Physical Stability of Beverage Emulsions as Influences of Orange Oil, Tragacanth and Arabic Gums Concentrations

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ABSTRACT

The objective of this study was to examine the influence of tragacanth gum concentrations on physical and mechanical properties of beverage emulsions formulated with arabic gum and orange oil. Beverage emulsions are oil-in-water emulsions and used to enhance juice-like appearance, to provide flavor and deliver functional ingredients (omega-3 fatty acids) to the beverages. Stability of beverage emulsions, in concentrated and diluted forms, is a chronic problem that plagues the flavor and beverage industries and is highly affected by certain physicochemical characteristics of polymeric emulsifiers (hydrocolloids gums) added into the water phase. The emulsions were prepared by adding 18-30% oil phase into hydrated arabic gum (6-12%), followed by addition of hydrated tragacanth gum (0.3-0.8%). The particle size distributions and zeta potential, surface tension, rheological properties and opacity stability of emulsions were characterized. Arabic gum decreased the surface tension between water and oil and therefore boosted up the stability of emulsions. Addition of oil was readily responsible for increasing the opacity of the emulsions. Rheological properties were affected by changing the concentration of main components. All the emulsions show the flow behavior index less than 1 which means they posed shear-thinning behavior.

Keywords: Beverage Emulsions; Tragacanth gum; Arabic gum; Rheology and Stability

INTRODUCTION

Beverage emulsions are classified as oil-in-water emulsions and are prepared by dispersing oil phase containing flavour or vegetable oils, weighting agents and functional ingredients in water phase containing various types of hydrocolloid, acid, preservatives and colouring agents. The stability of cloud or flavour emulsion for a desired period of time is a common issue in the beverage industry [1-3]. Final beverages will be prepared by dilution of concentrated beverage emulsion in acidified sugar solutions. The emulsion in both concentrated and diluted form must be stable for at least 6 month [2, 4]. According to the Stoke’s law, the stability of beverage emulsion is highly depended on the specific gravity of water and oil phases, droplet size and the rheological characteristics of the continuous phase [5]. Hydrocolloids which are used to prepare the aqueous phase in beverage emulsions could provide specific rheological properties for achieving stability of the emulsion. Gum arabic is the most commonly used biopolymer emulsifier in flavour beverage emulsion [2, 6]. This gum is able to form a film around oil particles and this could prevent the breakdown of emulsion due to steric stabilization and delaying coalescence [6, 7]. Mirhosseini& Tan reported that the concentration of arabic gum should be considered as a primary critical factor for the formulation of orange beverage emulsion [8]. Orange oils have been used as flavouring agents for many centuries. Recent studies have demonstrated that phytochemicals found in orange oil may also have health-promoting effects, such as anti-carcinogenic and anti-inflammatory activities [9, 10]. Oil is the most important ingredient for providing a cloudy appearance and turbidity to beverages and the particle size of oil droplets plays a major role in beverage emulsion stability [11]. Gum tragacanth is an effective stabilizer of colloidal suspension at very low concentrations. The stabilization effect of tragacanth is a result of the steric repulsion force [12]. Previous studies showed that emulsions based on Arabic gum and tragacanth have a greater stability due to higher surface activity and higher stability to acid and heat by tragacanth gum [13]. Therefore, the objective
of this study was to examine the influence of adding different levels of tragacanth gum as a stabilizer on the physical and mechanical properties of beverage emulsions formulated with arabic gum and orange oil.

**MATERIALS & METHODS**

Orange oil and Ester gum was kindly granted by esarom Company (Oberrohrbach, Austria) and Arabic gum from TIC Gums. Tragacanth gum was provided by Iranian local traders (Tehran, Iran). Sodium benzoate and potassium sorbate were used to reduce the chance of contamination in all prepared emulsions. Adjustment of acidity was done by food grade citric acid and di-sodium hydrogen phosphate. Deionized water was used to prepare all the solutions.

In order to estimate the effect of several mixture components on product properties a full 2^3 factorial experimental design was carried out. As the sum of all components were 100% and to be able to combine all factors independently the ratio of the components to water have been used as factors. Arabic gum (18-30 %) and tragacanth gum (0.1-0.3 %) were dissolved separately in de-ionized water and stored overnight for complete hydration. Oil phase was prepared by dispersing weighting agent (ester gum) into orange oil (1:1). Pre-emulsions were formed by stirring the oil phase (18-30 %) into the Arabic gum solution and then the solution of tragacanth gum was added followed by pre homogenization. Further size reduction was obtained by using a high pressure homogenizer.

Rheological parameters were obtained using a rheometer (Bohlin CVO). The droplets size distribution was determined using a Mastersizer (Malvern) and the zeta potential was measured by a Zetasizer (Malvern, Nano series). The opacity was determined from the absorbance of diluted emulsions in 660 nm using a spectrophotometer (Shimadzu). Surface tension was assessed with the aid of a tensiometer (Krüss, Easy Dyne).

**RESULTS & DISCUSSION**

**Opacity:** As it is demonstrated in the standardized pareto chart (Fig. 1), increasing the oil concentration augment the opacity of emulsions. This effect is due to the scattering the larger fraction of light and this trend is the same in all concentration of tragacanth gum. The significant interaction shows that this effect was also depend on the concentration of the other component.

**Surface tension:** The surface tension was directly proportional to the concentration of arabic gum (Fig. 2). Increasing the ratio of arabic gum to water decreases the surface tension of emulsions from 47.2 to 43.1 (mN/m). Garti and Reichman [14] reported that gum arabic behaves as a typical surface active protein and anchors strongly to oil phase via its proteinaceous part of the molecule and when this part is removed, denatured, or deactivated, the gum tends to lose its surface activity and emulsification capacity. Amphiphilic hydrocolloids such as arabic gum have the ability of film forming around droplets of oil particles which in turn prevents the breakdown of the emulsion owing to streic stabilization, thereby delaying coalescence.

**Particle size:** Adding the oil concentration increase the particle size due to increase in volume ratio of oil. Tragacanth augmentation also increases the average size of the oil droplets (Fig. 3). This may be explained by the fact that tragacanth gum has the affinity to interact with the arabic gum which already covers the droplets. Moreover, previous studies have shown for arabic gum stabilized emulsions, the addition of oil causes a clear increase of the average size of oil droplets and this effect could be seen clearly in less amount of Arabic gum[15].

**Zeta Potential:** As reported by Leiberman et al. [16], an absolute value of zeta potential less than -25 mV is indicative for flocculated emulsions. The zeta potential of our emulsions varied from -32 to -41 and therefore no flocculation has been observed. As shown in Fig. 4, arabic gum and tragacanth decrease the zeta potential, while oil increase the zeta potential.

**Rheological properties:** Rheological flow parameters were also affected by concentration of arabic gum, oil or tragacanth gum. Oil and tragacanth decreased the flow behavior index (n) (Fig. 5) and increased the consistency coefficient (k) (Fig. 6). All emulsions show the flow behavior index less than 1 which means they posed shear-thinning behavior.
Figure 1. Standardized pareto chart for opacity

Figure 2. Standardized pareto chart for surface tension

Figure 3. Standardized pareto chart for particle size
Figure 4. Standardized pareto chart for zeta potential

Figure 5. Standardized pareto chart for flow behaviour index

Figure 6. Standardized pareto chart for consistency coefficient
CONCLUSION

Oil is mainly responsible for the opacity of beverage emulsion. Addition of arabic gum decreases the surface tension between water and oil, hence, increasing the stability of emulsions. Hydrophobic interactions between the oil and proteins in tragacanth and arabic gums at the interface are responsible for the flow behavior and allow effective control for product development. The outcomes of this work may have practical applications for the design of industrial stable dispersions to provide opacity, flavor and to deliver functional ingredients into the beverages.

REFERENCES