Archive of SID

Iranian Food Science and Technology Research Journal
Vol. 13, No. 4, Oct- Nov 2017, p. 446-457

نشریه پژوهشهای علوم و صنایع غذایی ایران
جلد 13، شماره 4، مهر - آبان 1396، ص. 457-446

Evaluation of the effect of nanofiber cellulose and carboxy methyl cellulose on rheological properties and particle size of low-fat mayonnaise

L. Golchoobi[1], M. Alimi*[2], H. Yousefi[3]

Received: 2015.10.12
Accepted: 2016.02.15

Introduction: Mayonnaise, a semisolid oil in water emulsion containing vegetable oil, vinegar, egg yolk and optional ingredients such as salt, sugar and mustard, is a conventional old condiment containing high fat ingredient (minimum of 65%). The need to reduce the amount of saturated fat in diets, has led to the development of alternative processes to produce law fat mayonnaise. Cellulose and its physically-treated derivatives i.e. microcrystalline cellulose (MCC) and microfibrillated cellulose (MFC) lately investigated as NFC is one of the conventional fat replacers used in low-fat products formulation such as mayonnaise. Nanofiber cellulose (NFC) is a glucose polymer connecting together by β (1-4) glycosidic bonds. This low-cost new kind of cellulose can be obtained from physical modification of cellulose as naturally occurring carbohydrate that is renewable, biodegradable and nontoxic. Increased specific surface area, enhanced mechanical and hydrophilic properties of nanoscale cellulose are affected by the number of hydrogen bond in nanofiber chain of cellulose and low concentration of NFC suspension can form a stront and viscous semi-gel network. As a result, because of all the functional properties, NFC can be employed as a fat replacer in reduced or low calorie food products, and as an improver of the product structure consistency. In fact, because of downsizing cellulose to nanoscale, the surface to volume ratio of NFC increases and the surface hydroxyl groups participate in the formation of hydrogen bonds in the network. Hence, more appropriate mechanical properties for NFC are achieved, even in a lower dosage. Therefore, NFC is theoretically a proper thickener and stabilizer for low-fat systems. Carboxy methyl cellulose (CMC) is a synthesized derivate of cellulose which is gained by adding carboxy methyl groups (- CH2- COOH) to cellulose. CMC is used in different food systems with the E number E466 as emulsions stabilizer, control and modification of texture in various products. In this research, application of combination of nanofiber cellulose (0%-1%) and CMC (0%-1%) to optimize rheological properties and production of low-fat mayonnaise (30% oil) with desirable characteristics were studied. Due to the hydrophilic nature of cellulose derivatives, several research works have been focused on the stabilization of oil-in-water (o/w) emulsions specially salad dressing or low-fat and fat free mayonnaise by NFC. However, no information is available on NFC/CMC mixtures. The main aim of this study was to investigate the possible mutual interactions between NFC and CMC in mayonnaise formulation regarding to the nutritional benefits that each can be individually contribute to low-fat healthy products. Rheological characterization and particle size of low fat mayonnaise, containing NFC and CMC, were conducted to validate the practical applicability of the proposed formulation in food industry.

Materials and methods: The nanofiber cellulose of each formulation (0.25, 0.5, 0.75 and 1%) was first mixed with the related formulation water and pasteurized using a EUROSTAR power control-visc 6000 homogenizer for 5 min inside water bath at 85°C. Then, it was added to the raw materials of its treatment. After production of 5 samples, viscosity test was performed using a rotational viscometer. Then, particle size measurement (D[4,3] with distilled water as the solvent, a Mastersizer 2000 equipped to quartz cell and laser beam with λ= 634 nm), light microscopy (optical microscope, magnification of 100×) and rheological tests such as flow behavior (shear rate: 0.01-200 1/s), complex viscosity and frequency sweep (frequency: 0.01-100 Hz) were performed on 3 selected samples (stress-controlled rheometer with a serrated parallel-plate geometry). Commercial low fat mayonnaise (30% fat) produced by Behrouz factory was selected as the control sample.

1 And 2. M. Sc. Graduate and Assistant Professor, Food Science and Technology, Science and Research Ayatoolah Amoli Branch, Islamic Azad University, Amol, Iran.
3. Assistant Professor, Department of Wood Engineering and Technology, Gorgan University of Agricultural Sciences and Natural Resources, Gorgan, Iran.
(*Corresponding Author Email: Ahooora_mazdak@yahoo.com)

www.SID.ir

Archive of SID

Results & discussion: Overall, the viscosity results revealed that by the addition of NFC and CMC, only the sample containing 0.5% nanofiber cellulose and 0.5% CMC did not show significant difference compared to the commercial control sample ($p<0.05$). The results of flow behavior test of low-fat mayonnaise samples show a non-newtonian and pseudoplastic behavior in all samples. The obtained results of data fitting with Herschel-Buckley model indicated that the addition of NFC together with CMC did not significantly alter the flow behavior index, consistency coefficient and yield stress. Moreover, in frequency sweep test for selected samples containing NFC and CMC, the trend of changes in elastic modulus were higher than viscose modulus ($G'>G''$) that has revealed the predominating of the elastic features in the mentioned samples, similar to the trend of commercial control sample. The obtained data of complex viscosity was in consistency with this data. With respect to the obtained results of particle size distribution, the sample containing 0.5% nanofiber cellulose and 0.5% CMC were considered to have the minimum value of D[4,3] and desirable uniformity in comparison with other samples.

Conclusion: Considering the aforementioned results, in this study NFC50/CC50 sample containing 0.5% nanofiber cellulose and 0.5% CMC was employed to formulate low-fat mayonnaise with interesting particle size and rheological properties that is attributed to the synergistic interaction between 0.5% NFC and 0.5% CMC. In fact, the effect of fat reduction is balanced by replacing of 0.5% nanofiber cellulose and 0.5% CMC. Therefore, these hydrocolloids generated a robust gel-structure in the network of this sample. In addition, tridimensional gel structure was formed by physical entanglements among polymeric chains along with the development of the crosslinked network formed between both hydrocolloids. On the other hand, reduction of dispersion phase size and suitable uniformity of droplets in NFC50/CC50 sample resulted in appropriate monodispersity, which increases the resistance to deformation and the enhancement of its viscosity.

Keywords: Nanofiber cellulose, Carboxy methyl cellulose, Low-fat mayonnaise, Rheological properties, Particle size.

www.SID.ir