Effect of emulsifiers on oil separation problem and quality characteristics of *Tahin Helva* during storage

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Abstract *Tahin helva* is one of Turkish traditional confectionary foods. Sesame paste, sugar syrup and soapwort extract were used for *tahin helva*'s production. The purpose of this study was to solve the oil separation problem occurred in *tahin helva* by using food additives permitted as an emulsifier for *tahin helva* in the Turkish and EU Codex. Sorbitan tristearate (STS), sorbitan monopalmitate (SMP) and their combinations (STS:SMP, 1:1) were added to *tahin helva*, then *helva* samples were stored at the storage temperatures of 20 °C, 30 °C, and 40 °C. The emulsifiers did not have any effect on physical, chemical and sensory properties of *tahin helva* except on its oil content, whereas storage temperature and storage time had effects on those properties of *helva*. STS:SMP combination was found to be statistically more effective than SMP and STS formulations in preventing oil separation. Penetration force of *tahin helva* has increased by increasing the storage temperature and storage time. It was found that there was a decrease in $-a$ colour value of *helva*

through the storage time at 20 °C and 30 °C, while there was an increase in that value at 40 °C. The highest change in the moisture content of all *helva* samples through storage was observed at the storage temperature of 20 °C. Sensory scores for appearance, texture and flavour characteristics of *helva* have decreased significantly during the storage period.

Keyword *Tahin Helva* · Oil separation · Emulsifier · Sorbitan ester

Introduction

Foods through the world present different tastes to consumers according to climatic conditions, economic reasons, traditional habits in social life and cultural diversity of the nations. Turkish eating culture has a various food varieties and it is originated from Middle Asia. There are lots of traditional foods consumed through regional scale in Turkey (Tan 2004). *Tahin helva* is one of the Turkish traditional confectionary foods and it is produced at industrial scale in Turkey. The history of *tahin helva* has not been known completely, but it is said that this product has been produced since BC 3000. *Tahin helva* is also the most popular food in the Mediterranean and Middle East Countries such as Greece, Iran, Iraq, Jordan, and Saudi Arabia (Ozdemir et al. 2006).

The main ingredients of *tahin helva* are sesame paste (*tahin*), sugar syrup and *Saponaria officinalis* (soapwort) extract and they are mixed at different levels for the production. *Tahin helva* is then produced as a result of using a special mixing technique of these ingredients. Besides the main ingredients, nuts, walnuts, pistachio, cacao powder, and dried fruits may be added to enhance the flavour of *tahin helva* (Anon 2004). It was suggested to consume this product

Practical applications The oil separation problem is really considered as a very important problem in the aspects of both *helva* manufacturers and consumers in Turkey and also in other countries where this product is preferred to consume. Although the *helva* producers have been using different food additives or their combinations sold under several commercial names in order to reduce the oil separation level, it is observed that the problem has not been completely solved yet. There are many studies on chemical and microbiological properties of *tahin helva* and on its compounds. However, the studies on oil separation problem in *tahin helva* are very limited. So, we think that the results of this study will be used as a scientific source in the future studies and by confectionary manufacturers to improve quality of *tahin helva*.

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due to its high energy and nutritional value especially for sportsman, workers, teens, and pregnant women (Ceyhun Sezgin and Artik 2010, Var et al. 2004, Var et al. 2007). Turkish Food Codex describes the minimum limits for the chemical composition of *tahin helva* as; 27.50% for sesame oil, 52% for *tahin*, 11% for protein, 47% for total sugar (sucrose), and 97% for dry matter (Anon 2008).

Helva has a porous non-crystalline sugar melt particles surrounded by a precipitated protein layer originating from *tahin*. The sesame oil was found as a free fluid, filling in the spaces between sugar and protein particles. Therefore, *tahin helva* has got oil separation problem. It occurs by starting of the removing of the sesame oil from the product. The oil separation problem in *tahin helva* begins immediately after production and continues increasingly during storage of the product. This problem causes; 1) contamination of package material with oil, 2) changes on the colour of the *helva* negatively, and 3) changes in the texture of *helva* from a stringy and oily tender structure to a tough one. These changes affect the purchasing decision of the consumer, negatively due to the product looks stale and in low quality. It is also stated that the reason for this problem in *tahin helva* is due to the filling of spaces between protein and sugar particles with sesame oil physically in the non-emulsified form (Ereifej et al. 2005).

Although the *helva* producers have been using different food additives or their combinations sold under several commercial names in order to solve the oil separation problem, it is observed that the problem has not been completely solved yet. In addition, it was also determined that these additives did not contain the ones permitted to be used in this type of product. There are many studies on chemical and microbiological properties of *tahin helva* (Abu-Jdayil et al. 2002; Abu-Jdayil 2004; Alpaslan and Hayta 2002; Arslan et al. 2005; Ceyhun Sezgin and Artik 2010; Kahraman et al. 2010; Var et al. 2004, 2007; Yigit et al. 2007) and on other similar confectionery products (Itagi and Singh 2011; Itagi et al. 2011; Muresan et al. 2010). However, the studies on oil separation problem in *tahin helva* are very limited (Ereifej et al. 2005). The purposes of this present study were to solve the oil separation problem of *tahin helva* by using permitted food additives as emulsifiers and to evaluate the effects of the food additives on physical, chemical and sensory characteristics of *tahin helva* during storage at different temperatures.

Materials and methods

Materials

Traditionally prepared plain type *tahin helva* samples were used as the material in this study. The *helva* samples were

produced in a *tahin helva* manufacturer (Tatlan Food Company, Canakkale, Turkey) by using its sugar solution, *tahin* and *Saponaria officinalis* extract. Sorbitan monostearate (E491), sorbitan tristearate (E492), sorbitan monolaurate (E493), sorbitan monooleate (E494) and sorbitan monopalmitate (E495) were used to reduce oil separation and all were food grade. All chemicals were analytical reagents (Merck, Darmstadt, Germany).

Methods

Selection of emulsifiers and their concentrations

According to Turkish Food Codex (Anon 2008) sorbitan monostearate, sorbitan tristearate, sorbitan monolaurate, sorbitan monooleate and sorbitan monopalmitate are permitted emulsifiers to be used in *tahin helva* at a maximum concentration of 5 g/kg (0.5%), alone or in combination. These emulsifiers were evaluated for their suitability to this food product by taking their Hydrophilic Lipophilic Balance (HLB) values into consideration. HLB values for sorbitan monolaurate, sorbitan monopalmitate, sorbitan monostearate, sorbitan monooleate and sorbitan tristearate are 8.6, 6.7, 4.7, 4.3 and 2.1, respectively (Hepworth 2006). *Tahin helva* is a W/O (Water in Oil) emulsion type product because of its oil and moisture contents. Therefore, sorbitan monolaurate was eliminated from this study due to its more hydrophilic character (HLB:8.6) than others. Sorbitan monostearate was also not selected for this study. Because it has both higher HLB value than sorbitan monooleate and lower esterification degree than sorbitan tristearate. So, sorbitan monopalmitate, sorbitan monooleate and sorbitan tristearate were selected for preliminary experiments. In the preliminary experiments, these selected emulsifiers were added to *tahin helva* as alone and with sorbitan tristearate: sorbitan monopalmitate combination (STS:SMP, 1:1) at the concentrations of 2 g/kg, 3.5 g/kg and 5 g/kg. So, 12 different *helva* samples and a control sample having no emulsifier were produced and stored at 40 °C for four weeks. The oil separation levels of the samples were checked during the storage. At the end of the storage, ranking test was applied by ten trained panellists to the samples for sensory evaluation in order to determine consumer overall preferences. Through the preliminary experiments, it was found that the preventive effect of sorbitan monooleate on oil separation problem was too low in all concentrations according to the others. So, it was decided for sorbitan monooleate not to include to this study. It was also not determined any significant difference between the concentration levels of the emulsifiers according to the results of sensory evaluation. Therefore, it was decided to add sorbitan tristearate (STS), sorbitan monopalmitate (SMP), and sorbitan tristearate:sorbitan mono-

palmitate combination (STS:SMP, 1:1) at the concentrations of 0.35%, 0.35%, and 0.2%, respectively to *tahin* by taking the *helva* production cost into consideration.

Production of *tahin helva*

Tahin helva was produced by following the traditional production steps of the *tahin helva* manufacturer. These steps were observed during the production in the manufacturer and they are shown on Fig. 1. Through the production line, no changes were made except adding the food additives. They were directly added to *tahin* and then the *tahin* was mixed with a hand blender to obtain a homogenous mixture. The production was duplicated and its quantity was 10 kg for each formulation. A control sample having no emulsifier was also produced. After the bulk production of *tahin helva*, the product was moulded perpendicularly into small weights as 250 g and then packaged in plastic moulds. The samples were taken from these small packages as a cubic weighing almost 100 g and then put into a petri dish. The Petri dish contains filter paper and metal grids for allowing the leaked oil to remove from the sample completely during storage. Then, a beaker having suitable diameter for taking the cubic sample into itself was placed invertedly into the petri dish for avoiding moisture loss of the sample. The samples were later stored at the storage temperatures of 20 °C, 30 °C and 40 °C for 36 days to determine the effects of the emulsifiers, the storage temperature and the storage time

on the oil separation level in *tahin helva* and also to evaluate physical, chemical and sensory properties of *tahin helva*.

Colour measurement

Colour parameters were measured by CIE LAB Colour System. L^* for lightness, $-a$ for greenness, and $+b$ for yellowness values of *helva* samples were determined on the surface of *tahin helva* by using Minolta Chroma Meter CR-400 model colorimeter (Minolta Ltd., Japan) during storage. The instrument was standardized with white tile of CIE Lab colour scale. Colour measurements were repeated three times at different surfaces for each *helva* sample and colour measurements were duplicated.

Texture measurement

The texture of *helva* sample was evaluated by determining penetration force. Texture analyzer, TA.XTPlus (Stable Micro Systems Ltd., U.K.) with P3 probe was used. The penetration test was carried out on $15 \times 15 \times 15$ mm of *helva* sample at 20 °C. Test parameters were; 5 mm for the penetration distance and 2 mm/s for the test speed. The penetration force was automatically recorded and calculated by the TA 32 software program from the penetration force vs. time diagram in the unit of gram force (gf). Five measurements were made for each *helva* sample.

Fig. 1 The production steps for *tahin helva* (observation through the production in the *helva* manufacturer)

Moisture content

Moisture content of *helva* samples was determined by using vacuum drying method for confectionery products (AOAC International 2000).

Oil separation

The oil separation from the *helva* samples can be expressed as the decrease in the oil content of the samples during storage. Therefore, the oil content of *helva* samples through the storage was determined by using soxhlet extraction method (AOAC International 2000).

Sensory evaluation

Sensory evaluation was conducted with ten panellists (7 females and 3 males, ages ranged from 25 to 42 years old) by using a five-point scale scoring test in the aspects of appearance, texture and flavour characteristics of *tahin helva* (Demirag and Altug 1999) during storage. Panellists were consisted of academic staff and graduate students in the Department of Food Engineering at Canakkale Onsekiz Mart University. The panellists had 50 h of experience in sensory evaluation. Four samples were evaluated in each sensory panel session and each session was duplicated.

Statistical analysis

Statistical analyses were applied to the data by using Variance Analysis of Repeated Measurements to deter-

mine statistically significant differences ($p < 0.05$) between the factors of type of emulsifier, storage time and storage temperature and their interactions. Tukey Honestly Significant Differences (HSD) test was used for multiple comparisons. The statistical analyses were conducted by using the software packages of SPSS (Statistical Package for the Social Sciences, SPSS for Windows, release 15.0.6, USA) and SAS (Statistical Analysis System, SAS, version 9.1.3, SAS Institute Inc., NC, USA). Duplicate independent *helva* productions were carried out. Two parallel independent samples were taken for each analysis from each production. So, the values were expressed as mean $\pm$ standard error of four independent measurements ($n=4$).

Results and discussion

Colour

It was found that the changes on the colour parameter of lightness (L^*) for *tahin helva* during the storage were not significant ($p > 0.05$). This shows that type of emulsifier, the storage time and the storage temperature did not have any significant effect on L^* colour value of *tahin helva*. It was observed that the effects of the selected emulsifiers on the colour parameters of $-a$ and $+b$ for *tahin helva* were not significant ($p=0.942$ and $p=0.924$ for $-a$ and $+b$, respectively). However, a significant interaction between storage time and storage temperature was determined for both $-a$ and $+b$ values of *tahin helva* ($p=0.001$). This means that the storage temperature has a significant effect on the colour values of $-a$ and $+b$ for *tahin helva* depending on

Table 1 Changes in quality characteristics of *helva* samples during storage at different temperatures

Storage Temperature (°C)	Storage time (days)				
	0	6	12	24	36
Colour $-a$ value					
20	1.87 $\pm$ 0.07 ^{Aa}	1.91 $\pm$ 0.08 ^{Aa}	1.67 $\pm$ 0.07 ^{Aab}	1.71 $\pm$ 0.07 ^{Aab}	1.46 $\pm$ 0.05 ^{Ab}
30		1.97 $\pm$ 0.08 ^{Aa}	1.70 $\pm$ 0.09 ^{Abc}	1.76 $\pm$ 0.10 ^{Abc}	1.60 $\pm$ 0.09 ^{Ac}
40		1.86 $\pm$ 0.09 ^{Aab}	1.72 $\pm$ 0.10 ^{Ab}	1.95 $\pm$ 0.08 ^{Aab}	2.00 $\pm$ 0.16 ^{Ba}
Colour $+b$ value					
20	19.59 $\pm$ 0.17 ^{Ab}	20.35 $\pm$ 0.20 ^{Aa}	19.66 $\pm$ 0.31 ^{Ab}	19.96 $\pm$ 0.14 ^{Bab}	19.39 $\pm$ 0.14 ^{Cb}
30		20.59 $\pm$ 0.16 ^{Aa}	20.14 $\pm$ 0.24 ^{Aab}	20.69 $\pm$ 0.17 ^{Aa}	20.11 $\pm$ 0.21 ^{Bab}
40		20.79 $\pm$ 0.17 ^{Aac}	20.15 $\pm$ 0.38 ^{Aab}	21.18 $\pm$ 0.29 ^{Acd}	21.72 $\pm$ 0.44 ^{Ad}
Texture sensory scores					
20	3.88 $\pm$ 0.04 ^{Aa}	4.07 $\pm$ 0.06 ^{Aa}	3.23 $\pm$ 0.23 ^{Ab}	2.87 $\pm$ 0.16 ^{Ac}	3.33 $\pm$ 0.06 ^{Ab}
30		3.97 $\pm$ 0.07 ^{Aa}	3.75 $\pm$ 0.11 ^{Ba}	3.53 $\pm$ 0.11 ^{Ba}	2.86 $\pm$ 0.11 ^{Bb}
40		4.11 $\pm$ 0.09 ^{Aa}	3.45 $\pm$ 0.19 ^{ABb}	3.45 $\pm$ 0.14 ^{Bb}	3.52 $\pm$ 0.11 ^{Ab}

The results are expressed as mean $\pm$ standard error of four independent measurements ($n=4$). Different capital letters within a column and different small letters within a row show significant difference for each characteristic ($p < 0.05$).

the storage time. The changes in these Hunter colour values for *tahin helva* during the storage at different temperatures are shown in Table 1.

There is a general decrease in the colour value of $-a$ for *tahin helva* through the storage time at the storage temperatures of 20 °C and 30 °C (Table 1). It was noticed that this decrease has continued until 12 days of storage and then an increase in $-a$ value has begun for the storage temperature of 40 °C. These changes in $-a$ values of *tahin helva* samples were found to be significant after the storage time of 36 days, 12 days and 12 days at the storage temperatures of 20 °C, 30 °C and 40 °C, respectively ($p<0.05$). The colour value of $-a$ is a positive function of the storage temperature under each storage time. The effect of the storage temperature on the colour value of $+b$ for *helva* samples (Table 1) was found to be significant after the storage time of 24 days ($p<0.05$). No significant differences were observed in the colour values of $+b$ for *helva* samples stored at 30 °C and 40 °C in the storage time of 24 days, whereas significant differences were observed in between the colour values of $+b$ of *helva* samples in the storage time of 36 days for each temperature. The highest $+b$ value observed in *helva* samples stored at 40 °C in the storage time of 36 days.

Texture

The changes on textural characteristics of *tahin helva* samples during storage were determined by measuring the penetration force to describe the hardness of *helva*. These changes are graphically shown on Fig. 2 for each selected storage temperature.

There is an increase in the penetration force of *tahin helva* samples through the storage at each storage temperature. The penetration force for *tahin helva* was not significantly affected by addition of the emulsifier ($p=0.236$), whereas the storage time ($p=0.001$) and the storage temperature ($p=0.009$) affected individually to this textural parameter significantly. In the aspect of the storage time, the increase in the penetration force was found significant in the first 6 days of the storage ($p<0.05$). The penetration force of the samples stored at 40 °C was found higher and significantly different than the values obtained at the storage temperatures of 20 °C and 30 °C ($p<0.05$). The highest value of penetration force was also observed at 40 °C (Fig. 2). The reasons for this significant difference are; more oil separation from *tahin helva* samples and slower increase in moisture content of the samples stored at 40 °C than the samples stored at 20 °C and 30 °C.

Moisture

The effect of the emulsifiers on moisture content of *tahin helva* samples during storage was not significant ($p=0.254$),

Fig. 2 Changes in penetration force of *helva* samples at different temperatures. (C: *helva* samples without food additive; SMP: *helva* samples added sorbitan monopalmitate; STS: *helva* samples added sorbitan tristearate; SMP:STS: *helva* samples added Sorbitan monopalmitate:sorbitan tristearate). Each value is a mean of four independent measurements ($n=4$)

whereas a significant interaction was observed in between the storage time and the temperature for the moisture content of the samples ($p=0.001$). The effect of the storage temperature on the moisture content depends on the storage time. It was also obtained that the moisture content of the samples was affected by storage time individually and both the storage time and storage temperature until and after

12 days of storage, respectively. Figure 3 shows the changes in moisture content of *helva* samples during storage at the temperatures of 20 °C, 30 °C and 40 °C.

The moisture contents of *helva* samples added emulsifiers increased during storage at all selected temperatures (Fig. 3). In addition, *helva* samples stored at 20 °C became moister than the others. The reason for this might be due to very slow water vapour circulation in the air and much more moisture absorption by *helva* surface at this temperature than the others. It is emphasized that confectionary

products having high sugar content tend to get moisture during storage because of their hygroscopic structure. The moisture content for this type of products is very important because of being indicator of freshness. *Tahin helva* is given as a good example to these products and it is determined that the moisture content has got a very important effect on its durability and consumability (Mohos 2010; Edwards 2000).

Oil separation

The effects of the selected emulsifiers on the oil separation from *tahin helva* samples stored at selected storage temperatures were evaluated by determining the changes in the oil content of the samples. The changes of oil content of *helva* samples during their storage are shown in Fig. 4.

In Fig. 4, it can be seen that there was a general decrease in oil content of *helva* samples except the samples added SMP:STS combination during storage for all the storage temperatures. However, the rate of this decrease shows a slowing tendency through the storage. This means that the oil separation from *helva* samples has stopped after a time during storage. The decreases in the oil content of *helva* samples added SMP:STS during the storage were not significant for all storage temperatures. This indicates that oil separation problem in *helva* samples, in which sorbitan tristearate:sorbitan monopalmitate combination (STS:SMP, 1:1) was added at the concentration of 0.2%, occurs at the least ratio compared to the other *helva* samples. It was determined that all the factors; the selected emulsifiers, the storage time and the storage temperatures interacted significantly on oil separation from the *helva* samples ($p=0.007$). Decreases in oil contents of control and *helva* samples, in which sorbitan monopalmitate (SMP) and sorbitan tristearate (STS) were added, were found to be significant after the 24 days of the storage at 20 °C ($p<0.05$). The changes in oil contents of these *helva* samples were not significantly different until 24th days of the storage. No significant differences were observed between in the oil contents of SMP:STS added samples through storage time ($p>0.05$). At the storage temperature of 30 °C, the changes in the oil contents of control, SMP and STS added samples were found to be significant after 6th, 12th and 24th days of the storage, respectively ($p<0.05$). Any significant differences between the oil contents of SMP:STS added samples were not observed during the storage at this temperature ($p>0.05$). The changes in the oil contents of all samples except SMP:STS added ones were found to be significant after 6 days of the storage at the temperature of 40 °C ($p<0.05$). These results indicate that sorbitan tristearate:sorbitan monopalmitate emulsifiers combination (STS:SMP, 1:1) at the concentration of 0.2% was very effective in preventing oil separation from *helva* samples during the storage for all the selected storage temperatures.

Fig. 3 Changes in moisture content of *helva* samples at different temperatures (C: *helva* samples without food additive; SMP: *helva* samples added sorbitan monopalmitate; STS: *helva* samples added sorbitan tristearate; SMP:STS: *helva* samples added Sorbitan monopalmitate:sorbitan tristearate). Each value is a mean of four independent measurements ($n=4$)

Fig. 4 Changes in oil content of *helva* samples at different temperatures (C: *helva* samples without food additive; SMP: *helva* samples added sorbitan monopalmitate; STS: *helva* samples added sorbitan tristearate; SMP:STS: *helva* samples added Sorbitan monopalmitate: sorbitan tristearate). Each value is a mean of four independent measurements ($n=4$)

Uluöz et al. (1975) showed that oil leaked out from *tahin helva* at the ratio of 8.5% of its weight and they emphasized that addition of magnesium stearate and licorice extract (24%) at the concentration of 1% and 0.25% might be suitable for solving oil separation problem in *tahin helva*, respectively. However, they stated that comprehensive researches were required on solving this problem. Ereifej

et al. (2005) investigated the effects of various food ingredients such as palm oil, soy protein isolate, gelatine, lecithin, gum arabic, pectin, and ground sugar on oil separation in *tahin helva*. They stated that ground sugar, gum arabic and pectin decreased the oil leaked out from *tahin helva*, however this decreasing was not important practically. It was demonstrated that the addition of palm oil in the concentrations of 1% and 2.5% into *tahin helva* at 25 °C prevented the oil separation from *tahin helva*, whereas soy protein isolate, gelatine and lecithin were not effective. The effects of particle dimension and storage temperature on oil emulsion stability of *tahin* were investigated by Ciftci et al. (2007). It was found that oil emulsion stability was increased by the decreasing of particle dimension in *tahin* stored at 20 °C. Hence, oil emulsion stability became independent from particle dimension of *tahin* at 30 °C and above temperatures. The researchers have determined the emulsion stability of *tahin* depended on both storage temperature and particle dimension, hence they stated that storage temperature was more effective on emulsion stability than particle dimension. Eissa and Zohair (2006) investigated the changes of some quality characteristics in modified *helva* with dried mushroom (*oyster mushroom*, *Pleurotus sajor-caju*) during storage at 25 °C for 6 months. It was found that colour value of *a* and browning index of *helva* increased depending on the increasing mushroom concentration (from 10 g/kg to 120 g/kg) in *tahin helva*. The researchers stated that the addition of dried mushroom prevented oil separation in *helva*. In a study by Damir (1984), utilization of sunflower seed to produce *tahin* and *helva* was investigated. In the study, no differences were observed between sunflower and sesame *helva* samples in terms of textural and flavour characteristics. However, sunflower *helva* had distinctly dark colour than sesame *helva*. Oil separation in sunflower *helva*

Table 2 Appearance and flavour sensory mean scores of *helva* samples for both storage time and temperatures

		Appearance sensory scores	Flavour sensory scores
Storage time (day)	0	4.31±0.11 ^A	4.16±0.10 ^A
	6	4.39±0.04 ^A	4.12±0.05 ^A
	12	3.82±0.18 ^B	3.58±0.06 ^B
	24	3.83±0.06 ^B	3.31±0.15 ^C
	36	3.64±0.04 ^B	3.13±0.14 ^C
Storage temperature (°C)	20	3.77±0.08 ^B	3.63±0.06 ^A
	30	4.09±0.07 ^A	3.66±0.08 ^A
	40	4.13±0.06 ^A	3.70±0.08 ^A

The results are expressed as mean±standard error of four independent measurements ($n=4$). Different capital letters within a column show significant difference for both storage time and temperatures ($p<0.05$)

was followed during storage at room temperature for 90 days. The researcher also emphasized that the addition of glycerol monostearate had a pronounced stabilizing action resulting in reducing oil separation from 11.8% to 6.25%.

Sensory evaluation

Plain type of *tahin helva* has got smooth and homogenous surface and slightly sticky, oily, fibrous, crunchy and fragile texture, when it is produced, in the aspects of such sensory characteristics as appearance and texture, respectively. *Helva* has also got rich yellowish colour due to its high sesame oil content. However, this product begins to lose these sensory quality characteristics through the storage. In the present study, it was observed that *helva* had got a tough appearance and a dull colour after a period of storage and there were increases in textural properties of stickiness and fragility, whereas there was a decrease in the property of oiliness. According to the statistical results of sensory evaluation for *tahin helva* samples, it was found that the selected emulsifiers did not have any effect on the sensory characteristics of appearance ($p=0.756$), texture ($p=0.203$) and flavour ($p=0.953$) of *tahin helva*. On the other hand, it was observed that there was a significant interaction between the storage temperature and time in the aspect of the texture of *helva* ($p=0.00$). This means that the storage temperature significantly affected the texture of *tahin helva* depending on the storage time (Table 1).

Depending on the storage time, a general decrease in sensory textural scores of *helva* samples was also observed during storage period (Table 1). While the decreases in the texture scores of *helva* samples were found significant after 12 days of storage ($p<0.05$) for 20 °C and 40 °C, a decrease was found to be significant after 36 days of the storage at the temperature of 30 °C. As a result, *helva* samples stored at 30 °C were found more stable regarding sensory textural properties than *helva* samples stored at 20 °C and 40 °C.

It was also determined that the effects of both the storage time ($p=0.001$) and the storage temperature ($p=0.001$) were individually significant on appearance of *tahin helva*, while only the storage time significantly affected the flavour of *helva* ($p=0.001$) (Table 2).

There was a general decrease in the sensory scores of appearance and flavour of *helva* samples during storage (Table 2). It was determined that the decreases in the appearance and flavour scores of *helva* samples were found significant after 12 days of storage ($p<0.05$). No significant differences were observed between the appearance scores of *helva* samples stored at 30 °C and 40 °C in the aspect of storage temperature and the lowest appearance mean score (3.77) was found in *helva* samples stored at 20 °C.

Conclusion

Sorbitan tristerate:sorbitan monopalmitate: (STS:SMP, 1:1) combination at the concentration of 2 g/kg *helva* was obtained statistically more effective formulation than the other formulations used in this study on solving oil separation problem in *tahin helva* through the storage at the temperatures of 20 °C, 30 °C and 40 °C. The emulsifiers did not have any effect on the selected quality characteristics of the samples except in oil separation. Storage temperature and storage time were found more effective on physical, chemical and sensory properties of *tahin helva* than the emulsifiers. Thereby, the storage temperature and the storage time are important factors which should be considered in producing *tahin helva* in high quality. Further researches are needed to state the effects of different storage conditions, packaging materials and other food additives on *tahin helva* quality.

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