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Encapsulation of blackberry extract by basil seed gum-whey protein concentrate nanoemulsion: Rheological properties and encapsulation efficiency

Abstract

In this study, the effect of different mixing ratios of basil seed gum and whey protein concentrate (BSG:WPC, 25:75, 50:50, and 75:25) on physical (zeta potential and particle size) and rheological properties and encapsulation efficiency (EE) of blackberry extract O/W nanoemulsions were determined. The results showed that by increasing the BSG:WPC ratio from 25 to 75, zeta potential and particle size decreased (from -27.72 to -22.22 mV) and increased (from 913.52 to 1135.82 nm), respectively. A high ratio of BSG:WPC in nanoemulsion enhanced the consistency coefficient of nanoemulsions but reduced the EE. The EE percentage for the 25:75 BSG:WPC mixture was 90.97% and for the 75:25 BSG:WPC mixture was 81.80%. The observations indicated that the ratio of 25:75 BSG:WPC had the best potential for nano-encapsulation of blackberry extract.

Keywords: Basil seed gum - Blackberry - Encapsulation - Whey protein concentrate.

Introduction

Blackberry (*Rubus sp.*) fruit contains high levels of anthocyanins (especially cyanidin-3-glycoside and cyanidin-3-rutinoside) and other phenolic compounds, which contribute to its high antioxidant capacity and other biological activities (1). Processing can destroy and reduce the quality of natural antioxidants in fruits and vegetables. Nanoencapsulation is a more suitable procedure to enhancing bioactive compounds solubility, stability, and bioavailability (2). In food industries, emulsion-based systems must be stabilized by some emulsifiers. Basil seed gum (BSG) is an anionic hydrocolloid and has unique properties. BSG contains substantial thickening, stabilizing and surface-active properties. Its high stability is related to the formation of a solid-like structure and the viscoelastic layer around the oil droplets, which prevents accumulation and coagulation (3). Proteins facilitate the formation of emulsion due to the reduction of surface tension. It also stabilizes oil droplets against coalescence and coagulation by electrostatic repulsion mechanisms (4). Whey protein has excellent emulsifying properties that can be used alone or in combination with polysaccharides within the external aqueous phase of oil-in-water (O/W) emulsions (5). Therefore, this study aimed to investigate the potential of nanoencapsulation of blackberry extract by biopolymers mixture of basil seed gum and whey protein concentrate. In this regard, the influence of biopolymer mixing ratios (25:75, 50:50, and 75:25) on physical (Zeta potential and particle size) and rheological properties and encapsulation efficiency of O/W nanoemulsions were determined.

Experimental/Theoretical

WPC 80 (Protein content in dry matter: ≥ 80%) was supplied from Sachsenmilch Leppersdorf GmbH (Germany) and BSG was extracted from basil seeds. BSG and WPC stock dispersions at 0.5% (w/v) and 8% (w/v) concentrations were prepared, respectively. The binary mixtures of BSG:WPC with desired mixing ratios (25:75, 50:50 and 75:25) were used. For preparing nanoemulsion samples, the 79:1 ratio of the prepared mixtures and blackberry extract were mixed. The pH of the mixtures was adjusted to 5 and then stirred for 30 min at 40 °C, simultaneously the proper amount of sunflower oil was added. At the end, they homogenized at 12000 rpm for 5 min. The mean particle size of nanoemulsions was assessed using a Vasco-3 particle size analyzer and their Zeta potentials were determined using a Zeta Compact zetameter at 25°C. The rheological properties of the nanoemulsions were performed using a Bohlin viscometer in the range of 14 to 300 s^{-1} shear rate. The viscosity-shear rate data were fitted by the Power-law model. Encapsulation efficiency (EE) was determined as described by Robert et al. (6).

Results and Discussion

Zeta potential and particle size: The effect of different ratios of BSG and WPC on zeta potential and particle size of BSG-WPC nanoemulsions are shown in Fig. 1. Zeta potential is an important parameter characterizing stability of colloidal dispersion. The zeta potential of all samples was less than -30 mV, indicating a great condition for protecting the oil droplets against coalescence and creating stable nanoemulsions. With the decrease of BSG:WPC ratio in nanoemulsion the amount of zeta potential was driven toward a more negative charge. The nanoemulsion containing 25:75 BSG:WPC had the highest zeta potential and the best stability (Fig 1). According to Fig. 1, the emulsion that contained 25% BSG had the smallest particle size (913.52 nm), while the bigger particle size (1135.82 nm) belonged to the emulsions containing 75% BSG. It is well-known that the insufficient amount of the protein and/or polysaccharide for covering oil droplets in a nanoemulsion after homogenization can result in macromolecular bridging and bigger particle size.

Rheological measurement: Table 1 depicts the power-law model parameters of nanoemulsions. n_P values of all BSG:WPC ratios were less than 1 which confirmed non-Newtonian shear-thinning behavior of nanoemulsions. There were no significant differences in the n_P of the samples but it decreased when the BSG ratio increased. The consistency coefficient (k_P) of nanoemulsions was enhanced significantly by increasing the BSG:WPC ratio. Regarding k_P values of all blends, 75:25 BSG:WPC showed the highest (0.64±0.07) and 25:75 BSG:WPC showed the lowest values (0.06±0.01).

Encapsulation efficiency: Encapsulation efficiency was evaluated by measuring total phenolic content (Fig 2). The EE of samples was significantly ($P < 0.05$) influenced by the BSG:WPC ratios. EE percentage of powders containing 25:75 BSG:WPC was the highest value (90.97%). Increasing the BSG:WPC ratio to 75:25 reduced the EE of samples from 90.97% to 81.80%. This may be due to denaturation and changes in the structure of proteins during emulsification and freeze-drying conditions, which decreased the ability to protect the core material. Similar results have been reported by Najafi et al. (6).

Conclusion

The present study showed that the O/W nanoemulsions prepared by using proper ratios of biopolymers mixture within the external aqueous phase were effective in nanoemulsion stability and the EE of blackberry extract. The results confirmed that capsules produced by the 25:75 BSG:WPC had the lowest particle size and the highest zeta potential which generally as an indication of the increased stability, results in more retention of bioactive compounds. Also, results revealed that encapsulation by 25:75 BSG:WPC had the lowest k_p and the highest EE. Generally, we found that BSG:WPC mixtures at 25:75 ratios can be used as a well-suited mixture for encapsulating blackberry extract.

References

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Table 1. Rheological parameters of bail seed gum-whey protein concentrate nanoemulsions.

BSG:WPC ratio	Power-Law model Parameters			
	n_P (-)	*K_P (Pa.s^n)*	R^2	RMSE
25:75	**0.79±0.11**	**0.06±0.01^b**	**0.935**	**0.001**
50:50	**0.63±0.06**	**0.19±0.02^b**	**0.987**	**0.002**
75:25	**0.57±0.01**	**0.64±0.07^a**	**0.990**	**0.002**

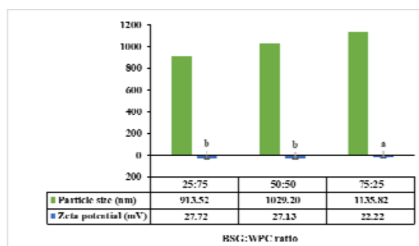

Fig. 1. Particle size and zeta potential of bail seed gum-whey protein concentrate nanoemulsions.

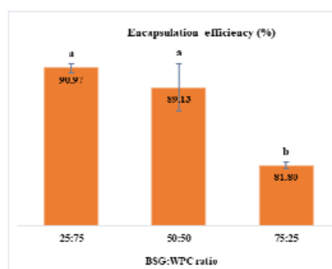

Fig 2. Encapsulation efficiency of bail seed gum-whey protein concentrate nanoemulsions.