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Role of food emulsifiers in milk coffee beverages

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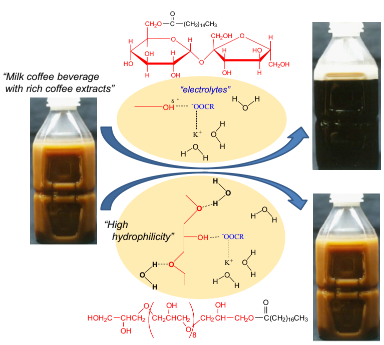
GRAPHICAL ABSTRACT



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ABSTRACT

To emphasize the coffee flavor, many milk coffee beverages contain coffee extracts; these are the so-called "rich milk coffee" beverages. When the content of the coffee extracts increases, milk coffee beverages become unstable. The milk ring formation, or oiling off, is accelerated in these kinds of drinks. We prepared a "rich milk coffee" beverage and studied the stability of the emulsion. We also investigated the influence of the food emulsifiers on the stability of the emulsion. We tried to test the emulsifier system in order to improve the emulsion stability. When the milk coffee beverage with a low light value for the roasted coffee beans sterilized by UHT was stored at a low temperature, the milk component strongly separated. We found that the sucrose monoester with a high HLB and diglycerol monoester accelerated the milk separation, and the decaglycerol monoester controlled the milk separation. We discussed the milk separation mechanism and showed that maintaining the hydration of the hydrophilic group in the rich milk coffee beverage was related to the combination of emulsifiers that control the milk separation.

1. Introduction

Beverages defined as RTD ("Ready to Drink"), such as canned or bottled milk coffee, contain milk components that have been subjected to a heat sterilization treatment for subsequent storage. Milk coffee beverages contain about 1% milk fat, forming an oil-in-water emulsion. Since the storage term for these milk coffee beverages is 6–12 months, the milk fat gradually floats towards the air–emulsion interface. Aggregation or flocculation [1–3] follows, and a milk ring is formed on the air–emulsion interface. Aggregation means sticking together of solid particles (like hard spheres) and flocculation means the association of polymer-coated particles (or droplets). Since milk proteins that are biopolymer adsorb on the surface of the oil droplet in milk coffee beverages system, we used the "flocculation" not "aggregation" in this paper. When flocculation happens, even if the milk coffee beverage is repeatedly shaken, the milk ring will not re-disperse and some

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lumps of the milk fat will float on the surface. If the degree of flocculation is severe, coagulation occurs in the milk fat and this leads to the separation of the oil and water (oiling off). If this oil sticks to the can or plastic bottle, consumers will get the impression that these beverages are of a low quality and will no longer purchase them.

Milk coffee beverages constitute a large percentage of the Japanese soft drink market. The scale of Japanese soft drink market is over 20,000 thousands kl/year. And the scale of Japanese coffee beverage market is 3000 thousands kl/year. To emphasize the coffee flavor, many milk coffee beverages contain coffee extracts; these are the so-called "rich milk coffee" beverages. When the content of the coffee extracts increases, milk coffee beverages become unstable. The milk ring formation, or oiling off, is accelerated in these kinds of drinks. This situation is aggravated by the fact that the plastic bottle is transparent: consumers can see that the milk fat has separated, so the product value depreciates and consumers complain.

We prepared a "rich milk coffee" beverage and studied the stability of the emulsion. We also investigated the influence of the food emulsifiers on the stability of the emulsion. We tried to test the emulsifier system in order to improve the emulsion stability.

2. Materials and methods

2.1. Preparation of milk coffee beverages

Roasted coffee beans were purchased from Unicafe Inc. (Japan). UHT sterilized milk was purchased from the Japanese supermarket, it contains 3.3% protein, 3.8% fat, 4.8% lactose, 0.7% minerals (Sodium: 41 mg, Potassium: 150 mg, Calcium: 110 mg per 100 g milk) and 87.4% water. We used the sucrose fatty acid ester sample of Mitsubishi-Kagaku Foods Corp. (Japan).

Two milk coffee beverages were prepared. We defined "Rich1" as the milk coffee beverage containing 6.5 wt% coffee beans (as unroasted coffee beans) and 8 wt% milk. "Rich2" is another milk coffee beverage that contains 7.0 wt% coffee beans (as unroasted coffee beans) and 12 wt% milk. The two kinds of roasted coffee beans used were Coffea Arabica (Colombian EX) and Robusta (Indonesian AP-1). As the roasting of coffee beans is proceeding, the color of coffee beans change into dark brown. We generally use the Hunter's Lab color space as an index of the degree of roasting, because the degree of roasting correlates closely with the light value. We can easily measure the light value with the Hunter color difference meter. The light values (LV) of 20 and 28 were used for "Rich 1", and that of 20, 22, 24, 26 and 28 were used for "Rich 2" milk coffee beverages. Sucrose palmitic acid ester (RYOTO™ Sugar Ester P-1670; HLB 16, with a monoester content of 80%) was used as an emulsifier.

Roasted coffee beans were extracted with 10 times de-ionized water as much as roasted coffee beans heated to 95 °C, thereby obtaining a coffee extract solution. The thus obtained coffee extract solution was mixed with milk and granulated sugar and further with an emulsifier. Then, de-ionized water was added to the mixture to obtain emulsion. After sodium bicarbonate was added to the emulsion to adjusting the pH, the emulsion was intimately mixed and homogenized at a temperature of 60–70 °C under a pressure of 15 MPa/50 MPa using a high-pressure homogenizer. Thereafter, the obtained emulsion was sterilized at 121 °C for 40 min using a retort sterilizer in the case of the canned milk coffee beverages, or was sterilized at 137 °C for 60 s (hold time for sterilization) using a plate-type Ultra High Treated (UHT) pasteurizer in the case of the plastic bottled milk coffee beverages, thereby obtaining a milk coffee beverages [4]. The composition of these milk coffee beverages is depicted in Table 1.

Table 1
Composition of milk coffee beverages.

Ingredient	Rich1	Rich2
Coffee beans (as unroasted beans)	6.5%	7.0%
Milk	8.0%	12.0%
Sugar	6.0%	
Emulsifier (Ryoto™ Sugar Ester P-1670)	0.04%	
pH (Sodium bicarbonate)	6.9	6.6
Water	79.46%	74.96%
Fat	0.30%	0.46%
Protein	0.26%	0.40%

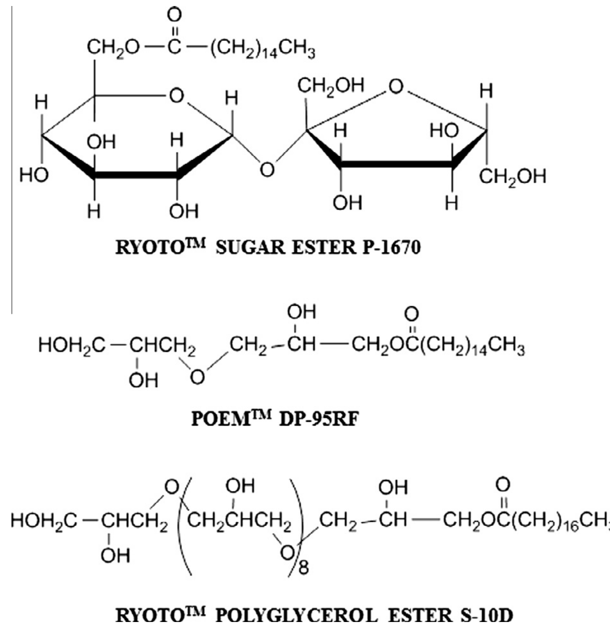

Fig. 1. Emulsifier structures.

2.2. Preparation of milk coffee beverages with various emulsifiers

The plastic bottled milk coffee of "Rich2" that contained Colombian EX (LV 26) was prepared by UHT sterilization. Sucrose palmitic acid ester (RYOTO™ Sugar Ester P-1670; HLB 16 (Mitsubishi-Kagaku Foods Corp., Japan)), diglycerol palmitic acid ester (POEM™ DP-95RF; HLB 8 (Riken Vitamin Co., Ltd., Japan)), and decaglycerol stearic acid ester (RYOTO™ polyglycerol Ester S-10D, HLB 14 (Mitsubishi-Kagaku Foods Corp., Japan)) were used as emulsifiers. The structures of these emulsifiers are depicted in Fig. 1.

2.3. Evaluation of milk coffee beverages

2.3.1. Oil drop size and distribution measurements

The median oil drop size and drop size distribution were measured using a LA-500 Laser Diffraction Particle Size Analyzer with a flow cell unit (HORIBA, Japan). The measurement of the droplet size analysis uses the Mie light scattering theory. The scattered light strength is decided by the particle diameter parameter α ($\alpha = \pi D/\lambda$; π: particles circumference length, D: single particle diameter, λ: incoming light's wavelength) and the particle's diffractive index m. Particle size distributions are calculated based on the collected scattered light strength's angle distribution value.

Milk coffee samples were poured into the cup of the analyzer and were diluted with de-ionized water. The median oil drop size