FACTORS AFFECTING TAHINI QUALITY

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Abstract

Sesame paste (tahini), produced from one of the oldest known oilseed sesame is an important traditional food product widely consumed in Anatolia since ancient times. In this study, the changes in the physical, chemical and rheological characteristics of tahini with respect to different sesame environmental growth conditions are evaluated. Processes applied during tahini production cause structural changes and the environmental conditions and producing mixtures may also affect the tahini structure. These changes in tahini rheology affect the storage period and viscosity of tahini.

Key words: *tahini, quality, processing*

1. INTRODUCTION

Sesame (*Sesamum indicum L.*, Pedaliaceae), is an annual plant, reaching a height of 80-120 cm and growing in Africa, Asia and Europe. Archaeological records demonstrated that sesame agriculture has a history of more than 5000 years in India. Sesame is a plant that grows in regions of tropical, subtropical and temperate climates. In the 90-120-day development period, the monthly temperature average should not be below 20 °C and the soil temperature should be at optimum 20-25 °C. Sesame requires a total temperature of 2500-2800 °C during the development period. Sesame is not very selective in terms of soil requirements. In sesame paste (tahini) production, 1.5-2 mm wide and 4 mm long sesame seeds are used (Weiss, 1983; Khidir, 1997; Omran, 1985). The sesame plant and sesame seeds are shown in Figure 1.

Figure 1. Sesame plant and sesame seed varieties.

The seeds can be red, black, brown, yellow and white in colour depending on the sesame variety. The sesame seeds are primarily used as sources of sesame oil or sesame paste in food industry. On the other hand, sesame seeds and sesame pulps are used as bakery and confectionery product decorations in food industry (Elleuch, 2011).

According to Food and Agriculture Organization (FAO) statistics, the world total sesame seed production comprised approximately 6.5 million tonnes in 11 million ha areas. The European Union (EU) sesame production values were 3.3 thousand tonnes in 266 ha areas in 2014. The sesame seed production of Turkey was 18 thousand tonnes in 26.5 thousand ha areas in 2014 (FAO, 2017). The ten largest sesame seed producers of the world and the sesame seed production values of the regions are shown in Figure 2. As can be observed from Figure 2, the largest sesame seed producers of the world are China, India and Myanmar. According to the regions, the world sesame seed production values are given for Asian countries - 59.1%, African countries - 36.3% and Americas countries - 4.5% (FAO, 2017).

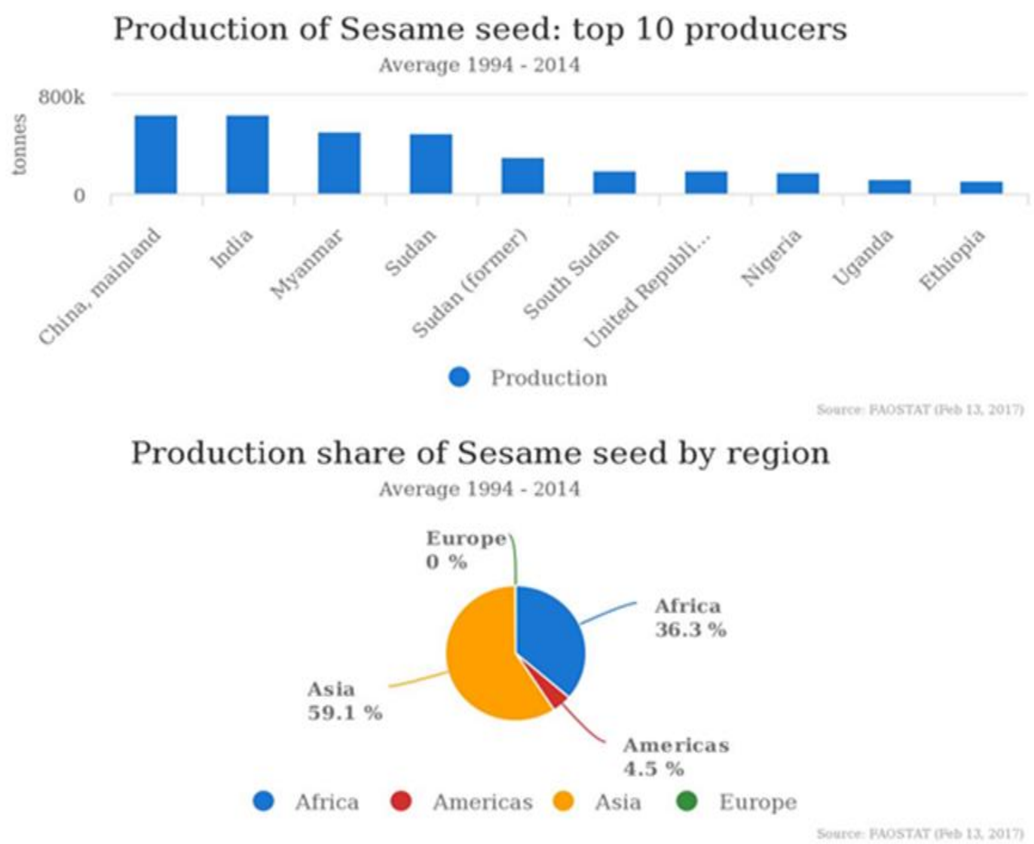

Figure 2. The largest sesame producers and regions of the world (FAO, 2017).

Sesame seeds contain approximately 52-61% crude oil, 16.44-22.07%crude protein, 6-20% crude fiber and 3.64-5.39% ash (Özcan, 1993). The chemical composition of the sesame seeds and sesame paste are given in Table 1.

As seen from Table 1, the proximate composition of sesame paste is found to be in the ranges of 46.90-58.70% crude oil, 17.88-24.27% crude protein, 3.25-4.70% crude fiber and 2.60-3.70% ash. These results demonstrated that by converting sesame seeds to sesame paste, moisture, oil, fiber and ash values decreased, while the protein content was not changed (Özcan, 1993).

Table 1. The chemical composition of the sesame seeds (Özcan, 1993).

Components	Sesame Seed	Sesame Paste
Moisture (%)	3.16-4.67	0.39-1.47
Protein (%)	16.44-22.07	17.88-24.27
Oil (%)	52.0-61.0	46.90-58.70
Crude fiber (%)	6.0-20.0	3.25-4.70
Ash (%)	3.64-5.39	2.60-3.70
NaCl (%)	nd	0.22-0.69
Sodium (Na) (%)	0.07-0.16	0.17-0.27
Potassium (K) (%)	0.17-0.60	0.24-0.53
Phosphorus (P) (%)	0.85-1.30	0.75-1.40
Copper (Cu) ppm	15.58-20.45	13.55-20.45
Manganese (Mn) ppm	16.61-22.66	14.34-21.90
Iron (Fe) ppm	65.20-85.95	52.02-80.92
Zinc (Zn) ppm	70.10-121.40	61.95-100.95

Sesame seeds are among the major vegetable oil resources. The sesame oil production values of the regions and the largest producer countries are given in Figure 3. The largest sesame oil producers were Myanmar, China and India in the world and the sesame oil production portions of the regions were as follows: Asia - 78.6%, Africa - 16.6%, Europe - 2.9% and America - 1.6%. The sesame oil production values of the World, EU and Turkey were 1.6 million tonnes, 37 thousand tonnes and 33 thousand tonnes, respectively (FAO, 2017).

The chemical composition of sesame oil and sesame paste oil are presented in Table 2. As can be seen from Table 2, the sesame oil fatty acid composition comprises 12-14 saturated fatty acids and 86-88% unsaturated fatty acids. The major unsaturated fatty acids are oleic (37-49%) and linoleic acids (35-47%) (Özcan, 1993).

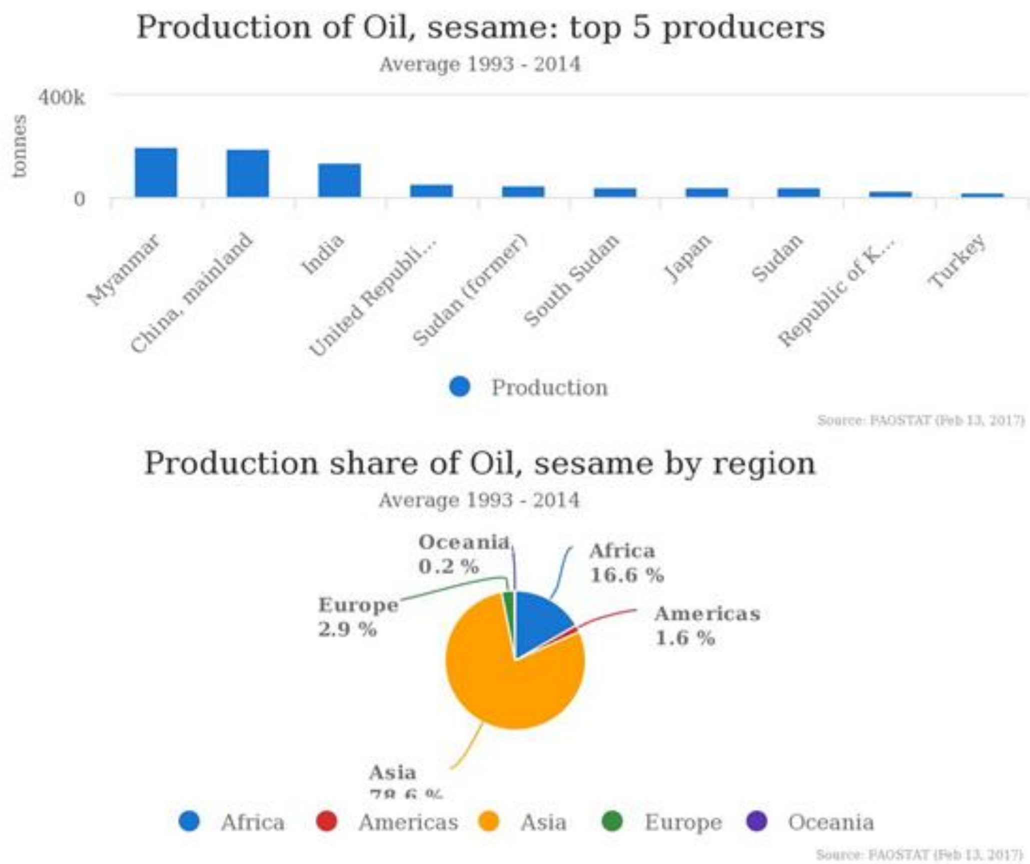

Figure 3. The largest sesame oil producers and regions of the worlds (FAO, 2017).

Table 2. Physico-chemical properties of the sesame oil and sesame paste oil (Özcan, 1993).

Components	Sesame Oil	Sesame Paste Oil
Relative density	0.9175-0.9223	0.9122-0.9155
Refractive index	1.4700-1.4707	1.4707-1.4716
Free fatty acids (%oleic)	1.05-1.96	0.21-0.95
Peroxide Value (meqO_2/kg)	1.93-3.62	1.63-2.99
Iodine value	106.50-117.70	110.61-118.27
Saponification value	174.90-196.60	179.10-197.70
Unsaponifables (%)	1.04-1.65	1.03-1.76
Palmitic acid	9.10-11.38	9.55-10.32
Stearic acid	0-0.15	nd
Oleic acid	31.61-57.19	37.42-45.04
Linoleic acid	30.79-57.33	43.25-52.34
Linolenic acid	0.30-0.79	0,34-1.93
Arachidonic acid	0-2.62	0-0.82

Sesame paste, also called tahini, is obtained from sesame seeds by applying the following steps: washing, peeling, roasting, crushing and grinding. The tahini production process is shown in Figure 4.

1. Washing: In this process, all of the organic and inorganic pollutants are removed by sieving or in salty water.
2. Peeling: The sesame seeds are held for 5-7 hours in water and afterwards the seeds hulls are peeled mechanically. When the sesame shell is not removed the sesame paste color turns to red.
3. Roasting: This process is applied to obtain the characteristic appearance and flavor of the tahini (sesame paste) and make the grinding process easier.
4. Crushing and Grinding: During this step, sesame seeds are converted to sesame paste (tahini) (Elleuch, 2011).

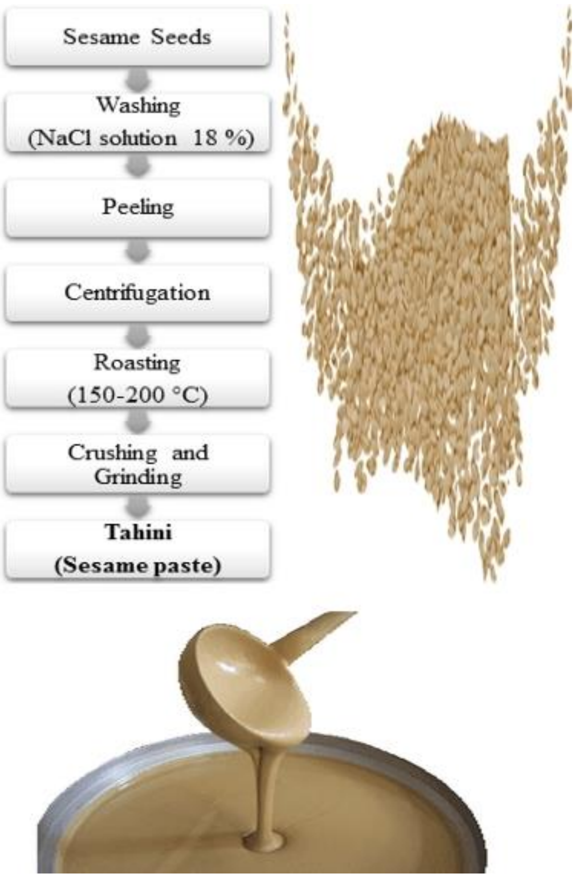

Figure 4. The sesame seed, sesame paste (tahini) and production scheme of the tahini.

Tahini (sesame paste) is a kind of colloidal suspension mainly composed of hydrophilic solids suspended in sesame oil. Also, sesame seeds possess endogenous antioxidants such as sesamin, sesaminol and sesamol. Hence, sesame seeds as well as their products exhibit strong resistance against oxidation. Besides, tahini is a nutritious, digestible and healthier food product due to its protein, bioactive components, fatty acids, important minerals and vitamins content. Tahini is stable against chemical deterioration, while phase separation is the major problem during its shelf life. On the other hand, tahini quality is mainly affected by sesame seed varieties, roasting time and temperature and particle size and distribution (Elleuch, 2011; Öğütcü et al., 2017).

The aim of this study was to investigate the factors affecting the physical, chemical, microbiological and sensory qualities of tahini.

2. QUALITY CHARACTERISTICS OF SESAME PASTE

2.1. Physico-chemical properties

Özcan and Akgül (1994) investigated 11 tahini samples from different sources and evaluated their moisture, ash, crude protein, crude oil, crude fiber and salt content. Additionally, the researchers investigated the relative density, refractive index, free fatty acids, peroxide value, iodine value, saponification value and unsaponifables of the tahini oil samples. The moisture, ash, crude protein, crude oil, crude fiber and salt were reported as 0.86%, 2.96%, 20.30%, 55.27%, 3.71% and 0.38%, respectively. The N, K, P, Cu, Fe, Mn and Zn of the tahini samples were reported as 0.23%, 0.37%, 1.11%, 17.38ppm, 71.80ppm, 18.52ppm and 78.59 ppm, respectively. In this study, the relative density, refractive index, free fatty acids, peroxide value, iodine value, saponification value and unsaponifables of the sesame oil samples were found to be 0.9139, 1.4716, 0.95%, 2.99 meq/kg, 118.27 g, 197.70 and 1.76%, respectively. Furthermore, the researchers aimed to investigate the fatty acid composition of the tahini samples via gas chromatography. The palmitic, oleic and linoleic acids were reported as 10.32, 45.04 and 52.34 in the tahini samples, respectively.

Akbulut (2008) investigated the mineral composition of dehulled and unhulled sesame paste and their blends. In this study, all samples contained high amounts of Ca, K, Fe, Mg, Na, P and Zn. The highest mineral concentration for the tahini samples and sesame seeds were 0.16-3.74 mg/kg Al, 2005.92-8794.09 mg/kg Ca, 14.04-21.19 mg/kg B, 15.39-33.67 mg/kg Cu, 165.7-437.66 mg/kg Fe, 4096.55-6876.06 mg/kg K, 2020.97-2482.87 mg/kg Mg, 12.56-21.31 mg/kg Mn, 0.74-1.55 mg/kg Mo, 605.81-2436.5 mg/kg Na, 4.78-8.66mg/kg Ni, 5019.89-7627.85 mg/kg P and 41.28-52.85 mg/kg Zn. Moreover, it was indicated that minerals such as Al, Ca, B, Cu, Fe, K, Mn, Mo, Na, Ni, P and Zn increased with increasing hulls content, while the Mg content decreased.

Borchani et al. (2010) analyzed the chemical characteristics and oxidative stability of sesame seeds, sesame paste and olive oils. The following values were obtained for raw sesame, sesame paste and olive oils, respectively: unsaponifiable matter 1.35, 1.46, and 1.50%; total phenols 14.21, 16.82, and53.33 mg kg^{-1} oil; chlorophylls 0.04, 0.09 and 1.88 μg g^{-1}; carotene 2.62, 3.66 and 19.10 μg g^{-1};refractive index 1.47, 1.47 and 1.47; saponification value 186.6, 185.75, and 97.94; iodine value 113.35, 91.34, and 81.23, acidity along with of 1.64, 1.10, and 1.12 mg KOH g^{-1} oil.Fatty acid profiles of raw sesame, sesame paste and olive oils showed a predominance of oleic acid (41.68%, 41.94%, and 52.14%, respectively) followed by linoleic-acid (38.29%,37.48%, and 17.82%, respectively).

2.2. Colloidal stability and rheological properties

Determination of the particle size and rheological behaviors of food products are important for their formulation, processing, transportation and storage, particularly in emulsions and suspensions. Sesame paste is a kind of protein-oil suspension hence; colloidal instability is the main problem during the storage of sesame paste. The phase separation of the sesame paste leads to negative perception on the consumers so, producers' reputation, economic and quality losses may occur. Therefore, prevention of phase separation is important to improve tahini colloidal stability and to understand its rheological properties (Öğütcü et al., 2017; Alpaslan and Hayta, 2002).

Alpaslan and Hayta (2002) reported the rheological properties of tahini containing 2, 4 and 6% pekmez (grape molasses) blends at 30, 40, 50, 60, 65 and 75 °C. The researchers indicated that all of the blends exhibited pseudoplastic behavior. On the other hand, the pekmez concentration and temperature were effective on the flow behavior and consistency values and the addition of pekmez improved the emulsion stability of the tahini/pekmez blends. The statistical evaluation proved that there were significant differences among the oiliness, mouth-coating, taste and overall acceptance, while there were no significant differences among the spreadability, firmness and adhesiveness. Also, addition of the pekmez was not significantly effective on the color values of the tahini samples (Alpaslan and Hayta, 2002).

Abu-Jdayil (2004) determined the steady and time-dependent flow properties of sweetened tahini in the temperature range between 25 and 45 °C. The sweetened tahini exhbited pseudoplastic and thixotropic flow behavior at all temperatures, while the apparent viscosity–shear rate data was described by power law model. As temperature increased the flow behavior index also increased and the consistency coefficient decreased significantly (Abu Jdayil 2004).

Arslan et al. (2005) prepared tahini / pekmez blends at different tahini concentrations (20–32%) and investigated their rheological properties at different temperatures (35– 65 °C). As a result of this study, tahini / pekmez blends were observed to exhibit Non-Newtonian, shear thinning behavior at all temperatures and tahini concentrations. The apparent viscosity of the tahini / pekmez blends increased with increasing tahini concentration and decreasing temperature (Arslan et al., 2005).

Altay and Ak (2005) investigated the effects of temperature, shear rate, storage time and constituents (oil and solids) on the rheological properties of tahini. The tahini samples exhibited pseudoplastic behavior and the consistency coefficients were influenced by temperature in the range of 20–70 °C. On the other hand, there were no significant changes in the rheological parameters of the tahini samples during the 1-year storage period. Additionally, tahini was found to contain 59% sesame oil which was found to exhibit Newtonian behavior. The presence of solid particles up to %20 was the reason for the fact that tahini exhibited Newtonian behavior, but above these concentrations tahini exhibited Non-Newtonian behavior (Altay and Ak, 2005).

Habibi-Najafi and Alaei (2006) prepared date syrup with different solid content (60 and 65°Bx) and mixed these samples with sesame paste at different ratios (45, 50, 55%). The viscosity of each blend was measured at different temperatures (25, 35, 45, 55 °C). The researchers indicated that all tahini samples exhibited pseudoplastic behavior at all experimental temperatures. The researchers demonstrated that increasing the sugar concentration led to a decrease in the oil leakage values of the tahini / sugar blends and the emulsion stability increased.

Çiftçi et al. (2008) reported seven sesame paste had different particle size and in these samples investigated their particle size distribution, colloidal stability, physico-chemical features, rheological analysis and color measurements. The particle size distribution of the seven different tahini samples ranged from 32.90 to 3.86 µm. The colloidal stability of the seven tahini samples stored at 20, 30 and 40 °C were 88-97, 84-94 and 80-92%, respectively. Çiftçi et al. (2008) reported that decreasing particle size improved the colloidal stability. Barnes et al. (1989) explained that decreasing the particle size improves interactions between solid phase and oil phase in suspensions and increases cohesiveness. On the other hand, especially particle sizes smaller than 5 µm increased the colloidal stability of tahini (Çiftçi et al., 2008). The researchers indicated that all tahini samples showed pseudoplastic and thixotropic characteristics and decreasing the particle size increased the tendency from elastic to viscous character of the tahini samples. In the same study, the color measurements showed that colour values of the tahini samples were getting darker with decreasing particle size (Çiftçi et al., 2008).

3. CONCLUSION

In the present study, the processes affecting tahini quality were discussed. Tahini is a significant product, now gradually turning from traditional product to more conventional and preferred food product due to its high nutritious value. Thus, the quality of tahini during shelf life is being paid a special attention, since the main problem during tahini storage is oil phase separation. The level of oil phase separation might be reduced by controlling particle size distribution within the product, product formulation control, as well as addition of stabilizers.

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