



Investigation of Emulsions Stability from two Gums belong to (*Gummiferae* Family) and their Combinations

Rabeea M.A. Daoub^{a,b,c*}, Misni Misran^b, Amel Haouas^a, Amai A. Ali^d, Fatma Saadi^a, Elfatih A. Hassan^c, Mohammed E. Osman^c

^a Department of Chemistry, College of Science, Northern Border University, Arar, Saudi Arabia

^b Department of Chemistry, Faculty of Science, University of Malaya, 50603, Kuala Lumpur, Malaysia

^c Sudan University of Science and Technology, P.O. Box 407 Khartoum, Sudan

^d Department of Pharmacology and Toxicology, College of Pharmacy, Rafha, Northern Border University, Arar, Saudi Arabia



Abstract

Acacia seyal var. *seyal* (ASY) and *Acacia tortilis* var. *raddiana* (ATR), both of which are members of the *Gummiferae* series, were used as representative gum samples to make oil-in-water (O/W) emulsions with different amounts of isopropyl myristate (IPM) oil. According to an analysis of the emulsion's oil droplet size, ATR produced smaller oil droplets than ASY gum. Phase separation stability tests showed very stable emulsions, and morphological analysis of the emulsion showed that both gums formed compact spherical oil droplets. Blended gum emulsions with a 20% IPM oil concentration were prepared. The appearance of blended gum emulsions after they were incubated for seven days at 45°C, displayed spherical, dense, and smaller droplets compared to the individual gums. Phase separation tests for blended emulsions indicated exceptional stability, particularly in the 3:7 ratio of ASY to ATR combination.

Keywords: *Gummiferae*; *Acacia seyal*; *Acacia tortilis*; Surfactants; Structure-activity relationships; Carbohydrates.

1. Introduction

Various tree species secrete natural gums, each possessing distinct physicochemical properties, and these gums find diverse applications [1]. The three most significant gum trees used for commerce are Arabic gum, gum karaya, and gum tragacanth [2]. Historically, the basic chain structure and structural components that contribute to the gum's polymeric form were used to classify natural gum exudates from plants into various classes [3].

It is evident that gums from distinct species, such as *Acacia senegal* var. *senegal* and *Acacia seyal* var. *seyal*, showcase significantly varied traits. Even within the same species, diverse varieties and individuals from different origins yield gums with distinct characteristics. Recognizing these differences in species, varieties, and environmental factors is crucial for producing Arabic gum tailored for the intended final utilization [4, 5]. The distinctive feature of *Acacia* gums lies in their water solubility, setting them apart from other hydrocolloids. By acting as thickeners, stabilizers, film formers, suspending agents, flocculants, and emulsifiers, these gums—which are extensively utilized in the food industry—play a vital role in altering and controlling the rheological features of aquatic food sources. Among them, *Acacia senegal* var. *senegal* gum is the most commonly utilized in food applications, primarily due to its superior emulsifying properties compared to *Acacia seyal* var. *seyal* gum [6]. Furthermore, solutions of gum derived from *Acacia senegal* var. *senegal* typically exhibit lower color intensity compared to those from *Acacia seyal* var. *seyal*. These characteristics account for the variations in pricing, with *Acacia senegal* var. *senegal* gum commanding a higher price than *Acacia seyal* var. *seyal* in the global market [7].

The conventional definition of an emulsion is a dispersion of one liquid's droplets in another, with the two being immiscible [8]. From a physicochemical standpoint, emulsions and colloidal dispersions are systems that lack thermodynamic stability and can separate into two immiscible phases either rapidly or gradually over time [9]. To enhance their kinetic stability, emulsions, and colloidal dispersions, which are inherently thermodynamically unstable, can be fortified. This involves introducing small quantities of surfactant molecules (such as polysorbates and phospholipids), proteins (like milk proteins), and/or thickening agents (such as gelatin or gums) into the emulsion. Often, stability is achieved through these additions. Among the factors contributing to the physical instability of emulsions, variations in emulsion droplet size are notable [10]. An emulsion may become unstable due to a number of processes, including phase inversion, creaming, flocculation, partial Ostwald ripening, and the formation of coalescence [11]. Beverage emulsions, categorized as oil-in-water (O/W) emulsions, can be classified into two types: emulsions of cloud and flavor/cloud. Similar to the stability criteria for soft drinks, both types of beverage emulsions must demonstrate notable stability in their end products in both concentrated and diluted versions [12]. The development of a white ring and/or a glossy coating of oil around the container's neck are typical signs of beverage emulsion degradation. The emergence of these visual signs is attributed to various physicochemical

*Corresponding author e-mail: rabiea.daoub@gmail.com; (Rabeea M.A. Daoub).

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processes occurring within the beverage emulsion, specifically creaming, flocculation, and coalescence, all of which contribute to the occurrence of emulsion defects.

The goals of this research encompass delineating the size and morphology of droplets, as well as determining the percentage of emulsion fraction in a conventional beverage emulsion concentrate. This concentrate is formulated by utilizing gum exudates from *Acacia seyal* var. *seyal* (ASY) and *Acacia tortilis* var. *raddiana* (ATR), as well as blends of these gums. Additionally, the study aims to assess the practicability of incorporating gum blends in the preparation of emulsions.

2. Materials and methods

2.1. Materials

ASY gum was supplied by Dr. E. A. Hassan, while ATR gum was personally gathered by the author (R. M. A. Daoub) from Wd-Mahala Forest, located 45km southeast of Khartoum, with support from the Forests National Corporation (FNC) Sudan staff. Iso Propyl Myristate (IPM) oil from Spectrum Chemical MFG. CORP was utilized in this study as the dispersed phase. Deionized water was consistently employed in all aspects of this research.

2.2. Samples preparation

For additional examinations, the gum nodules were manually cleaned, allowed to air dry at room temperature, pulverized with a mill and pestle, and then placed in plastic containers with the proper labels.

2.3. Preparation of emulsions

To generate 30% (w/w) gum solutions, an appropriate amount of gum samples—calculated by their dry weight—were dispersed into a measured amount of water that was deionized. The samples were dissolution with a magnetic stirrer for 3 h, followed by overnight to ensure complete hydration. Subsequently, the solution was centrifuged for 10 min at 2500 rpm and 25°C to eliminate air bubbles and insoluble particles [13]. The solution underwent filtration using a 100 µm mesh. Different quantities of IPM oil were used into an appropriate volume of aqueous gum solution to achieve oil concentrations of (10%-20% w/w) and a consistent gum concentration of (20% w/w). Emulsions were then prepared utilizing an ULTRA TURRAX T25 basic IKA homogenizer, at 24,000 rpm for 5 min. The resulting emulsions were placed in an incubator at 45.0±0.1°C, undergoing an accelerated aging process. The stability of the emulsions was assessed by monitoring any physical changes in the emulsion over a period of four weeks.

2.4. Preparation of emulsions of gum blends

Emulsions were created by combining different permutations of gums with IPM oil to attain a total gum content of 20% and oil content of 20%, totalling 10 g. Emulsions containing a blend of ASY and ATR gums were prepared according to the formula detailed in Table (1).

Table 1: The percentage of the used ingredients for ASY and ATR emulsion.

Sample	components of the 20% gum mix		IPM Oil%	Water%
	ASY %	ATR%		
100% ATR	00	100	20	60
1:4 ASY: ATR	20	80	20	60
3:7 ASY: ATR	30	70	20	60
2:3 ASY: ATR	40	60	20	60
1:1 ASY: ATR	50	50	20	60
4:1 ASY: ATR	80	20	20	60
100% ASY	100	00	20	60

2.5. Particle size analysis

The mean particle size of emulsions containing *Gummiferae* gums was assessed using the COULTER N4 PLUS instrument. To conduct the measurement, 0.05g of emulsions were diluted with 5ml of deionized water. Particle size measurements were carried out at 25°C using a clear quartz cuvette with a path length of 1cm.

2.6. Morphology of emulsions

The Leica PM RXP light polarizing microscope, produced by Leica Microsystems GmbH, was used to observe emulsion particles. It featured a high-voltage beam, a polarizing unit, and a JVC Color Video camera (model KY F550). The camera was connected to a PC running Leica QWin image analysis software, which enabled digital image capture and analysis, specifically for measuring and analysing droplet size in the sample. Prior to examination, samples were diluted in deionized water (three times w/w). A droplet of the emulsion was placed on a microscope slide and covered with a cover slip for observation under the microscope [14]. The study involved the examination of alterations in droplet size and the overall appearance of emulsions containing *Gummiferae* gums and their blends. These observations were conducted after one and seven days of incubation at 45°C.

2.7. Phase separation stability test

By measuring the heights of the phases in question and expressing the emulsion fraction as a percentage, the instability of emulsions containing *Gummiferae* gums and their blends in relation to phase separation was assessed [15, 16]. These observations were conducted during a four-week incubation period at 45°C.

3. Results and discussion

3.1. Particle size analysis

COULTER N4 PLUS was used to measure the droplet size in emulsions produced with *Gummiferae* gums (ASY and ATR). Three measurements were averaged to determine the size of the droplets, Figures (1&2) show the average droplet size of the ASY and ATR gums emulsions at different IPM oil concentrations. ATR gum produced smaller size droplets than ASY gum, i.e., better emulsion capacity, and this could be explained by ATR gum's high protein content (10.378%), that the hydrophobic protein moiety adsorbed at the oil-water contact and the hydrophilic polysaccharide protruded into the continuous phase imparting emulsion stability through electro steric mechanism [17] with the dominance of the steric contribution [18].

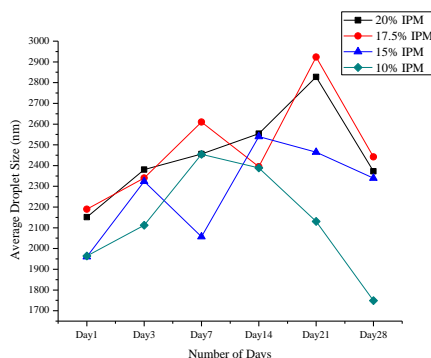


Fig. 1: ASY gum emulsion droplet size over time at different IPM oil concentrations.

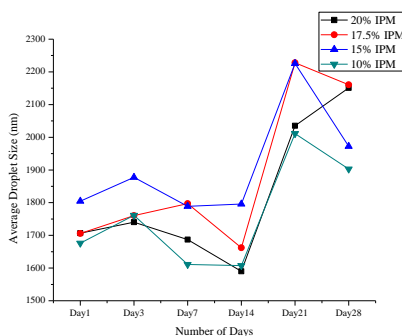


Fig. 2: ATR gum emulsion droplet size over time at different IPM oil concentrations.

3.2. Emulsions morphology

Figures (3&4) depict the morphological characteristics of emulsions formed with the two *Gummiferae* gums after one and seven days of incubation at 45°C, with varying concentrations of IPM oil. The oil droplets exhibited a spherical shape and maintained their structure, indicating a high level of stability and droplet elasticity facilitated by the gums. In other words, the gums created a network around the droplets and made the continuous phase more viscous. In the case of ASY gum emulsion, there was noticeable growth in the size of oil droplets. Conversely, in the ATR gum emulsion, the droplet size remained stable and uniform throughout the seven days of incubation.

Compared to emulsions made by each gum alone, those made with varying ratios of ATR and ASY gum mixes (Figures 5 and 6) showed smaller and more stable droplets. In general, smaller and more consistent oil droplets were produced by adding more ATR gum to the blend. For the ASY and ATR gum blend, the ideal combination ratio was determined to be 3:7.



Fig. 3: Microscopy images of ASY gum emulsion samples after one day (D1) and seven days (D7) of incubation at 45°C with varying IPM oil concentrations: 20%, 17.5%, 15%, and 10%



Fig. 4: Microscopy images of ATR gum emulsion samples after one day (D1) and seven days (D7) of incubation at 45°C with varying IPM oil concentrations: 20%, 17.5%, 15%, and 10%.



Fig. 5: After one day of incubation at 45°C, microscopy images of ASY and ATR gum blend emulsions (1:4, 3:7, 2:3, 1:1, and 4:1 ASY: ATR) with 20% IPM oil concentration were obtained.

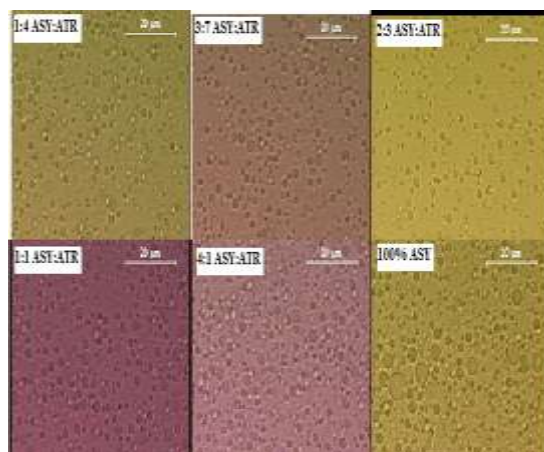


Fig. 6: After seven days of incubation at 45°C, microscopy images of ASY and ATR gum blend emulsions (1:4, 3:7, 2:3, 1:1, and 4:1 ASY: ATR) with a 20% IPM oil concentration were obtained.

3.2. Stability test regarding phase separation

As shown in Figures 7 to 9, emulsion fractions were evaluated for emulsions containing *Gummiferae* gums and their blends during the course of a 28-day incubation period at 45°C. For the 20% IPM oil concentration, the ASY gum emulsion remained stable against phase separation until the seventh day, whereas lower IPM concentrations started to gradually separate. On the other hand, ATR gum emulsion was more stable than ASY gum. These findings support the previous findings, highlighting the fact that both gums performed best at an oil content of 20% because emulsions with lower oil concentrations were less stable. Blended gum emulsions were formulated with a 20% IPM oil concentration, chosen for its superior stability. Figure (9) illustrates the emulsion fraction percentage of ASY, ATR gums, and their blends in various proportions (1:4, 3:7, 2:3, 1:1, and 4:1). Generally, a higher proportion of ATR gum resulted in increased stability against separation. However, the emulsion formed with a 30% ASY and 70% ATR (3:7) gum combination exhibited the highest stability.

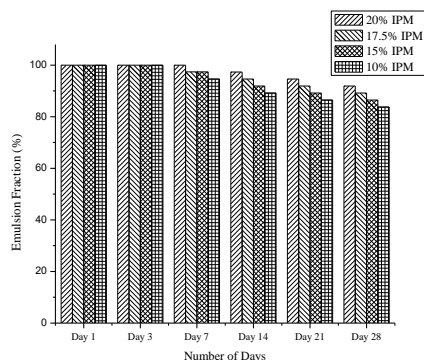


Fig. 7: The ASY gum emulsion proportion percentage after 28 days of incubation at 45°C with different amounts of IPM oil

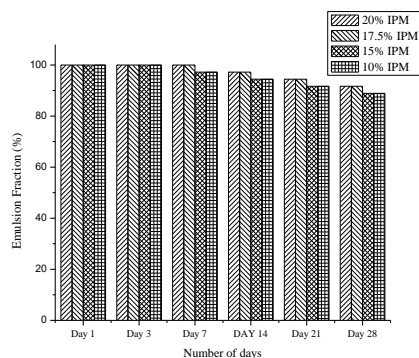


Fig. 8: ATR gum emulsion proportion percentage following a 28-day incubation period at 45°C with different amounts of IPM oil.

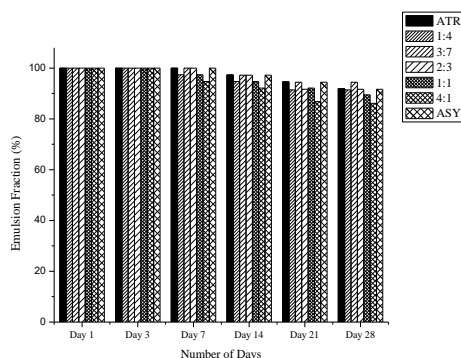


Fig. 9: The percentage of ASY and ATR gum emulsion fractions and blends of 1:4, 3:7, 2:3, 1:1, and 4:1 underwent incubation for 28 days at 45°C with a 20% IPM oil concentration.

4. Conclusion

The emulsions generated from *Gummiferae* gums at various IPM oil concentrations (20%-10%) exhibited the following characteristics:

- Different levels of stability were observed, with ATR gum emulsion demonstrating greater stability compared to ASY gum. The optimal formulation was found to be the 20% oil concentration.
- Blending gums from the same *Gummiferae* series at the ideal oil concentration resulted in emulsions with exceptional stability. The most effective combination was determined to be 3:7 (ASY: ATR).

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Conflicts of interest "There are no conflicts to declare".

Ethical approval Not applicable.

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