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The Effect of Different Stabilisers on the Quality Properties of Tahini Milk

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ABSTRACT
This study aimed to explore the chemical, physical, rheological, and sensory attributes of tahini milk produced with varying ratios of stabilizers, ranging from 0% (without a stabilizer) to other ratios including 0.2%, 0.08%, 0.06%, 0.04%, and 0.02% of κ-carrageenan; 0.2% of xanthan gum; 0.2% of carboxymethyl cellulose; 0.2% of salep; 0.2% of guar gum; and 0.2% of carob gum. Tahini milk is produced by incorporating tahini, sugar, and various stabilizers into semi-skimmed milk. Although the addition of different stabilizers did not affect its pH or acidity values, there were significant differences in the emulsion stability values, with the tahini milk exhibiting non-Newtonian flow behaviour. The addition of stabilisers was observed to have a significant effect on the colour and appearance, consistency, mouthfeel, and general acceptability scores of the tahini milk samples. Yet it did not affect the taste and odour or creaminess scores. The sample with 0.04% κ-carrageenan presented the highest scores in sensory evaluation. Based on the given results, tahini milk with the addition of 0.04% κ-carrageenan is recommended for production and consumption.

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Farklı Stabilizatörlerin Tahinli Sütün Kalite Özellikleri Üzerine Etkisi

ÖZET
Bu çalışmanın amacı, %0 (stabilizatörsüz) ile %0,2, %0,08, %0,06, %0,04 ve %0,02 κ-karragenan, %0,2 ksantan gam, %0,2 karboksimetil selüloz, %0,2 salep, %0,2 guar gam ve %0,2 keçiboynuzu gam gibi farklı oranlarda stabilizatör kullanılarak üretilen tahinli sütün kimyasal, fiziksel, reolojik ve duyusal özelliklerini incelemektir. Tahinli süt, yarım yağlı süte tahin, şeker ve çeşitli stabilizatörlerin eklenmesiyle üretilmiştir. Farklı stabilizatörlerin eklenmesi pH veya asitlik değerlerini etkilemese de emülsiyon stabilite değerlerinde önemli farklılıklar olmuştur ve tahinli süt Newtonyen olmayan akış davranışı göstermiştir. Stabilizatör ilavesinin tahinli süt örneklerinin renk ve görünüm, kıvam, ağız hissi ve genel kabul edilebilirlik puanları üzerinde önemli bir etkiye sahip olduğu, ancak tat ve koku ve yağlılık puanlarını etkilemediği görülmüştür. 0.04 κ-karragenan içeren numune duyusal değerlendirmede en yüksek puanları almıştır. Elde edilen sonuçlara göre, %0,04 κ-karragenan ilaveli tahinli süt, üretim ve tüketim için tavsiye edilmektedir.

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INTRODUCTION
Stabilizers increase the viscosity and water absorption capacity of foods. They also improve texture and sensory properties (Akin et al., 2019). Derived from the cell wall of red seaweed (*Rhodophyceae*), carrageenan is a polysaccharide characterized by hydrophilic linear sulphated galactans (Sedayu et al., 2019). It is divided into three primary categories based on repeating disaccharide units into three primary divisions: lambda (λ), kappa (κ), and iota (ι). Their interactions with various food components confer different properties such as water

retention, thickening, gelling, and stabilization in food products (Udo et al., 2023). Xanthan gum is a cream-colored, odorless, free-flowing powder. Its remarkable solubility in both cold and hot water leads to the development of viscosity, even at low concentrations of the substance (Gumus et al., 2010). Classified as a heteropolysaccharide, xanthan has a primary structure composed of repeating pentasaccharide units. The main chain is formed by β-D-glucose units linked at positions 1 and 4, mirroring the chemical structure of cellulose (Garcia-Ochoa et al., 2000). Because of its distinctive rheological properties, carboxymethyl cellulose (CMC) is widely used in various fields, including food formulations, product innovation and processing. This cellulose derivative is characterized by the addition of carboxymethyl groups to the hydroxyl groups of the glucose unit, which gives it a unique attribute (Mohod & Gogate, 2011).

Salep is a stabilizer obtained from the roots of the wild orchid (*Orchidaceae*). Salep drink is usually prepared by adding salep and sugar to milk in winter, and it is consumed as a hot drink (Bozdoğan & Yaşar, 2016). Salep is the main ingredient of Maraş ice cream. Its functional properties vary depending on the glucomannan content. As the glucomannan content increases, so does its stabilizing function. Glucomannan is also a water-soluble fibre that improves health (Yaşar & Bozdoğan, 2018). Locust bean gum, derived from *Ceratonia siliqua* L., an ancient Mediterranean plant, and known as carob gum, is now used in the production of many foods (Nasrallah et al., 2023). The locust bean contains galactose and mannose, which form galactomannan. It finds extensive industrial applications (Barak & Mudgil, 2014). Guar gum originates from the endosperm found within the seeds of *Cyamopsis tetragonolobus*, belonging to the legume family. When guar gum, a hydroxyl group-rich polymer, is added to water, it forms hydrogen bonds that impart significant viscosity and thickness to the solution (Thombare et al., 2016).

Sesame is a plant of the Pedaliaceae family. *Sesamum indicum* L. is cultivated to produce sesame seeds, which contain approximately 4.40% moisture, 21.00% protein, 54.26% fat, and 4.41% ash. They encompass a blend of unsaturated fatty acids, such as oleic and linoleic acids, alongside saturated fatty acids, including palmitic and stearic acids (Ünal & Yalçın, 2008). The numerous sesame varieties distributed worldwide have seed colors ranging from white to black (Kurt, 2018). Sesame is rich in fat, protein, minerals, vitamins, and dietary fiber. The sesame oil obtained through traditional extraction methods is particularly abundant in unsaturated fatty acids, fat-soluble vitamins, and amino acids. Sesame seeds contain approximately 21.9% protein and 61.7% fat, along with essential minerals such as iron (Fe) and calcium (Ca) (Wei et al., 2022). The Arabic term 'tahini', alternatively referred to as 'tahina' or 'tahana', is extensively consumed in nations like Syria, Lebanon, and Jordan, and its popularity has spread throughout the Middle East, Central Asia, and Africa. Its appeal has grown particularly in recent years, attributed to its role as a versatile condiment that enhances vegetarian culinary creations (Labban & Sumainah, 2021). The Turkish Food Codex describes it as follows: "Tahini: A product obtained by grinding sesame seeds (Sesamum indicum L.) in a mill after separating their shells, drying and oven-roasting according to the technique." It must contain at least 50% fat and 20% protein, at most 1.5% moisture, 3.2% ash and 2.4% acid (in oleic acid)" (TFK, 2015). Roasting enhances the flavor, color, and texture of sesame-based products, thereby improving their overall acceptability (Sert & Mercan, 2019). In Türkiye, tahini is mainly used to make halva. It is eaten with grape molasses for breakfast, especially in the winter months. It is also widely used in baking, as a topping for desserts like pumpkin pie, as a sauce, and in making hummus (Bayrakçı, 2018; Karakuş & Yaşar, 2025).

Oil-in-water (O/W) emulsions are prevalent in various food products, including ice cream, yogurt, and mayonnaise. The physical stability of these emulsions plays a crucial role in determining food quality and must be maintained for the desired shelf life. Several factors influence emulsion stability, including the properties of surface-active components, formulation variables, droplet size, and particle distribution (Kowalska & Żbikowska, 2016). Sesame tahini represents a colloidal suspension primarily consisting of hydrophilic solids dispersed in sesame oil. To utilize tahini effectively as an ingredient in various food products or to develop new creamy formulations, it is essential to enhance its colloidal stability. Understanding the rheological properties of tahini and their relationship with particle size is critical for optimizing its functional application (Çiftçi et al., 2008). One effective strategy to enhance emulsion stability is the incorporation of thickeners that increase viscosity. For instance, κ-carrageenan forms a robust network by interacting with casein micelles, thereby reducing the necessity for hydrophobic interactions and disulfide bonds among proteins. This interaction effectively inhibits droplet aggregation, thereby improving the stability of particulate emulsions (Xu et al., 2024).

Milk is recognized as one of the most versatile and valuable foods and is an essential part of the human diet. Approximately 80% of the world's population consumes dairy products, which provide essential macro- and micronutrients such as high-quality proteins, fats, calcium, potassium, phosphorus, vitamin D, riboflavin, and vitamin B12 (Linehan et al., 2024). This study aimed to develop a new functional food product by combining tahini and milk. Stabilizers such as κ-carrageenan, xanthan gum, carboxymethyl cellulose (CMC), carob gum, salep and guar gum were selected to increase the emulsion stability of the product. Although stabilizers are essential for product stability, there is no research on their use in the production of tahini milk. The aim of this study was to investigate the effects of κ-carrageenan, xanthan gum, CMC, carob gum, salep, and guar gum on the physicochemical, rheological, and sensory properties of tahini milk.

MATERIAL and METHOD

Material

Tahini (Aktahin, Osmaniye, Türkiye), sugar (Torku, Konya, Türkiye), homogenized semi-skimmed UHT milk (Dost Milk, Istanbul, Türkiye) and stabilizers (κ-carrageenan, xantham gum, carob gum, CMC, and guar gum) (Tate & Lyle, Türkiye) were purchased from the market, and salep was supplied from Kahramanmaraş, Türkiye.

Metod

Tahini Milk Production

Preliminary trials showed that the use of κ-carrageenan, salep, xanthan, carob gum, CMC, and guar gum at a concentration of 0.2% was effective in tahini milk. However, tahini milk produced with 0.2% κ-carrageenan showed a very firm and non-flowing structure. Based on the results of these trials, κ-carrageenan concentrations of 0.02%, 0.04%, 0.06%, and 0.08% were found to be more suitable, and production was carried out at these concentrations. The materials used in the production of tahini milk are presented in Table 1. A portion of 1000 g homogenized semi-skimmed UHT milk was used as the base into which 120 g of tahini and 120 g of sugar were added, each making up 9.68% of the mixture. Different stabilizers, labelled A to K, were added separately at different concentrations: A (0%, no stabilizer added), B (0.02% κ-carrageenan), C (0.04% κ-carrageenan), D (0.06% κ-carrageenan), E (0.08% κ-carrageenan), F (0.2% κ-carrageenan), G (0.2% xanthan gum), H (0.2% CMC), I (0.2% salep), J (0.2% locust bean gum), and K (0.2% guar gum). The homogenization process involved using an Ultra Turrax homogenizer (Janke & Kunkel KG, IKA, Werk, Germany) operating at 15000 rpm for 3 minutes. Subsequently, the homogenized tahini milk underwent exposure to a temperature of 90°C for 20 minutes through heat treatment, followed by a second round of homogenization at 15000 rpm for 3 minutes. The resultant product was gradually cooled to ambient temperature, then dispensed into 1-liter glass bottles, safely sealed, and preserved at 4°C until analysis.

Table 1. Materials used in tahini milk production
Çizelge 1. Tahinli süt üretiminde kullanılan malzemeler

Tahini Milks	Amount of Milk (%)	Amount of Sugar (%)	Amount of Tahini (%)	Amount of Stabilizer (%)
A	80.65%	9.68%	9.68%	0%
B	80.65%	9.68%	9.68%	0.02% κ-carrageenan
C	80.65%	9.68%	9.68%	0.04% κ-carrageenan
D	80.65%	9.68%	9.68%	0.06% κ-carrageenan
E	80.65%	9.68%	9.68%	0.08% κ-carrageenan
F	80.65%	9.68%	9.68%	0.2% κ-carrageenan
G	80.65%	9.68%	9.68%	0.2% xanthan gum
H	80.65%	9.68%	9.68%	0.2% CMC
I	80.65%	9.68%	9.68%	0.2% salep
J	80.65%	9.68%	9.68%	0.2% carob gum
K	80.65%	9.68%	9.68%	0.2% guar gum

Compositional analysis of tahini milk

The titratable acidity values of tahini milk were determined using the titrimetric method, as specified in AOAC (2005) guidelines, and the outcomes were represented as a proportion of lactic acid content. The pH values were measured using the Orion Star™ A 211 pH meter. Dry matter ratios were determined gravimetrically in accordance with AOAC (2005) standards, and the results were reported as a percentage of dry matter. The analysis of tahini fat content conformed to the Soxhlet method as outlined in the AOAC (2005) guidelines. Protein and nitrogen levels were assessed using the micro-Kjeldahl method in accordance with AOAC (2005) standards. Crude fiber content was calculated by following AOAC (2005) procedures, and ash content was determined using the wet combustion method specified in the AOAC (2005) guidelines. The results were calculated as a percentage.

Emulsion stability analysis of tahini milk

Forty grams of tahini milk were placed into 50 ml centrifuge tubes, and the samples were heat-processed in a water bath maintained at 80°C for 30 minutes. The centrifuge tubes containing tahini milk were then cooled under tap water for 15 minutes. The chilled tubes were placed into a centrifuge and underwent centrifugation at

4000 × g for a period of 10 minutes. The separated oil and water were taken with a Pasteur pipette and measured in mL. Emulsion stability (ES) was calculated with the following formula (Akbulut & Coklar, 2008).

1.*ES (%) = 100-(AS+AY)*

2.*AS (%) = Amount of water separated (ml) x 2.5*

3.*AY (%) = Amount of oil separated (ml) x 2.5 x d*

4.*d= Specific gravity of oil*

Sensory analysis of tahini milk

The sensorial analysis was performed by 15 trained individuals (7 males, 8 females, who were aged 20-60 years). Samples were taken from the refrigerator, brought to room temperature, and presented to them. The panel members independently judged the sensory analysis using hedonic scoring (Meilgaard et al. 1999).

Rheological analysis of tahini milk

The rheological assessment of tahini milk samples involved using a Thermo Scientific Haake GmbH rheometer, operating under shear rates ranging from 0 to 100 1/s. This controlled stress rheometer was outfitted with a TCP/P Peltier temperature control unit, and rheological measurements were conducted employing a cone and plate sensor (diameter=3.5 cm, angle=2), affixed to the rheometer. The experimental analyses were replicated in two sets, following the methodology outlined by Karaca et al. (2009).

Statistical analysis of tahini milk

The data from the tahini milk samples underwent analysis of variance, which was conducted using the SPSS 18.0 software package. Subsequently, a Duncan multiple comparison test was executed to identify significant group differences at confidence intervals of 95% and 99%.

RESULTS and DISCUSSION

Composition and emulsion stability of tahini milk

According to Table 2, the composition analysis of sample A showed that the dry matter, fat, protein, crude fibre, and ash values of tahini were determined as 24.66%, 6.58%, 5.65%, 0.38%, and 2.83%, respectively.

Table 2. Composition of tahini milk
Çizelge 2. Tahinli sütün bileşimi

Dry matter (%)	24.66±0.75
Fat (%)	6.58±0.45
Protein (%)	5.65±0.04
Crude fibre (%)	0.38±0.02
Ash (%)	2.83±0.04

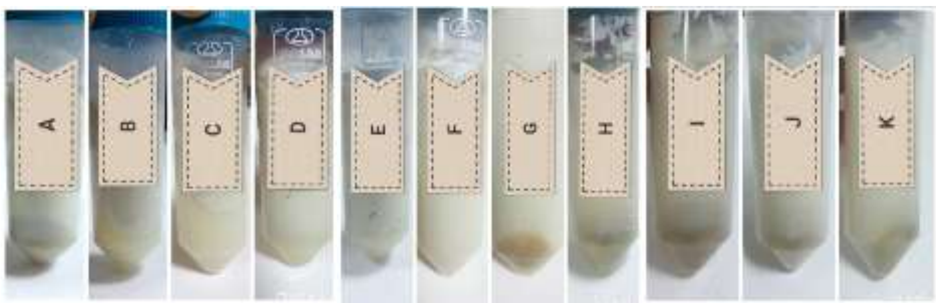
The pH levels and titratable acidity of tahini milk beverages exhibited a narrow range, with values falling between 6.82 and 6.85 and between 0.11 and 0.13, respectively, in terms of lactic acid (Table 3). Notably, the incorporation of various stabilizers demonstrated no statistically significant impact on both pH and titratable acidity values in tahini milk, ($p>0.0068$). Such a finding is consistent with the earlier investigation conducted by Yasar et al. (2009), who noted that the composition, titratable acidity, and pH of a drink containing salep, carob gum, guar gum, and their combinations remained unaffected. Similarly, Karaca & Guven (2016) reported that the utilization of diverse stabilizers, including salep, guar gum, CMC, alginate, and locust bean gum, exerted no discernible influence on the pH levels of ice cream.

The emulsion stability of tahini milk (A) without a stabilizer addition (0%) was 91.25%, while that of the other tahini milk was reported to be 100%. The addition of different stabilizers exerted a statistically significant impact on the emulsion stability of tahini milk ($p<0.0082$). While fat separation occurred in sample A without any stabilizer addition, no fat separation occurred in the other samples (Table 3). Moreover, as given in Figure 1, the incorporation of κ-carrageenan prevented the formation of any sediment at the base of the tubes containing samples B, C, D, E, and F. Without a stabilizer, samples of xanthan gum, CMC, salep, and locust bean gum showed sediment accumulation at the bottom of the tubes. Hence, the tahini milk with the addition of κ-carrageenan is not expected to form sediment, while the other samples are expected to accumulate sediment during storage. In conclusion, xanthan gum, CMC, salep, and locust bean gum are not appropriate for the manufacturing of tahini milk due to the likelihood of sediment formation.

Table 3. The pH, titratable acidity and emulsion stability of tahini milk
Çizelge 3. Tahinli sütün pH, titrasyon asitliği ve emülsiyon stabilitesi

Tahini Milk	pH	Titration Acidity (% lactic acid)	Emulsion Stability (%)
A	6.84±0.01	0.12±0.01	91.25±2.02[b]
B	6.85±0.01	0.11±0.01	100±0.00 [a]
C	6.83±0.01	0.12±0.01	100±0.00[a]
D	6.83±0.02	0.13±0.01	100±0.00[a]
E	6.84±0.01	0.12±0.01	100±0.00[a]
F	6.85±0.03	0.12±0.01	100±0.00[a]
G	6.83±0.01	0.11±0.01	100±0.00[a]
H	6.84±0.02	0.12±0.01	100±0.00[a]
I	6.84±0.01	0.13±0.01	100±0.00[a]
J	6.82±0.01	0.12±0.01	100±0.00[a]
K	6.83±0.03	0.12±0.02	100±0.00[a]

[a-b]Statistically distinct letters within the same column indicate significant differences in means ($p<0.05$).



Samples

Figure 1. View of emulsion stability results
Şekil 1. Emülsiyon stabilite sonuçlarının görünümü

κ-Carrageenan interacts with casein micelles in milk to form a strong network, which reduces hydrophobic interactions and disulfide bond formation between proteins (Lu et al., 2025). This interaction enhances the stability of milk-tahini emulsions. In contrast, other stabilizers tested did not exhibit the same stabilizing effect.

The stability of the emulsion is primarily governed by the variety and amount of the stabilizer employed, along with the pH value of the medium (Shi et al., 2023). Stabilizers, comprising diverse polysaccharides, employ varying mechanisms to stabilize emulsions due to differences in their chemical composition. Certain polysaccharides possess amphiphilic properties, characterized by acetyl and methoxy groups in addition to hydrophilic hydroxyl groups. Through adsorption at the polysaccharide-oil-water interface, these compounds effectively reduce interfacial tension, resulting in the formation of stable droplets (Shao et al., 2020). Emulsions crafted with κ-carrageenan exhibited the swiftest digestion rate and the most extensive digestion extent among the formulations studied (Shi et al., 2023).

Alpaslan & Hayta (2002) investigated the mixtures of tahini molasses, adding tahini in concentrations of 0% to 6%. Results showed that the emulsion stability of the mixture ranged from 37.5% to 51.3%, with a clear trend of increased stability as a result of higher molasses additions. Similarly, in a study by Akbulut et al. (2012), tahini-honey mixtures were produced by incorporating different ratios of pine honey (3%, 6%, and 9%) into regular tahini and Bozkır tahini. The findings demonstrated a direct correlation between the emulsion stability of the tahini-honey mixture and the proportional increase in honey content.

Rheological properties of tahini milk

The rheological properties of tahini milk with and without a stabilizer (control) were investigated at shear rates ranging from 0-100 1/s. Figure 2 illustrates the shear stress values of the samples plotted against the shear rate and the resulting graphical representation.

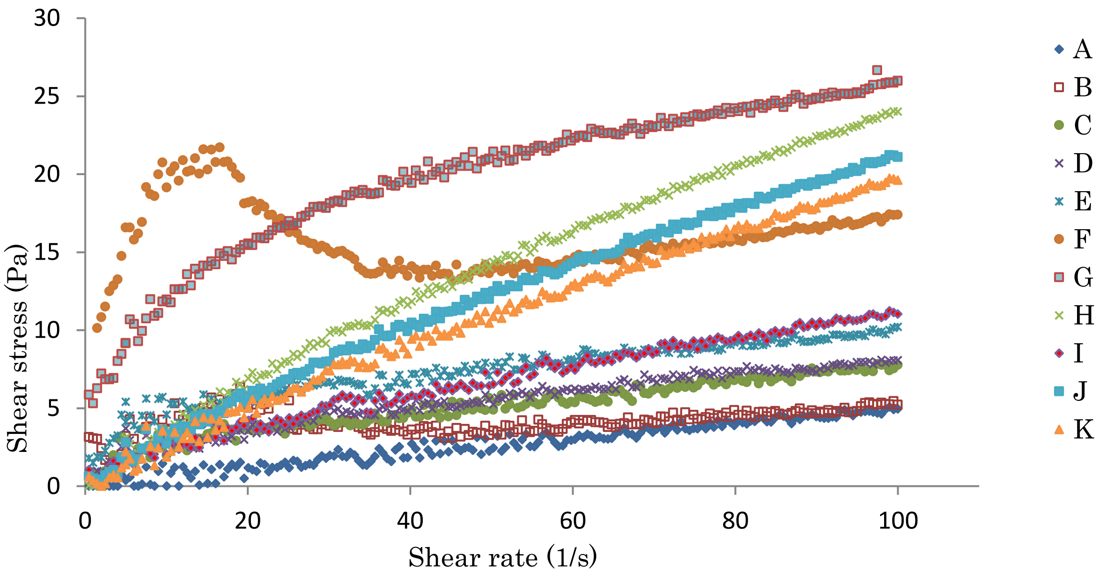


Figure 2. Variation of shear rate-shear stress values of tahini milk
Şekil 2. Tahinli sütün kayma hızı-kayma gerilimi değerlerinin değişimi

As depicted in the chart, the values of shear rate and shear stress for the tahini milk samples with stabilizer additives do not change linearly (Figure 2). In general, the tahini milk samples show non-Newtonian pseudoplastic flow behaviour; however, sample F demonstrates anomalous flow behaviour. Toker et al. (2013) and Şanlidere Aloğlu et al. (2018) investigated the rheological properties of ice cream mixtures. They revealed shear rate-shear stress values and determined that ice cream samples exhibited non-Newtonian pseudoplastic flow behaviour. Yasar et al. (2009) utilized salep, guar gum, and carob gum stabilizers in the production of the salep milk drink. Their study focused on examining the impact of these stabilizers on the rheological properties of salep. The findings revealed that the samples exhibited non-Newtonian flow behaviour, as the shear rate-shear stress values were not subject to a linear change.
The shear rate/viscosity values of tahini milk were plotted as shown in Figure 3. As illustrated in the provided graph, the viscosity values decrease as the shear rate increases, confirming that the tahini milk samples have non-Newtonian flow characteristics.
The rheological data of tahini milk samples were successfully described by the Ostwald-de.

5. Waele model ($\tau = k\gamma^n$) except for the sample F with 0.2% κ-carrageenan added.

Shear stress (τ) is represented as Pa, Shear rate (γ) as 1/s, and the coefficient of viscosity (k) as Pa s^n.

The Ostwald-de Waele model values of the tahini milks are presented in Table 4. The R^2 values of the Ostwald-de Waele model varied between 0.9763 and 0.9991, except for sample F with the addition of 0.2% κ-carrageenan. The sample F with 0.2% κ-carrageenan added to tahini milk did not fit the Ostwald-de Waele model, as given in Table 4. Hence, this sample was described by the polynomial equation given below.

6. $Y= 8.341+1.218x+0.1093x^2 -0.01929x^3+0.001007x^4 -2.704e\text{-}05x^5+4.2e\text{-}07x^6 -3.813e\text{-}09x^7 +1.882e\text{-}11x^8 -3.907e\text{-}14x^9$

$R^2= 0.9846$, $x= \gamma$ in (1/s), $y= \tau$ (Pa)

As the concentrations of stabilizers added to the tahini milk samples increased, the coefficient of consistency (k) values increased, and the flow index (n) values in the sample (F) with 0.2% κ-carrageenan ranged from 0.33 to 0.90.

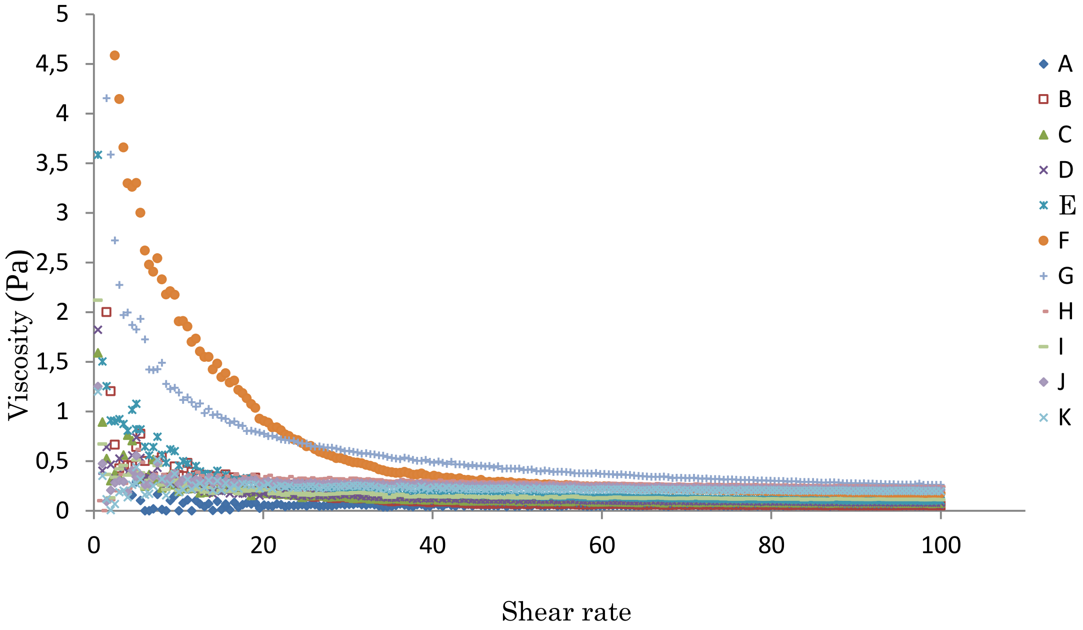


Figure 3. Variation in shear rate-viscosity values of tahini milk
Şekil 3. Tahinli sütün kayma hızı-viskozite değerlerindeki değişim

Hydrocolloids used in the categorization of ingredients in foods can be bifurcated into two groups: anionic (κ-carrageenan, CMC, pectin) and neutral (LBG, xanthan, and guar). Anionic hydrocolloids interact with positively charged groups on the surface of casein micelles, forming a stronger casein network and leading to earlier coagulation of caseins. In contrast, neutral hydrocolloids elevate the viscosity of the continuous phase. The inclusion of these substances enhances the thickness of food products (Yousefi & Jafari, 2019; Arab et al., 2023). Yaşar et al. (2009) investigated the rheological characteristics of salep milk beverages, revealing that the addition of stabilizers (such as corab gum, salep, and guar gum) increased the consistency coefficient. They also documented the flow behavior index ranging from 0.22 to 0.45 at 25 °C and from 0.29 to 0.43 at 50 °C. Moreover, Pon et al. (2015) produced ice cream by adding stevia at different ratios and investigated the effect of stevia on rheological properties. They observed that the consistency coefficient exhibited an ascending trend as the concentration of stevia sugar increased, spanning the range of 0.20 to 0.34. Additionally, the study revealed that the flow index varied between 0.42 and 0.58. Akbulut et al. (2012) initiated a study to examine the rheological attributes of tahini, which showed non-Newtonian pseudoplastic flow properties. The viscosity coefficients of the samples ranged from 9.34 to 37.53, while the flow indices ranged from 0.4226 to 0.7266.

Table 4. Ostwald-de Waele Model values for tahini milk
Çizelge 4. Tahinli süt için Ostwald-de Waele Modeli değerleri

Tahini Milk Samples	k	n	R^2
A	0.077	0.90	0.9763
B	0.092	0.80	0.9815
C	0.826	0.48	0.9769
D	0.835	0.49	0.9881
E	2.153	0.33	0.9796
F	15.94	-0.002	0.016
G	5.80	0.33	0.9963
H	0.635	0.79	0.9990
I	0.518	0.66	0.9933
J	0.519	0.81	0.9991
K	0.381	0.86	0.9982

Sensory properties of tahini milk

The sensory characteristics of dairy products have a significant impact on the consumer's food choices and acceptance attitudes (Ozdemir & Ozcan 2020). Statistical analysis revealed a significant impact of various stabilizing agents on the appearance characteristics of tahini milk ($p<0.0064$). The panelists gave sample C the highest scores for its vibrant colour and appealing appearance, closely trailed by sample I (Table 5). Although the colour profile exhibited uniformity across all tahini milk variants, distinctive differences in appearance, notably in sample F, were observed. The inclusion of 0.2% κ-carrageenan resulted in a transformative effect, endowing the mixture with a solid yoghurt-like consistency, rendering it unsuitable for consumption in its liquid form. Altun (2024) documented that employing distinct stabilizing agents altered the color and appearance scores of ice cream.

Table 5. Sensory properties of tahini milk
Çizelge 5. Tahinli sütün duyusal özellikleri

Tahini Milk	Colour and Appearance (1=Worst 9= Best)	Consistency (1=Overflow 9= Excessive viscosity)	Taste and Odour (1= Worst 9= Best)	Creaminess (1= Leanest 9= Fattest)	Mouthfeel (1= Least mouth filling 9= Most mouth-filling)	General acceptability (1= Worst 9= Best)
A	6.15±1.42^{bc}	4.10±1.48^{f}	6.55±1.57	3.27±0.57	4.35±1.75^{d}	5.80±0.63^{bc}
B	6.46±1.37^{bc}	4.65±1.38^{e}	6.05±1.57	3.17±0.53	4.45±1.14^{cd}	5.89±0.76^{bc}
C	7.30±1.34^{a}	7.45±1.15^{a}	6.30±2.05	3.24±0.47	5.45±1.70^{c}	6.94±0.66^{a}
D	6.10±1.65^{bc}	5.05±1.70^{d}	6.15±1.38	3.18±0.87	5.55±1.35^{bc}	6.30±0.92^{b}
E	5.30±1.52^{cd}	4.10±0.78^{f}	6.30±1.75	3.14±0.79	6.20±1.76^{ab}	5.74±1.16^{bc}
F	4.75±1.74^{d}	3.10±1.48^{g}	6.75±1.51	3.13±0.64	6.65±1.72^{a}	4.59±1.03^{d}
G	5.15±1.92^{cd}	4.20±1.23^{ef}	6.25±1.68	3.10±0.89	6.30±1.78^{ab}	5.47±1.00^{c}
H	6.50±1.23^{bc}	6.90±1.07^{ab}	6.55±1.87	3.07±1.10	5.70±1.59^{b}	6.24±1.85^{b}
I	6.75±1.37^{ab}	6.10±1.71^{c}	7.15±1.03	3.00±0.74	5.40±1.16^{bc}	6.14±0.97^{b}
J	6.00±1.23^{c}	6.30±1.38^{b}	6.75±1.55	3.09±1.08	6.15±1.38^{ab}	6.18±0.99^{b}
K	6.45±1.57^{bc}	5.90±1.44^{cd}	6.55±1.76	3.49±1.01	5.65±1.69^{bc}	6.29±1.04^{b}

$^{a-f}$ Statistically distinct letters within the same column indicate significant differences in means ($p<0.05$).

The consistency scores of the tahini milks were significantly affected by different stabilizers ($p<0.0058$), with the highest score attributed to sample C (Table 5). The panelists stated that tahini milk samples A and B were low in viscosity, while D was slightly too thick. Samples E and G were also described as very viscous, while sample F was too firm.

The taste and odour scores of tahini milks fell within the range from 6.05 to 7.15, and the application of various stabilizing agents exhibited no statistically significant impact on these attributes ($p>0.074$) (Table 5). The proximity of taste and odour in tahini milk is attributed to the robust aroma of tahini used in its production, coupled with the minimal stabilizer content. This aligns with findings by Azarikia & Abbasi (2010), who observed no significant statistical impact on the odour of doogh, an acidic milk drink, when different stabilizers were introduced. The levels of stabilizers used are limited in their effects on the taste and odour profile of camel milk yogurt. Even at low concentrations, the camel milk yogurt samples with added stabilizers retained the characteristic taste and aroma associated with camel milk (Ibrahim & Khalifa, 2015).

Creaminess is defined as the determinant effect of a thick, smooth, slippery, and soft liquid in the mouth, serving as an indicator of richness and high quality. The perception of creaminess is influenced by various structural factors, including rheology, oil droplet size, percentage of incorporated air, and the number and size of ice crystals (BahramParvar et al., 2013). The panellists rated the creaminess of tahini milk samples between 3.00 and 3.49 (Table 5). However, statistical analysis revealed that the effect of different stabilizers on the richness scores of the tahini milk samples was not significant ($p>0.062$). Consistent with the evaluations conducted by the panelists, the tahini milk samples did not convey an excessive sense of creaminess, and the samples were assessed as similar.

Sample F had the highest mouthfeel score with 6.65, followed by G with 6.30. The least favorable rating was assigned to sample A, which lacked the addition of any stabilizer (Table 5). The panelists found sample F to be firmer with a good mouthfeel. Furthermore, they pointed out that the sample with 0.2% xanthan gum had a good mouthfeel due to its higher consistency. They also noted that the sample with no added stabilizer (A) was viscous yet lacking mouthfeel.

The total acceptability score of tahini milk was highest in sample C, while sample F received the lowest score (Table 5). Statistical analysis indicated a significant impact of different stabilizers on the total acceptability score of tahini milk ($p<0.0078$). This aligns with findings from Koksoy & Kiliç (2004), who, in their analysis of ayran with various stabilizers, observed that different stabilizers significantly influenced its overall acceptability, emphasizing their key role in shaping the beverage's sensory perception. The sensory attributes of buffalo milk-based sandesh can be enhanced by the addition of stabilizing agents such as carrageenan, carboxymethyl cellulose (CMC), or sodium alginate prior to the manufacturing process. Of these stabilizers, carrageenan has been shown to be the most suitable for optimizing the sensory quality of the final product (Sanyal et al., 2011). The values presented in Table 5 appear to resemble the findings of this study.

CONCLUSION

The introduction of various stabilizers exhibited a negligible impact on the pH levels and titratable acidity of tahini milk samples. However, the addition of stabilizers was found to prevent fat separation in the milk samples. κ-carrageenan did not cause sedimentation, whereas xanthan gum, CMC, salep, and locust bean gum did. The shear rate-shear stress values of the stabilized milk samples showed non-Newtonian flow properties, with the consistency coefficient increasing with higher stabilizer concentrations. The value of the flow index of tahini milk with added κ-carrageenan ranged from 0.33 to 0.90. In summary, incorporating xanthan gum, CMC, salep, and carob gum in tahini milk production is not advisable due to their propensity for sedimentation. The sensorial tests revealed that the addition of stabilizers affected the colour, appearance, consistency, mouthfeel, and overall approval of the tahini milks. Nevertheless, the scores for taste, odour, fat, and stickiness had no significant impact on the outcome. The sensory assessment outcomes reveal a preference for the tahini milk sample enriched with 0.04% κ-carrageenan, indicating its potential suitability for integration into manufacturing processes.

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The authors declare that they have contributed equally to the article.

Statement of Conflict of Interest

The authors of the article declare that there is no conflict of interest.

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