Uluslararası İleri Doğa Bilimleri ve Mühendislik Araştırmaları Dergisi
Sayı 7, S. 19-23, 8, 2023

Araştırma Makalesi

IJANSER

https://as-proceeding.com/index.php/ijanser
ISSN: 2980-0811

International Journal of Advanced Natural Sciences and Engineering Researches
Volume 7, pp. 19-23, 8, 2023

Research Article

A Study on Stability and Physicochemical Properties of Soybean Oil-in-Water Emulsions Prepared with Exudate Apple Gum

Mukaddes Karataş[1*] and Ercan Aydoğmuş[1]

[1]*Department of Chemical Engineering, Engineering Faculty, Fırat University, 23119, Elazığ, Türkiye*

[*]*Email of corresponding author: mkozturk@firat.edu.tr*

(Received: 01 July 2023, Accepted: 28 September 2023)

(5th International Conference on Applied Engineering and Natural Sciences ICAENS 2023, July 10-12, 2023)

ATIF/REFERENCE: Karataş, M., & Aydoğmuş, E. (2023). A Study on Stability and Physicochemical Properties of Soybean Oil-in-Water Emulsions Prepared with Exudate Apple Gum. *International Journal of Advanced Natural Sciences and Engineering Researches*, 7(8), 19-23.

Abstract – Emulsions are systems in which two immiscible substances, such as oil and water, are dispersed together with the help of an emulsifying agent. This study has aimed to investigate the effect of apple gum exudate as an emulsifier on the stability and physicochemical properties of soybean oil-in-water emulsions. The stability of apple gum has been investigated in terms of gum concentration and sodium chloride (NaCl) concentration in oil-in-water (O/W) emulsions. The presence of electrolytes has been evaluated under different environmental conditions to determine whether apple gum could increase the emulsion's resistance to destabilizing factors. The surface and interface tension of the gum under different conditions, the particle size of the prepared emulsions, and the emulsion stability index have been characterized. The results of this study revealed that apple exudate gum has the potential to be used as a natural emulsifier in various fields, especially in the food industry, but it needs to be developed by examining more parameters.

Keywords – Soybean Oil-In-Water, Natural Emulsifier, Surface Tension, Exudate Apple Gum

I. INTRODUCTION

Emulsion systems are two-phase mixtures of immiscible liquids, typically oil and water, stabilized by an emulsifier. Emulsifiers are substances that reduce the interfacial tension between two immiscible phases and form a stable mixture by allowing them to disperse and form small droplets within each other. Emulsifier molecules have hydrophilic (water-loving) and lipophilic (oil-loving) regions that help prevent droplets from coalescing or separating over time [1].

Emulsions are common in a variety of industries, including food, pharmaceuticals, cosmetics, and personal care products. They play a crucial role in stabilizing and dispersing active ingredients, improving tissue, and enhancing sensory properties. Emulsion systems are important in many industries because of their ability to form stable mixtures of immiscible liquids, allowing the development of a wide range of products with unique properties and functionalities [2].

Emulsions can be classified as oil-in-water (O/W) emulsion, in which oil droplets are dispersed in the continuous phase of water, and water-in-oil (W/O) emulsion, in which water droplets are dispersed in a continuous oil phase, according to the nature of the continuous phase and the dispersed phase. In an oil-in-water emulsion, oil droplets are stabilized by emulsifiers, which typically have a hydrophilic (water-loving) head and a lipophilic (oil-loving) tail. These emulsifiers lower the interfacial tension between oil and water, prevent oil droplets from coalescing, and allow a stable emulsion to form. In water-in-oil emulsion, the water droplets are prevented from coalescing by reducing the interfacial tension between water and oil by emulsifiers, which have a lipophilic (oil-loving) head and a hydrophilic (water-loving) tail. In both emulsion types, emulsifier selection and oil-to-water ratio play a very important role in determining the stability and properties of the emulsion. The stability of emulsions is affected by factors such as temperature, pH, and the presence of electrolytes [3,4].

Determination of emulsion stability is very important for several reasons, such as product quality, shelf life, formulation optimization, and cost and waste reduction. Methods for assessing emulsion stability include visual observation of phase separation, measurement of droplet size distribution, zeta potential analysis, and rheological measurements. These techniques provide insights into the physical and chemical properties of the emulsion and help in understanding the mechanisms of instability, ultimately enabling the development of strategies to improve stability [5-7].

Despite the advantages of emulsions, their application areas are limited because they are thermodynamically unstable systems by nature. The phase separation of emulsions, which tend to separate into their liquid phases over time, occurs due to several factors such as gravitational forces, coalescence (droplets coming together), and Ostwald maturation (growth of larger droplets at the expense of smaller droplets) [8,9].

It is used with an emulsifier, which is a key ingredient in emulsion-based products, to eliminate these instabilities of emulsions. Emulsifiers are substances that help stabilize emulsions by reducing the interfacial tension between the two immiscible liquids (such as oil and water) and promoting the formation and maintenance of small droplets dispersed in the continuous phase [10].

They are also known as surfactants or surface-active agents. Emulsifiers play key roles in emulsion stability by effectively reducing interfacial tension, forming a protective layer, and inhibiting processes that lead to droplet aggregation The primary role of emulsifiers is to prevent or delay the separation of the dispersed phase from the continuous phase in an emulsion. They achieve this by forming a protective barrier around the droplets, reducing their tendency to coalesce or merge [11].

Natural emulsifiers such as gums are often preferred in food, cosmetics, and personal care products, as they offer a more natural and environmentally friendly alternative to synthetic emulsifiers. Different gums have been used in food applications as natural emulsifiers in O/W emulsions. Gums such as gum arabic (GA), which is the bark exudate gum of *Acacia senegal* and *A. seyal*, and apricot gum (*Prunus armeniaca L.*), which is the bark exudate gum obtained from apricot trees, are some of the exuded gums studied as emulsifiers [12-14].

Apple gum exudate is a natural polysaccharide obtained from apple trees. As a natural emulsifier, it has the potential to replace or complement synthetic emulsifiers that are widely used but can raise concerns about environmental impact and consumer preferences for natural ingredients [15].

Understanding its emulsifying properties and its effect on emulsion stability contributes to the development of more sustainable and environmentally friendly emulsions. Research on apple gum exudate as an emulsifier for soybean oil-in-water emulsions could provide valuable insights for the food and cosmetic industries and potential benefits in terms of sustainability, product performance, and consumer appeal. For this purpose, this study investigated whether apple gum exudate is a valid natural alternative to stabilize soybean oil-in-water emulsions.

II. MATERIAL AND METHOD

Materials

Apple exudate gum was collected from apple trees grown in Elazığ (Türkiye). The raw gum was washed with purified water to remove impurities such as bark pieces, dirt, and other plant residues. After the washed gum was dried in the sun, it was ground and sieved. The powdered apple gum with a mesh size between 50 and 100 was used in this study. Sodium azide used to prevent microbial degradation in prepared gum solutions was obtained from Merck. All solutions were prepared using deionized water. All reagents used were of analytical grade).

Gum solution preparation

Apple gum solutions (0.05%, 0.08%, 0.1%, 0.3%, and 0.5% (w/v)) were prepared by dissolving gum powder in distilled water. Sodium azide was added to the gum dispersions (0.02 g/L) to inhibit microbial growth and a homogeneous mixture was obtained by mixing with a magnetic stirrer for 2 h at room temperature. Similarly, apple gum was added to NaCl solutions to examine the effect of NaCl concentration (0.2, 0.4, 0.6, 0.8, and 1.0 M). The prepared solutions were stored at 4 ± 1°C for 24 h to ensure complete hydration of the biopolymer.

Emulsion preparation

Oil-in-water emulsions were prepared by dispersing soybean oil in gum solution. 15 mL of soybean oil was added to 50 mL of each gum solution and homogenized for 2 min at 1,656 x g rpm using a Silverson STL-2 homogenizer (Silverson Machines Ltd., UK) to evenly disperse the oil molecules in the emulsion. Prepared emulsions were immediately separated into different glass tubes for emulsion and stability studies and used within 48 h.

Emulsion stability

To evaluate the long-term stability of the emulsions, an acceleration test at 60 °C, which is a heating method for high temperatures, was applied [16]. The prepared emulsion samples were sealed in 20 ml glass bottles and stored in an oven at 60oC for 30 days. The height of the emulsion layer was monitored and recorded at regular intervals from the starting day. The emulsion stability index (ESI) was calculated as follows (Eq. 1). Vc is the cream layer volume and Vi is the initial emulsion volume.

$$ESI = \frac{V_c}{V_i} x100 \quad (1)$$

Interfacial tension

Interface tension of apple gum dispersions (0.5% w/w) with soybean oil was measured at room temperature with a tensiometer (BZY-100, VTSYIQI, USA) using the Du Nouy ring method. The densities of the gum solution (0.5% w/w) and soybean oil were 1.0 g/cm3 and 0.92 g/cm3, respectively.

Particle size distribution

Particle size distribution was determined using a PSS Nicomp 380 ZLS operating by the dynamic light scattering method (PSS Nicomp, Santa Barbara, CA). Samples (approximately 1 mL) were placed inside the sample holder of the particle size analyzer and then measured directly without dilution. Emulsions were analyzed in duplicate immediately after preparation.

III. RESULTS AND DISCUSSION

Effect of gum and NaCl concentration on emulsion stability

Emulsion stability was calculated by visually measuring the height of the prominent serum (translucent) layer formed at the bottom of the glass bottle after 0, 1, 5, 10, 20, and 30 days of storage of freshly prepared emulsions in an oven at 60 °C. As can be seen in Figure 1, ESI increases with increasing gum concentration and the creaming process slows down. Some naturally derived plant polysaccharides, such as tragacanth gum, and acacia gum, contain a small number of protein fragments linked by covalent or non-covalent bonds. Protein molecules are naturally amphiphilic, making them generally superior surfactants than polysaccharides. In these gums containing protein fragments, the protein molecules are adsorbed at the oil-water interface during emulsification, while the polysaccharide molecules are mainly in the continuous phase to improve the viscosity of the continuous phase and prevent aggregation [17].

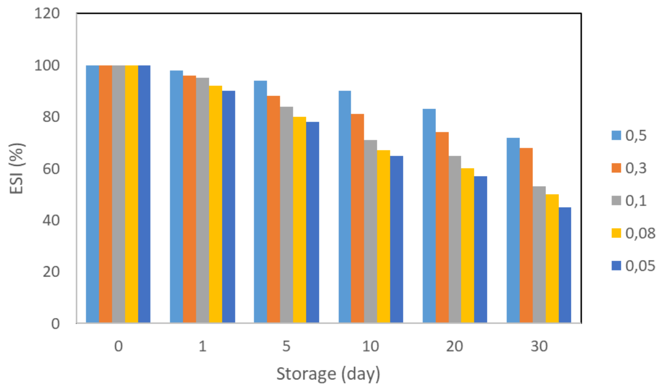

Figure 1. Emulsion stability indices after 30 days of storage at 60 °C for emulsions with different gum concentrations

When the effect of the presence of NaCl on ESI was examined, it was observed that the emulsion samples containing NaCl were very unstable during the first five days and phase separation occurred. It is thought that this situation is caused by salt, reducing the electrostatic repulsion between the droplets in the oil phase and increasing the ionic strength [18].

Surface and interfacial tension measurements

The interfacial tension measured at the soybean oil-water interface without gum added was 29.4 mN/m. It is extremely important to determine the interface properties of surfactants, which are known to have the ability to form and stabilize emulsions [19]. Therefore, the interfacial tension of apple gum was measured at different concentrations to better understand the interfacial properties at soybean oil-water interfaces (Figure 2). As seen in Fig. 2, the interface tension decreased with increasing concentrations of apple gum. This result indicates that the gum is adsorbed on the soybean oil-water interface [20].

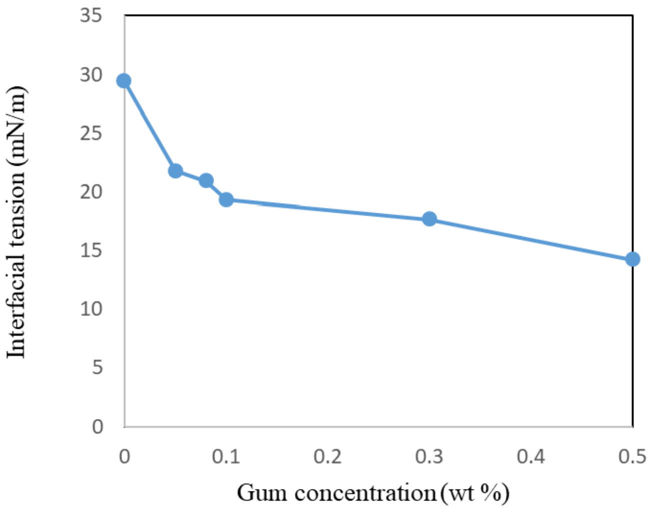

Figure 2. Variation of the interfacial tension as a function of the apple gum concentration

Particle size distribution

The particle size distribution of emulsion droplets was determined using the dynamic light scattering method on gum preparations of different concentrations. Particle size intensity-Gaussian distributions and corresponding indices of apple gum and non-apple gum to soybean oil-water emulsions are shown in Figure 3 and Figure 4. The addition of gum appears to cover a larger surface area and results in the formation of a greater number of small particles [21].

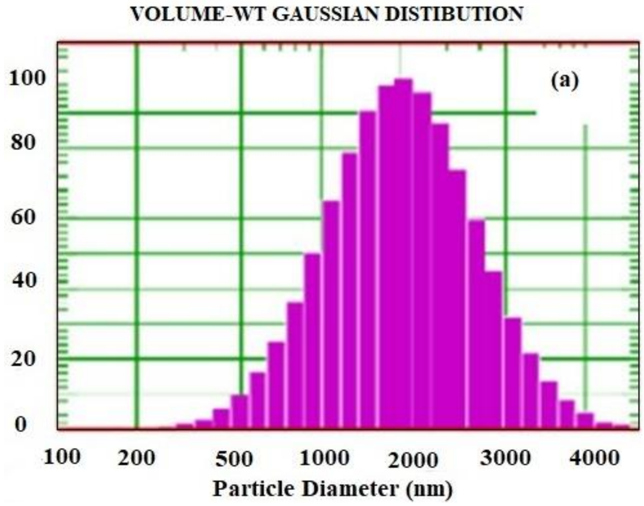

Figure 3. Particle size analysis of soybean oil-water emulsions (emulsifier concentration 0%)

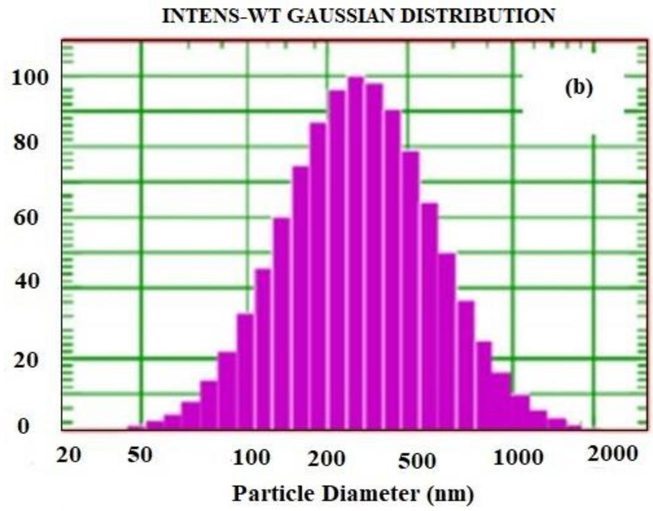

Figure 4. Particle size analysis of soybean oil-water emulsions (emulsifier concentration 0.5%)

IV. CONCLUSIONS

Emulsions are chemical systems in which an emulsifying agent is used to disperse two immiscible substances, such as oil and water, together. This study aims to examine the stability and physicochemical characteristics of soybean oil-in-water emulsions after adding apple gum exudate as an emulsifier. In oil-in-water (O/W) emulsions, the stability of apple gum has been examined in terms of gum concentration and sodium chloride (NaCl) concentration.

It has been examined under various environmental settings whether the presence of electrolytes could boost the emulsion's resilience to destabilizing elements. The created emulsions' particle size, emulsion stability index, and surface and interface tension of the gum under various conditions have all been characterized. According to the study's findings, apple exudate gum has the potential to be employed as a natural emulsifier in a variety of industries, particularly the food industry, but additional research is required to fully develop this idea.

REFERENCES

[1] Sjöblom, J., Stenius, P., Simon, S., Grimes, B.A., *Emulsion Stabilization*. Encyclopedia of Colloid and Interface Science. Springer, Berlin, Heidelberg, 2013.

[2] McClements, D. J., Jafari, S.M., *Improving emulsion formation, stability and performance using mixed emulsifiers: A review*. Advances in Colloid and Interface Science, 2018: 251, 55– 79.

[3] Piacentini, E., *Emulsion*. In: Drioli, E., Giorno, L., *Encyclopedia of Membranes*. Springer, Berlin, Heidelberg, 2016.

[4] Maphosa Y., Jideani V.A. *Factors affecting the stability of emulsions stabilized by biopolymers*. Science and Technology behind nanoemulsions, 2018: 65-81.

[5] Ribes S., Fuentes A., Barat J.M., *Effect of oregano (Origanum vulgare L. ssp. hirtum) and clove (Eugenia spp.) nanoemulsions on Zygosaccharomyces bailii survival in salad dressings*. Food Chemistry, 2019: 295, 630-636.

[6] Tekin, Z.H., Avci E., Karasu S., Toker O.S., *Rapid Determination of Emulsion Stability by Rheology-based Thermal Loop Test*. LWT - Food Sci. Technol., 2020, 122, 109037.

[7] Karthik, P., Ezhilarasi P.N., Anandharamakrishnan, C., *Challenges associated in stability of food grade nanoemulsions*. Critical Reviews in Food Science and Nutrition, 2017: 57(7), 1435-1450.

[8] Capek I., *Degradation of kinetically-stable o/w emulsions*. Adv Colloid Interface Sci, 2004, 107, 125-155.

[9] Kumar, N., Mandal, A., *Surfactant Stabilized Oil-in-Water Nanoemulsion: Stability, Interfacial Tension, and Rheology Study for Enhanced Oil Recovery Application*. Energy & Fuels, 2018: 32(6), 6452-6466.

[10] Tadros, T., Izquierdo P., Esquena J., Solans C., *Formation and stability of nano-emulsions*. Advances in Colloid and Interface Science, 2004: 108–109, 303-318.

[11] André, V., Willenbacher, N., Debus, H., Börger, L., Fernandez, P., Frechen, T. et al., *Prediction of emulsion stability: Facts and myth*. Cosmetics and Toiletries Manufacture Worldwide, 2003: 102-109.

[12] Chung, C., Sher, A., Rousset, P., McClements, D. J., *Use of natural emulsifiers in model coffee creamers: Physical properties of quillaja saponin-stabilized emulsions*. Food Hydrocolloids, 2017: 67, 111– 119.

[13] Hosseini, A., Jafari, S.M., Mirzaei, H., Asghari, A., Akhavan, S., *Application of image processing to assess emulsion stability and emulsification properties of Arabic gum*. Carbohydr. Polym., 2015: 126, 1-8.

[14] Shamsara, O., Jafari, S.M., Muhidinov, Z.K., *Fabrication, characterization and stability of oil in water nano-emulsions produced by apricot gum-pectin complexes*. International Journal of Biological Macromolecules, 2017: 103, 1285-1293.

[15] Bouyer, E., Mekhloufi, G., Rosilio, V., Grossiord, J.L., Agnely, F., *Proteins, polysaccharides, and their complexes used as stabilizers for emulsions: alternatives to synthetic surfactants in the pharmaceutical field*. Int. J. Pharm., 2012: 436, 359–378.

[16] Yao, Y.T., Wang, W.Y., Liu, H.M., Hou, L.X., Wang X.D., *Emulsifying properties of Chinese quince seed gum in oil-in-water emulsions*. Lebensmittel-Wissenschaft & Technologie, 2021: 147, 111560.

[17] Tang, Q., Huang, G., *Improving method, properties and application of polysaccharide as emulsifier*. Food Chem., 2022: 376, 131937.

[18] Kulmyrzaev, A., Chanamai, R., McClements, D.J., *Influence of pH and $CaCl_2$ on the stability of dilute whey protein stabilized emulsions*. Food Res. Int., 2000: 33, 15-20.

[19] Bai, L., Huan, S., Li Z., McClements, D.J., *Comparison of Emulsifying Properties of Food-Grade Polysaccharides in Oil-In-Water Emulsions: Gum Arabic*, Beet Pectin, and Corn Fiber Gum. Food Hydrocolloids, 2017: 66, 144– 153.

[20] Vasile, F.E., Martinez, M.J., Ruiz-Henestrosa, V.M.P., Judis, M.A., Mazzobre, M.F., *Physicochemical, interfacial and emulsifying properties of a non-conventional exudate gum (Prosopis alba) in comparison with gum arabic*. Food Hydrocolloids, 2016: 56, 245-253.

[21] Huang, X., Kakuda, Y., Cui, W., *Hydrocolloids in emulsions: particle size distribution and interfacial activity*. Food Hydrocolloids, 2001: 15, (4–6), 533-542.