Note

Effects of Salt and pH on Property of Emulsion Prepared with Monolaurin Monoglucoside .

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The effects of salt and pH on the reduction of interfacial tension and the emulsifying property of monolaurin monoglucoside [MG(C12:0)-G] were investigated. MG(C12:0)-G made an emulsion of an oil in water (O/W) type. The creaming stability of the emulsion prepared with 0.05% MG(C12:0)-G did not change up to 0.2 M salt and at various pHs, and under these conditions the medium droplet size in the emulsion was constant. The ratio of oil phase weight to total weight separated by centrifuging the MG(C12:0)-G emulsion was constant up to 0.2 M salt, and at various pHs. Its emulsifying property was superior to that of sucrose esters of fatty acids.

In our previous report (Nakae *et al.*, 1999), we attempted to improve a useful emulsifier, monoacylglycerol (MG) by making it more hydrophilic, and described the efficient formation of monoacylglycerol monoglucoside (MG-G) by rice α-glucosidase. We also described the solubility and the foaming power of monocaprylin monoglucoside [MG-(C8:0)-G], monocaprin monoglucoside [MG(C10:0)-G] and monolaurin monoglucoside [MG(C12:0)-G]. Since MG-(C8:0)-G, MG(C10:0)-G and MG(C12:0)-G are more hydrophilic than the original MGs, it is expected that each of them is suitable for making oil in water (O/W) type emulsions in food.

In general, foods, especially processed foods are often in an acidic pH or in the presence of salt, and occasionally in both conditions. In such cases the emulsion stability is maintained by using more than two types of emulsifier. Accordingly, it is important to produce an emulsifier which is stable both in an acidic pH and in the presence of salt. An emulsion prepared with a nonionic emulsifier is generally not thought to be significantly affected by electrochemical factors. However, it is well known that an emulsion prepared with sucrose esters of fatty acids (SE) which is a nonionic emulsifier has aggregations of electrochemical factors and is not stable in an acidic pH or in the presence of salt (Fujita & Suzuki, 1990a; 1990b).

In this report, we attempted to confirm the reduction of interfacial tension and the emulsifying properties of MG-(C12:0)-G under various conditions of salt and pH.

The preparation of monoacylglycerol monoglucoside was done by the previously reported method of Nakae *et al.* (1999).

Figure 1 shows the reduction in interfacial tension at the water/kerosene interface depending on the concentration of MG(C8:0)-G, MG(C10:0)-G and MG(C12:0)-G 6 h after the preparation, and lysophosphatidylcholine (from egg yolk; LPC, Sigma Co., Ltd., St. Louis, MO) was used as a reference. Interfacial tension at the water/kerosene interface was

measured using a Wilhelmy type interfacial tensiometer (CBVP-A3; Kyowa Interface Science Co., Ltd., Saitama) at 25°C. The interfacial tension at the water/kerosene interface without an emulsifier was 42.1 mN/m at 25°C. The tensions with MG(C8:0)-G and LPC significantly decreased up to 0.001% content, and were constant above that. These tensions decreased with the MG(C10:0)-G and MG(C12:0)-G content and dropped to almost zero. From these results, the reductions in interfacial tension at the water/kerosene interface of MG(C10:0)-G and MG(C12:0)-G were more than that of LPC. It is expected that the emulsifier with a lower interface tension has higher emulsifying ability. So, it was thought that the emulsifying abilities of MG(C10:0)-G and MG(C12:0)-G would be superior to that of LPC. Accordingly, in this study we used MG(C12:0)-G which would have the lowest interface tension.

Preparation of the emulsion was followed by a slight modification of the method of Shimbo *et al.* (1993). The mixtures of kerosene (0.5 g) and each aqueous solution sample (0.5 g) with MG(C12:0)-G were vigorously stirred in a tube with a homogenizer (Physcotron mixer; Micro-Technittion Co., Ltd., Chiba) at 18,000 rpm for 30 s at 25°C. Then, the prepared emulsion was transferred to a graduated tube and kept at 25°C, and the water phase separation was determined with an image analyzer (SUPER ASPECT; Mitani Corporation, Fukui) by the previously reported method of Chen *et al.* (1993). The emulsion image determined by the image analyzer via a CCD video camera was processed in the analyzer and computer to measure the water phase separation. Since MG(C12:0)-G had the emulsifying activity and was a nonionic and hydrophilic emulsifier, sucrose esters of fatty acids (SE; F-160, Dai-ichi Kogyo Seiyaku Co., Ltd., Kyoto) (nonionic and hydrophilic ones) were used as a reference to compare these properties. The emulsion stability of the O/W type was earlier found to be related to the emulsion breakdown, namely, the phenomenon

from creaming and flocculation to coalescence (Bergenståhl & Claesson, 1990). The water phase separation of the O/W emulsion is an indicator of creaming and so was estimated. Change in the creaming stability of the water/kerosene (1:1, w/w) emulsion was calculated in terms of the ratio of the separated water phase to total solution as a function of time. The effects of $CaCl_2$ and pH on the water phase separation in the emulsions prepared with 0.05% MG(C12:0)-G and SE are shown in Fig. 2. The pH of the emulsion was adjusted by adding HCl or NaOH and its ionic strength was adjusted by adding NaCl. The water phase separation of the MG(C12:0)-G emulsion was constant up to 0.2 M $CaCl_2$, while that of the SE emulsion increased remarkably with 0.01 M $CaCl_2$. The effects of NaCl concentration on the water phase separation in emulsions prepared with 0.05% MG(C12:0)-G and SE showed the same results (data not shown). The water phase separation of the MG(C12:0)-G emulsion was constant at various pHs, while that of the SE emulsion remarkably increased below pH 4.7.

The emulsifying activities were evaluated by measuring the droplet size distribution and medium droplet size of the emulsions prepared with the above emulsifiers immediately after preparation using a laser scattering particle size distribution analyzer (LA-700; Horiba Co., Ltd., Kyoto) at 25°C. The
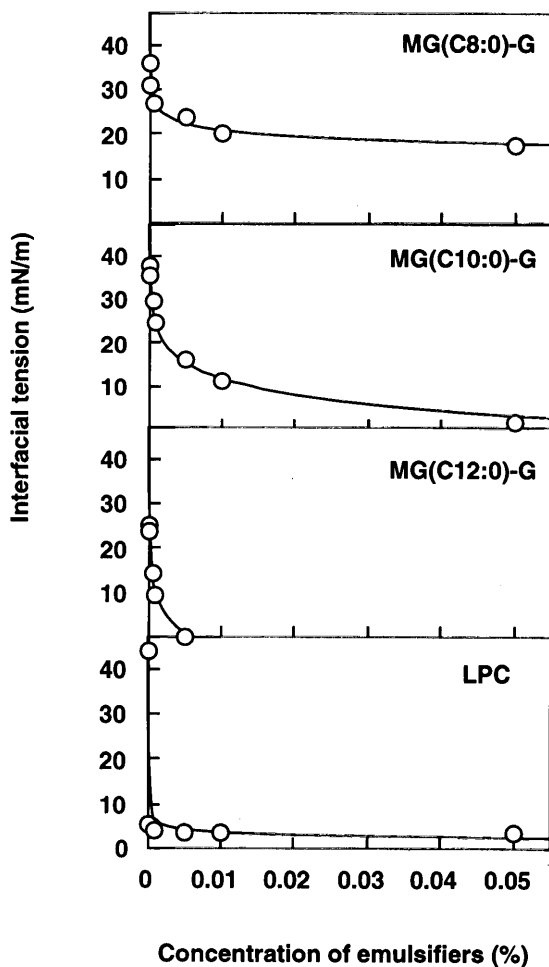
effects of pH on the droplet size distributions of the emulsions prepared with 0.05% MG(C12:0)-G and SE are shown in Fig. 3. In the MG(C12:0)-G emulsion, the droplet size distributions at pH 3.2 were not different from those at pH 6.5, however, in the SE emulsion, the distributions at pH 3.2 shifted to a much larger size.

Flocculation and coalescence are influenced by the physical strength of the interfacial film, the electrostatic repulsive force between electrical double-layers of identical signs, and so on (Friberg et al., 1990). To estimate this physical strength, the ratio of the oil phase separation was measured by centrifuging the emulsions. The mixtures of kerosene (0.5 g) and each aqueous solution sample (0.5 g) were vigorously
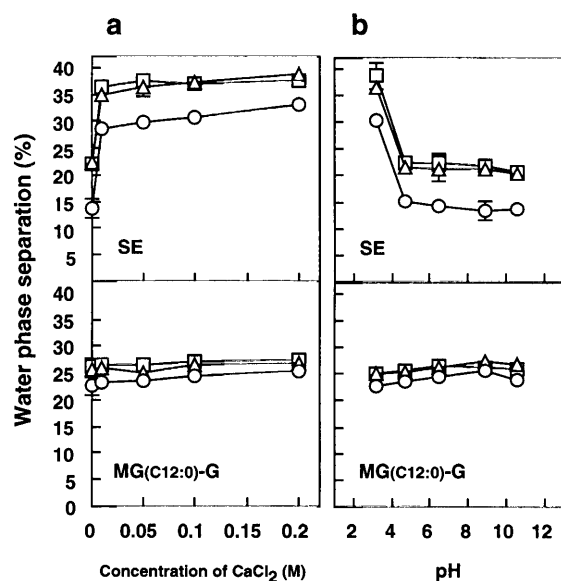

Fig. 2. Effects of $CaCl_2$ concentration and pH on the water phase separation in the emulsions prepared with 0.05% MG(C12:0)-G and SE. The creaming stabilities are given in terms of ratio of separated water phase to total solution during aging for 1 (○), 3 (△) and 24 (□) h. Each value represents mean±SD, $n=3$.

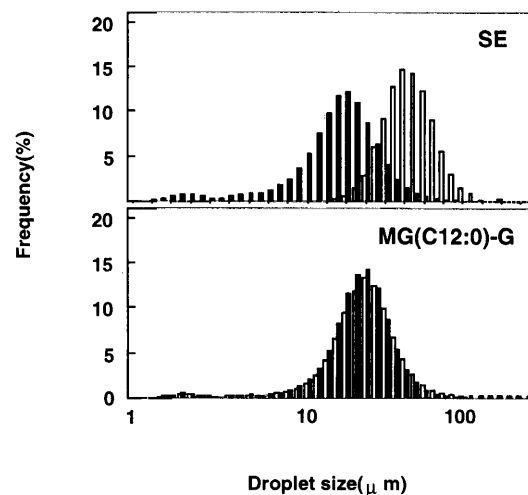Fig. 1. Interfacial tension at water/kerosene interface to MG(C8:0)-G, MG(C10:0)-G, MG(C12:0)-G and LPC content.

Fig. 3. Effects of pH on the droplet size distribution in emulsions prepared with 0.05% MG(C12:0)-G and SE. For pH 3.2 (□) and pH 6.5 (■).
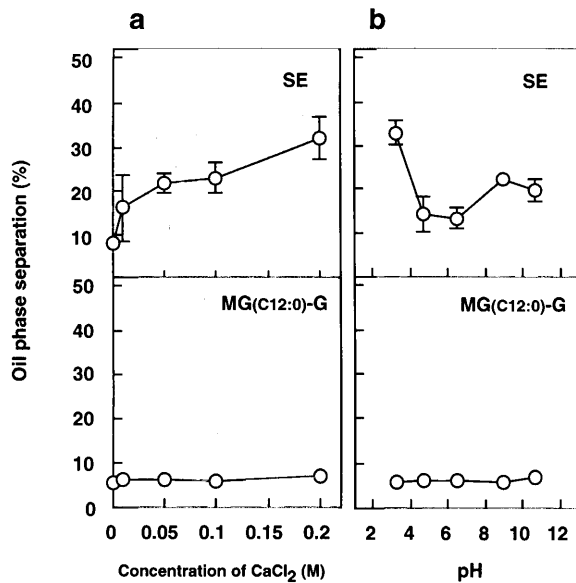
Fig. 4. Effects of $CaCl_2$ concentration and pH on oil phase separation by centrifuging the emulsions prepared with 0.025% MG(C12:0)-G and SE. Each value represents mean±SD, $n=3$.

0.025% MG(C12:0)-G and SE showed the same results (data not shown). The oil phase separation of the MG(C12:0)-G emulsion was constant at various pHs, while that of the SE emulsion remarkably increased below pH 4.7.

In these results, all factors of emulsion stability, water phase separation, medium droplet size, droplet size distribution and the oil phase separation of the emulsion prepared with MG(C12:0)-G with the addition of salt or in an acidic pH were superior to those of the SE emulsion. The emulsion prepared with SE was not stable under these conditions. The MG(C12:0)-G emulsion was argely unaffected by electrochemical factors, and remained stable even with the addition of salt or in an acidic pH.

stirred in a tube with a homogenizer (Physcotron mixer) at 18,000 rpm for 60 s at 25°C. The prepared emulsion was centrifuged at 3000×g at 25°C for 30 min and the ratio of the separated oil weight was expressed as a percentage of the overall emulsion weight. The effects of $CaCl_2$ and pH on the oil phase separation following contrifugation of the emulsions prepared with 0.025% MG(C12:0)-G and SE are shown in Fig. 4. The separation of the emulsion prepared with MG(C12:0)-G was constant up to 0.2 M $CaCl_2$, while that of the SE emulsion increased remarkably with the addition of $CaCl_2$, and then broke down. The effects of NaCl concentration on the oil phase separation in emulsions prepared with

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