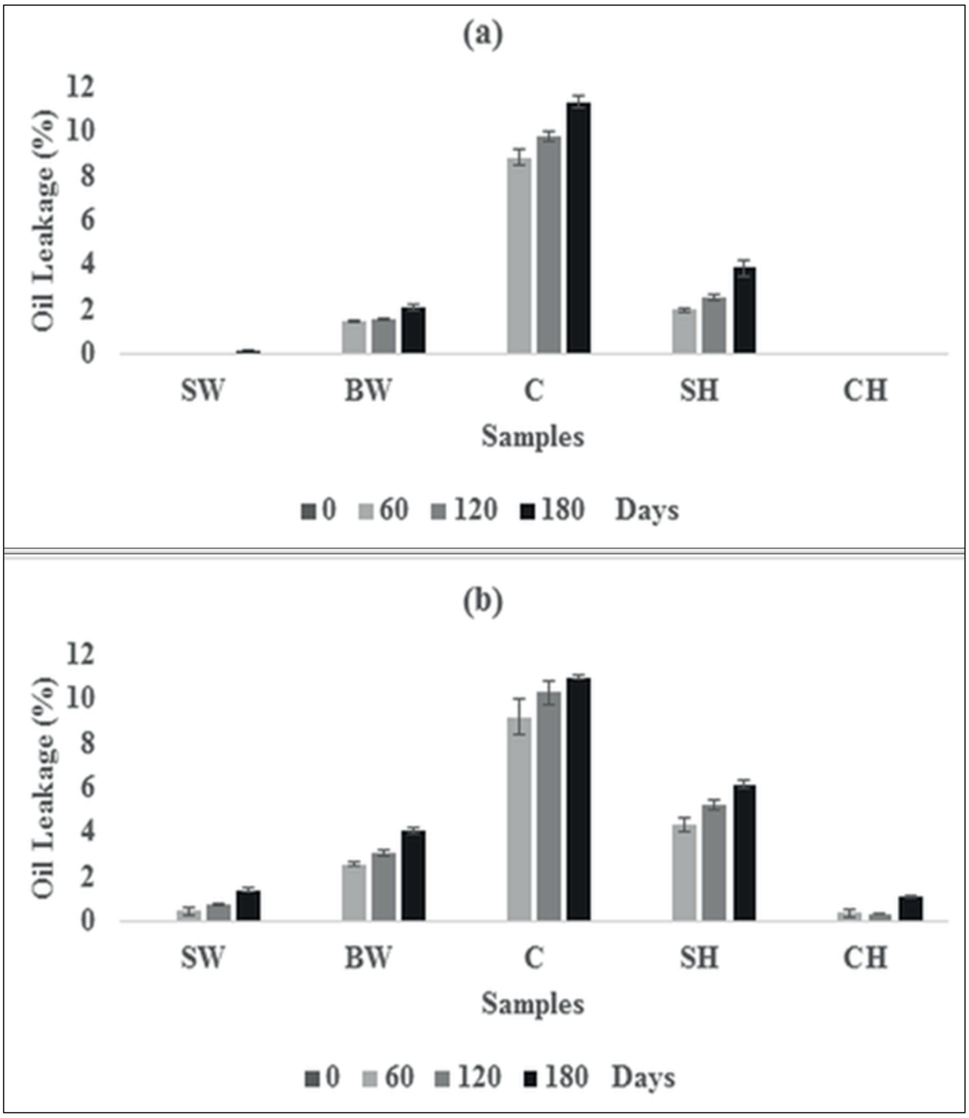

Figure 3 - The oil leakage values of the tahini halva samples during the storage period a) 25°C, b) 35°C. (SW; tahini halva prepared with sunflower wax, BW tahini halva prepared with beeswax, C: tahini halva samples without additives, SH: tahini halva sample prepared with shellac wax and CH: tahini halva samples prepared with hydrogenated palm stearin)

cially available additive against oil leakage in tahini halva and the oil leakage results are similar to the SW sample at both storage temperatures. These findings demonstrated that the "SW" additive was as effective as "HPS" against oil leakage in tahini halva (Fig. 3). The reduction of oil leakage is directly proportional to the stability of the organogel structure formed in tahini halva. The stability and ability of natural waxes to restrict oil leakage depended on characteristics such as purity, wax type, oil binding capacity, melting point, crystalline structure and addition levels [26]. The oil restriction process in tahini halva can be explained with sesame oil immobilised within self-assembled crystalline three-dimensional network of waxes. Hughes et al. [27] reported that a potential strategy for limiting oil migration is the gelation of any free oil which would be prone to migrate. Stortz et al. [13] indicated that organogels prepared with ethyl cellulose (EC) can be effective in reducing or preventing oil migration from cream fillings. Also, the researchers reported that oil leakage from cookies was reduced by increasing the addition level of EC. Patel et al. [12] reported that chocolate paste prepared with commercial oil-binder and with shellac oleogel exhibited no phase separation when stored at 30°C for four weeks. The results of the studies dealing with the restriction of oil mobility via organogelation are quite similar to our findings.

TEXTURAL FEATURES OF TAHINI HALVA

The texture of food products is important for consumer preferences. Especially, fats in foods provide some functional properties such as plasticity, elasticity and spreadability leading to smooth and homogeneous structure. Moreover, fats in foods sometimes may be a major problem such as oxidation, off-flavour, and oil leakage. As one of the textural properties of the tahini halva samples, the hardness values were measured with the TA-XT texture analyser and results proved that oil was one of the most important ingredients for the desirable texture of tahini halva. Our previous studies reported hardness values of ta-

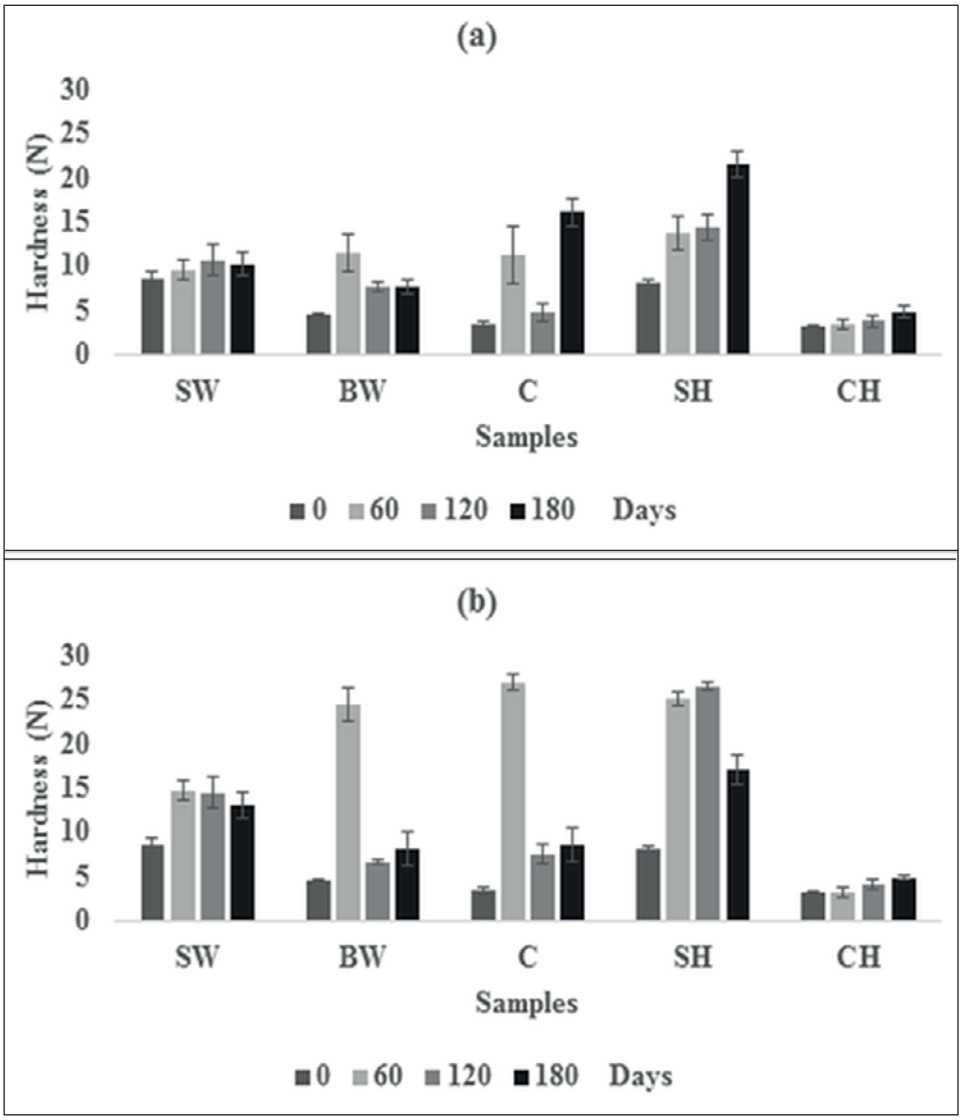

Figure 4 - The hardness values of the tahini halva samples during the storage period a) 25°C and b) 35°C. (SW; tahini halva prepared with sunflower wax, BW tahini halva prepared with beeswax, C: tahini halva samples without additives, SH: tahini halva sample prepared with shellac wax and CH: tahini halva samples prepared with hydrogenated palm stearin.)

the results are given in Figure 4. The hardness values of the tahini halva samples stored at 25 and 35°C varied between 3.24-21.49 and 3.24-26.94 N, respectively. The SW, BW and CH tahini halva samples stored at 25°C preserved their textural stability during the six-month storage period, while the SH and C samples did not preserve. Additionally, SW and CH tahini halva samples stored at 35°C were structurally stable during the storage period. Moreover, the tahini halva samples stored at 35°C had higher hardness values, when compared with the samples stored at 25°C. This might be explained with the fact that the hardness values of the tahini halva samples increased with the increase in oil leakage rates. These hini samples were within the range of 6.40 - 25.89 N, while Elleuch et al. [7] reported that the hardness values of plain, date fibre, sesame testae and emulsifier added halva samples ranged from 7.63 to 67.24 N. Literature findings are similar to our findings.

The XRD patterns of the tahini halva samples are indicated in Figure 5. For all the fresh tahini halva samples, the peaks observed at around 3.70, 4.10 and 4.60 Å were defined as characteristic of β' polymorph peak except for the C sample. The β' polymorph form is a desirable structure for the consumers and it is the reason for smooth, homogeneous and soft texture [26]. Öğütcü et al. [14] reported similar XRD patterns for the fresh tahini halva samples. Moreover,

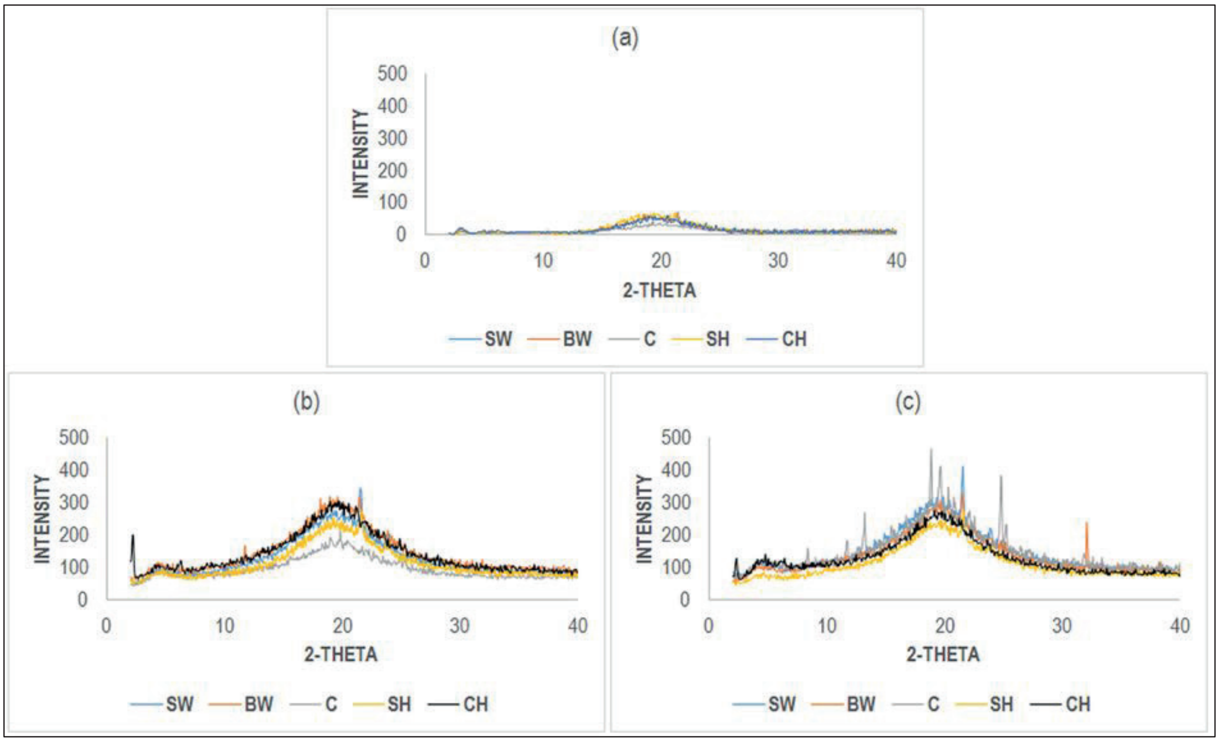

Figure 5 - XRD patterns of the tahini halva samples a) fresh halva samples b) halva samples stored 6 months at 25°C and c) halva samples stored 6 months at 35°C. (SW; tahini halva prepared with sunflower wax, BW tahini halva prepared with beeswax, C: tahini halva samples without additives, SH: tahini halva sample prepared with shellac wax and CH: tahini halva samples prepared with hydrogenated palm stearin.)

for the samples stored at 25°C similar peaks were observed at the end of the storage period. On the other hand, for the tahini halva samples (SW, BW and SH) stored at 35°C, the peaks at around the 3.70, 4.10 and 4.60 Å were observed. The crystal structure of C (control) sample extremely changed when compared with the tahini halva samples containing additives. The XRD patterns of the tahini halva samples indicated that both storage temperatures (25°C and 35°C) did not negatively affect the structural features of the tahini halva samples containing sunflower wax, shellac wax and beeswax (Fig. 5).

CONSUMER TESTS

The consumer preference test results for the tahini halva samples, are indicated in Figure 6. Sensory properties of the fresh, 25 and 35°C six-month stored tahini halva samples including the four sensory terms such as "appearance", "texture", "flavour", and "acceptability" were evaluated by potential halva consumers. For the fresh samples, in terms of all sensory characteristics, it was determined that CH sample was the most favoured sample by the consumers, while C sample was least appreciated. Among the samples stored at 25°C for 6 months, SW and CH halva samples had higher hedonic scores than the BW, SH and C tahini halva samples. A similar trend was observed for the samples stored at 35°C for 6 months. Moreover, the fresh BW and SH samples had higher hedonic scores, while the stored BW and SH samples had lower hedonic scores at the end of the storage period. However, the hedonic scores of the fresh SW and CH samples were similar to the stored SW and CH samples hedonic scores. As mentioned above, these results demonstrated that there was a positive relationship between the oil leakage values and hedonic scores of the samples. According to oil leakage values of the halva samples, the BW, SH and C halva samples had higher oil leakage rate than SW and CH halva samples, hence the hedonic scores of the SW and CH samples were higher than that of the other samples.

In this study, the effect of storage temperature on the physico-chemical, thermal, and textural characteristics of tahini halva samples prepared with natural waxes, such as sunflower wax, shellac wax and beeswax, were evaluated during a 6-month storage period. Natural wax addition into traditional tahini halva was made to reduce the oil leakage issue often observed in high-oil containing products. The results revealed that in terms of restricting oil leakage, sunflower wax was as effective as HPS, which is currently commercially used in traditional halva processing. The results revealed that storage at 25°C, a typical autumn-winter temperature, affects the physico-chemical and textural properties of the tahini halva samples less when compared with those stored at 35°C, and similarly these results were in conjunction

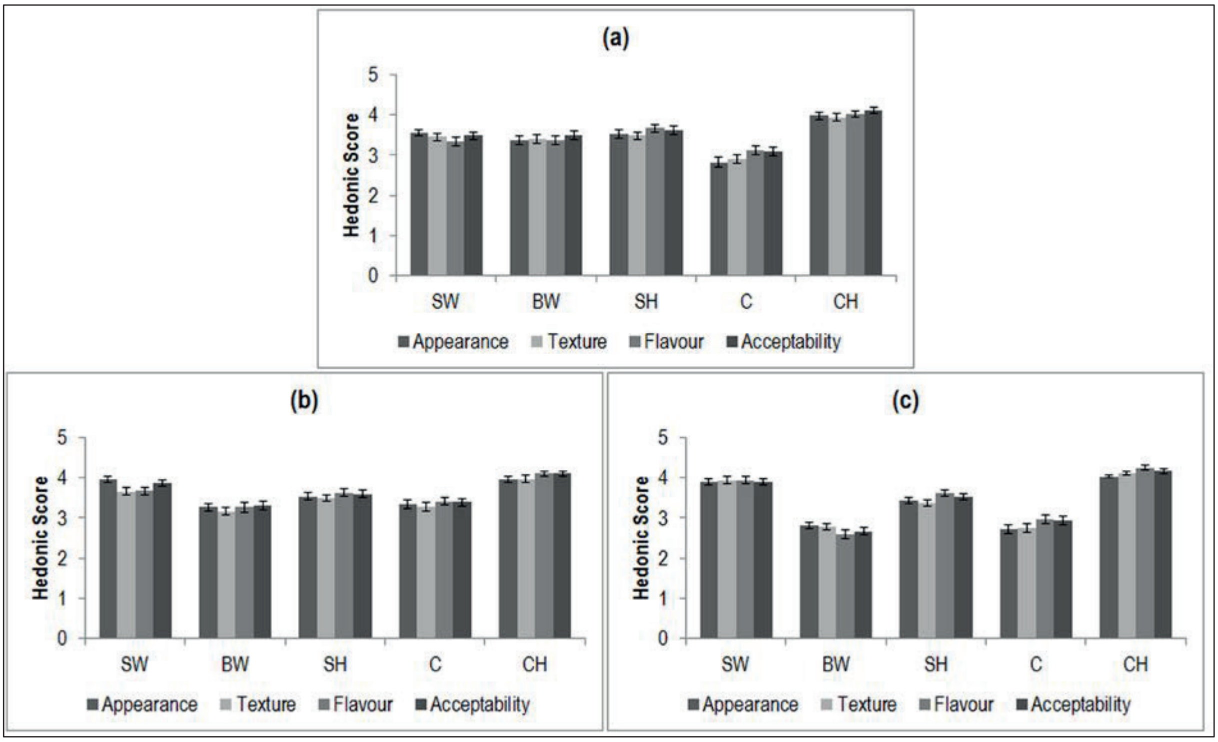

Figure 6 - Consumer preferences scores of the tahini halva samples a) fresh halva samples b) halva samples stored 6 months at 25°C and c) halva samples stored 6 months at 35°C. (SW; tahini halva prepared with sunflower wax, BW tahini halva prepared with beeswax, C: tahini halva samples without additives, SH: tahini halva sample prepared with shellac wax and CH: tahini halva samples prepared with hydrogenated palm stearin.)

with the consumer preference tests. In this study, the effect of the natural wax addition on the physico-chemical, textural and sensorial characteristics of tahini halva during storage was monitored and evaluated for the first time.

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Conflicts of Interest
The authors have declared that there are no conflicts of interest.

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