Food grade nanoparticles obtained from natural source ingredients

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INTRODUCTION

The use of nanotechnology in food brings a lot of excitement to research but may be perceived by consumers as a potential risk due to lack of understanding of its principles and benefits. One way to overcome such resistance may be the use of food grade ingredients from natural sources. However, due to their variability and instability the use of ingredients from natural sources limits the development of nano-systems. Chitosan is a cationic biopolymer of great interest mainly due to its low toxicity and antimicrobial properties. Its positive charge allows complexation with oppositely charged molecules, interacting readily with negatively charged compounds such as phospholipids and other anionic biopolymers. Such complexes may be used as delivery systems for incorporation of a number of bioactive compounds, which would be of great interest for food industry.

The main objective of this work was to produce and characterize chitosan-based nanoparticles using food grade ingredients from natural sources, studying the effect of mechanical processing conditions (rotor-stator or ultra high pressure homogenization) and the influence of the addition of a surfactant on the obtained nanoparticles characteristics.

MATERIALS & METHODS

Nanoparticles were prepared by adding a cationic biopolymer to negatively charged compounds (lecithin or sodium caseinate above isoelectric point). The effect of mechanical processing conditions (rotor-stator or ultra high pressure homogenization) was studied. The addition of a surfactant was also evaluated. A 0.02 % chitosan solution was prepared in lactic acid 1 % and the final pH was adjusted to 3.5. Tween 20 was added to half of the chitosan solutions in order to evaluate the influence of a surfactant on the properties of the formed particles. Alcoholic lecithin and sodium caseinate (pH 7) solutions (2.5 % w/v) were prepared separately. The chitosan solutions were firstly sheared in a rotor stator device (Ultra Turrax), with slow addition of caseinate or lecithin. Then the solutions were submitted to a two-stage high pressure homogenization. Samples were taken before and after high pressure homogenization in order to evaluate the effect of this stage on the production of nanoparticles. Zeta potential and hydrodynamic diameters of all samples were measured in a Zetasizer equipment immediately after preparation and after 20 days of refrigerated storage.

RESULTS & DISCUSSION

Particle sizes ranged from 50 to 200 nm and were dependent on the added compound, the processing conditions and the presence of Tween 20 (Figure 1a). Even though zeta potential of both chitosan-lecithin and chitosan-caseinate samples were +28 and +17 mV respectively, almost all samples showed to be stable after the 20-day storage with no differences on their size observed within the evaluated period (Figure 1). The exception were the samples processed only with the Turrax device with no addition of surfactant, in which an increase of 50 % in particle size was observed after 20-day storage. This indicates that the shearing effect promoted by the rotor-stator device itself was not sufficient to promote system stabilization. In this case, either aggregates may have formed or the core/shell structure may have "opened", enhancing the measured hydrodynamic diameter during storage.

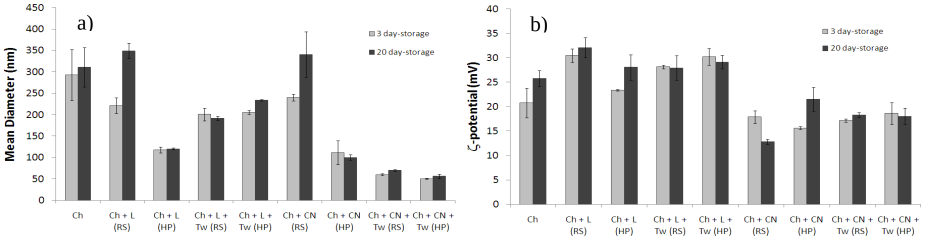

Figure 1. a) Hydrodynamic diameter and b) Zeta potential of particles composed with chitosan (Ch), lectin (L), caseinate (CN) and/or tween 20 (Tw) and processed using rotor-stator (RS) or high pressure homogenization (HP) right after preparation (light grey) and after 20 (dark grey) day storage.

Considering the particles formed with no surfactant addition, it can be noticed that high pressure homogenization allowed reducing in 50 % the particles size of samples as compared to particles produced only with the rotor-stator device. For lecithin particles, one can envisage a process of emulsification of the lipid fraction followed by opposite charge binding. In the caseinate/chitosan systems, the high shear promoted by the homogenizer may also unfold proteins [1], which would lead to an enhancement of their binding sites and thus a stronger link (tighter particles) between the protein and the chitosan, resulting in smaller sizes as compared to the lecithin/chitosan formulations.

When evaluating the effect of surfactant, it can be observed that Tween 20 addition had no visible effect on samples homogenized by ultra-high pressure, although a distinct behaviour may be observed between lecithin and caseinate nanoparticles. In the first case, obtained particles showed similar sizes to the particles prepared using only the rotor-stator device, while in the latter particles even smaller than the ones submitted to homogenization were produced. Such results were related to the binding properties of the ingredients, which were modified in different manners, depending on the added compound (caseinate or lecithin).

CONCLUSION

Nanoparticles were successfully produced by ionic complexation using ingredients from natural sources. It was observed that both composition and mechanical process influence particle size. Generally, responses were attributed to an increase on biopolymers binding properties between chitosan and the caseinate/lecithin.

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