Saponin-based micelles for the solubilisation of lipophilic food ingredients

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INTRODUCTION AND OBJECTIVES

Many commonly used food ingredients and food additives are lipophilic compounds like nutritional oils, fat-soluble vitamins and food colorants. These substances need to be emulsified or solubilised to incorporate them in the food matrix. Taking into consideration the increased health awareness and concerns of consumers against food additives, a major issue in the food industry is the replacement of food additives by natural compounds and ingredients. In this context lipophilic compounds like chlorophyll or carotenoids gain importance. Isolated from their original matrix, these compounds are prone to oxidation and need stabilisation.

A possibility to incorporate lipophilic food ingredients is the solubilisation via formation of micelles. The technique is currently limited by the availability of suitable food-grade tensides.

Aim of the present study was to investigate the suitability of saponins extracted from the Chilenean soap bark tree (*Quillaja saponaria* Molina) to solubilise the carotenoid lutein for incorporation in food matrices.

MATERIALS AND METHODS

A commercially available extract of *Quillaja saponaria* Molina, purified with a saponin content of 75% of the total dry matter was used in the study as well as purified powdered saponin provided from Sigma Aldrich. Lutein was a kind gift of Chr. Hansen GmbH, Germany.

Micellar solutions have been prepared under continuous agitation for 24h at 20 °C. Excess lutein was isolated by centrifugation and removed from the micellar solution.

Interfacial tension measurement and the determination the critical micelle concentration was determined using the pendant drop technique (OCA-20, Dataphysics GmbH, Germany). The surface concentration of saponins and the surface occupation were calculated using the Langmuir model, the Frumkin model and the adsorption equation of Gibbs. Size and zeta-potential of the micelles was analysed by dynamic and electrophoretic light scattering, respectively, using a Zetasizer Nano (Malvern Instruments). Micelle load with lutein was determined using a spectrophotometric assay and the color of the micellar solution was analysed using a chroma-meter CR300 (Konica Minolta Sensing Europe B.V.)

RESULTS AND DISCUSSION

Quillaja saponin in low concentration exhibited a relatively high loss of surface tension, which indicates a powerful surfactant. E.g. 0.1 g/L decreased the surface tension of water at the air-liquid interface to 37 mN/m (data not shown). The CMC determined in the present study was about 0.01 g/L for a solution of a the Quillaja saponin extract and 0.1 g/l for the powderous saponin from Sigma Aldrich. The latter is in the magnitude of the CMC as reported in the literature with 0.1 to 1 g/L (Chen, Hsiao, & Chen, 2008; Güçlü-Ustündağ & Mazza, 2007; Mitra & Dungan, 1997; Peixoto et al., 2011; Pekdemir, Copur, & Urum, 2005; Stanimirova et al., 2011).

The pH had an influence on the CMC of saponin based micelles, which is in agreement with data of Mitra & Dungan (1997). In contrast, the presence of glucose had no influence on the CMC (Figure 1). Calculations of the surface occupation using the Frumkin, Langmuir and Gibbs adsorption equations verified this (data not shown).

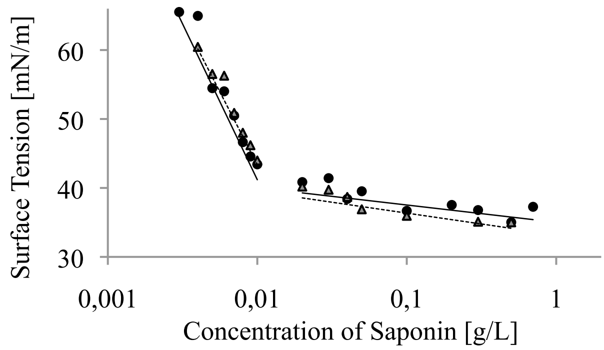

Figure 1: Surface Tension of two samples, with 5%(▲,----) and without (•, −) glucose, in dependence of Concentration of Saponin

Table 1 shows the changes in the values of the particle size, the zeta-potential and the absorption through solubilisation of lutein. Compared the non-load solutions with the lutein-load solutions the particle size, the zeta-potential and the absorption increase significantly.

Table 1: Overview of the measured particle size, zeta-potential and absorption of the micellar solution before and after incorporation of lutein as well as their standard deviations

	without lutein	with lutein
Particle Size	6.9 ± 0.1 nm	167.4 ± 3.3 nm
Zeta-Potential	-8.1 ± 2.9 mV	-20.6 ± 1.2 mV
Absorption	0.064 ± 0.001	0.167 ± 0.018

Furthermore a significant change in the results of the color measurement gives proof to the incorporation of lutein in the saponin-micelles. The difference in the lightness *L* between both samples is negligible, but the difference in *a* and *b* is clearly visible (Figure 2).

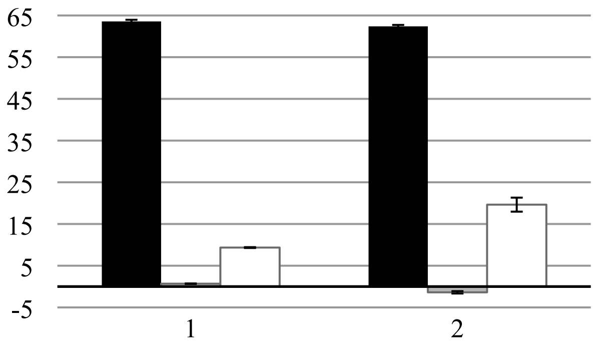

Figure 2: Influence of the color, here L (■), a (■), b (□), on the micellar solution (1) adding lutein (2)

The pH (3, 5 and 7) did not show any significant influence concerning neither the zeta-potential nor the particle size (data not shown) indicating that micelles loaded with lutein can be prepared in the pH range studied. Also the presence of glucose, which is frequently present in foods like non-alcoholic beverages, had no effect on the zeta-potential or particle size of the saponin-micelle (data not shown).

CONCLUSION

Lutein has successfully been incorporated in saponin-based micelles. Incorporation led to an increase in size and zeta-potential of the micelles, furthermore photometric and colour measurements proved the incorporation. With respect to incorporation in non-alcoholic beverages it was shown that pH and presence of carbohydrates does not affect the stability of the micelles. Therefore the present study can be considered as a proof of concept for solubilisation of lipophilic food ingredients in saponin-based micelles.

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