THE EFFECT OF CHITOSAN, VANILLIN AND POLYSORBATE 60 CONCENTRATIONS ON HARDNESS AND OIL LOSS CAPACITY OF CHITOSAN-BASED OLEOGELS

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Introduction

The consumption of processed food containing industrial *trans*-fatty acids (iTFA) is negatively associated with increased non-communicable diseases risk. Therefore, eliminate iTFA from the global food supply is mandatory apart from 2023, mainly by removing partially hydrogenated oils (PHOs) from food products, the primary source of iTFA[1]. Oleogels have emerged as a viable alternative to replace PHOs because their tridimensional network provides technological properties similar to PHOs, creating food products with desirable sensorial attributes besides healthier. Several oleogels have been used as fat-replacer. However, oleogels containing polysaccharides already used as food additives by the food industry, such as chitosan, have stood out in this field. Recently, our research group developed chitosan-based oleogels comprised of canola oil, vanillin, and polysorbate 60 that were used successfully as fat-replacer in cookies[2]. However, the physical and mechanical properties of these oleogels were modified when the concentrations of vanillin and polysorbate 60 was changed, and this effect needs to be understood in-depth to expand the use of chitosan-based oleogels for different food applications. Besides, variation in chitosan concentration also might alter the mechanical signature of oleogels. Therefore, this study aimed to investigate the concentration effect of chitosan, vanillin, and polysorbate 60 on the physical and mechanical properties of chitosan-based oleogels (hardness and oil loss capacity) using an experimental design approach.

Material and Methods

Chitosan-based oleogels using canola oil were prepared by the emulsion-template method[2]. The effect of the concentrations of chitosan (0.42, 0.75, and 1.07%), vanillin (0.05, 0.52, and 1.0%), and polysorbate 60 (0, 0.25, and 0.50%) on the hardness and oil loss capacity of oleogels was assessed using a face-centered central composite design composed of a full factorial design and star points, totaling 17 experimental runs. Pareto chart was used to identify the significant effects of the model. *p*-Values <0.05 were considered significant. Statistics Software (version 8.0, StatSoft Inc., Tulsa, EUA) was used for creating the experimental design.

Hardness measurement was carried out using a TA-XT *plus* Texture Analyzer (Stable Micro Systems, Surrey, UK) equipped with a 5 kg load cell with a cylindrical probe (36 mm of diameter) and a double compression test (pre- and post-test speed of 13 mm/s, test speed of 10 mm/s). Trigger force was 0.1 N, and the interval between compressions was 5.0 s [3]. Oil loss was measured by the percentage of oil migration over 24 hours at room temperature. Oleogels were placed into filter papers supported by a Petri plate and oil loss was calculated by weighing filter papers and Petri plates before and after the samples was placed in the paper [4].

Results and Discussion

The hardness and the oil loss capacity of oleogel varied from 4.36 N to 26.07 N and from 22.9% to 53.0%, respectively. The linear first-order effects of the concentration of chitosan (1.9×10^{-18}), vanillin (0.008), and polysorbate (0.001) significantly affected the hardness of oleogels. Moreover, the interaction between vanillin and polysorbate also significantly affected this parameter (0.002). The linear and positive effect of these components resulted in a significant fitted model for this response variable ($R^2 = 0.85$, and R^2 adjusted = 0,83). Consequently, the hardest oleogel were structured using 1.07% chitosan, 1.0% vanillin, and 0.50% polysorbate 60, whereas the softest oleogel used 0.42% chitosan, and 0.05% vanillin, without polysorbate. Otherwise, oil loss capacity was significantly affected only by the first-order effect of chitosan concentration (8.0×10^{-6}), resulting in a significant fitted model for this response variable ($R^2 = 0.96$, and R^2 adjusted = 0.90). Hence, oleogels containing the highest chitosan concentration retained more oil, whereas the opposite was observed for oleogels with the lowest chitosan concentration. Therefore, the oil loss capacity of chitosan-based oleogels can be easily tuned by altering the concentration of chitosan used to structure oleogel.

The strength of the network formed in chitosan-based oleogels relates to the cross-linking reaction between the chitosan amino groups and vanillin aldehyde groups which stabilize the polymer network by Schiff bases and, consequently, increase hardness [2]. In parallel, the addition of polysorbate 60 may provide a more compact structure by forming new hydrogen bonds with chitosan-crosslinked network [5]. The hardness of oleogels is related to their spreadability property, a fundamental characterist to specify the use of oleogels as fat-replacers. Therefore, softer chitosan-oleogels with higher spreadability properties can be used to replacer PHOs in margarine. Meanwhile, harder oleogels can replaced PHOs in ice creams to maintain their structures, for example. Oil loss is an unwanted property in oleogels because of its close relationship to the physical stability of the network[4], and should be maintained lower than 30%.

Conclusion

A variation on chitosan, vanillin, and polysorbate 60 and their interactions was more determinant to modify the hardness than the oil loss capacity of oleogels that was altered only by chitosan concentration. Further studies should be made to obtain optimized oleogels with a certain degree of compliance between the hardness and oil loss capacity.

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