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Effect of non-thermal processing techniques on milk components and dairy products: Mini review

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Abstract
The aim of the current work is to review the effects of non thermal processing technologies on the components in milk such as proteins, enzymes etc. and how the properties of different dairy products change due to these treatments. In this review the effect of Ultrasonication, Micro fluidization, High pressure processing on different milk varieties and how the characteristics of dairy products change when they are produced with milk treated with above techniques. According to previous works it could be seen that there are favorable as well as unfavorable effects of the above mentioned techniques on dairy products.

Keywords: dairy, high pressure processing, micro fluidization, ultra sonication

1. Introduction

Ultrasonic transducers can convert the electrical energy to the acoustic energy that causes vibrations in the molecules of the food systems. The driving force in ultra sonication technique in milk is acoustic cavitation caused by the ultrasonic waves passing the liquid milk. The size of cavities becomes large in successive cycles and finally produces acoustic cavitation bubbles. Ultimately, thousands of bubbles are formed, and a violent collapsing occur in millisecond scale by expanding the attractive forces between the molecules in food system. This effect is able to change the structural and functional properties of milk and milk constituents [1]. According to a study carried out on the effect of sonication a whey protein concentrate, it was found that the enthalpy of denaturation of whey proteins decreased when whey protein concentrate solutions were subjected to sonication for small time durations up to 5 min but prolonged sonication raised the enthalpy of denaturation that could be due to protein aggregation. It was found that Sonication has not altered the thiol content but resulted in minor changes to the secondary structure and hydrophobicity of the protein [2]. A study carried out on the effect of ultrasound on skim milk it was found that when skim milk was sonicated, whey proteins and whey–whey aggregates present in the milk were denatured and formed soluble whey–whey/whey–casein aggregates which further interacted with casein micelles to form micellar aggregates during the initial 30 minutes of sonication and when sonication was done for a prolonged time it resulted in the partial disruption of some whey proteins from these aggregates. Due to sonication the size of casein molecules, size of fat globules in skim milk were reduced [3]. A mixture of α-Lactalbumin and β-Lacto globulin was subjected to high intensity ultrasonication. There β-Lactoglobulin dimer began to unfold into monomeric units exposing the thiol groups and the hydrophobic regions. A-Lactalbumin appeared to be more strongly affected by sonication, since surface hydrophobicity was increased significantly. Hence, in mixtures of the two proteins, the exposed thiol groups in the β-Lactog; obulin are able to interact with the disulfide bond of α-Lactalbumin reulting to a decrease in hydrophobicity and an increase in aggregate particle size at higher sonication levels [4]. It has been found that controlled application of ultrasonic energy can assist break up large CN and whey protein aggregates, thereby influencing macroscopic properties, such as viscosity, without inducing changes to the casein micelles or mineral balance of milk [5]. When considering the effect of ultrasonicaion on the gels formed by milk proteins, it was reported that gel was unaltered by sonication. Sonication before the addition of Tetra sodium pyro phosphate (TSPP) resulted a firm gel with a fine protein network and low syneresis, In contrast, sonication after TSPP addition resulted to an inconsistent weak-gel structure with high syneresis [6]. The viscosities of dairy fluid systems such as whey protein concentrates, milk protein retentates and calcium caseinate solutions were substantially reduced by ultrasonic treatment, and this was attributed to reductions in particle sizes as a consequence of the treatment [7]. When ultrasonication was done to whole milk, the ultrasonication can cause considerable homogenization of the fat globules, and the newly exposed fat globule surface will be stabilized by milk proteins. Ultra-sonication treatment of the whole milk, the shear forces generated by cavitations and micro-jetting, can be used to produce highly functional fat globules/milk protein complexes that are different to those produced by conventional homogenization [8]. The effect of ultrasonication on renneting properties of milk such as renneting time, rennet curd firmness and rennet gel network has been determined. According to that, in milk that was ultrasonicated at pH 8.0 and re-adjusted to pH 6.7 the renneting properties were significantly changed compared to those in non-sonicated milks. These renneting properties were attributed to the reduction in the size of particles in milk and changes to the protein hydrophobicity caused by physical effects of cavitation when applying low frequency ultrasound [9].

2. Micro fluidization

Micro fluidization is a process that is designed for two streams of milk to collide together at 180^0 angle [10] and the resulting cavitation, turbulence, and shear disrupts the lipid droplet and its surrounding membrane. When Compared to lower pressure homogenization, micro fluidized milk has smaller sized lipid droplets with fewer intact or semi-intact casein micelles at the lipid interface. Some of the smaller lipid droplets actually are embedded into a portion of the micelle [11]. In cheese made with micro fluidized milk it was seen that there is no change in composition of milk except for a slight reduction in protein. The size of fat droplet was reduced, a fine emulsion was observed by and confocal microscopy with scattered agglomerations. Coagulation properties of the milk treated at 54°C and 125 or 170 MPa has shown extended coagulation times and weaker gels. A dense matrix with well dispersed fat–protein droplets was observed in the gels formed from micro fluidized milk [12]. Micro fluidization reduces milk fat globule size and results a multiplication of the number of globules, Cheeses made from micro fluidized cream were higher in moisture and had a softer texture. The increase of cheese yield had been assigned more retention of fat and moisture [13]. Micro fluidization of cheese milk showed a decrease in the ability of the Mozzarella cheese to melt and flow. Micro fluidization of cheese milk decreased the lipid droplet size, increased the distribution of the small lipid droplets, and embedded smaller droplets into the protein matrix, and altered the fat–protein interactions and the rheological properties of the Mozzarella cheeses [14]. In another work it has been found that there were no significant deference in composition or microstructure between mozzarellas made from no homogenized milk and milk homogenized at 10. 3^0C and 34 MPa because this temperature does not sufficiently liquefy the fat for complete micro fluidization, and this pressure do not reduce the size of the fat globules. The fat globules in the cheese became smaller at higher pressures and temperatures [15]. When micro fluidization was applied to milk to form frozen products, various pressures had affected some properties of frozen dairy desserts. Nonfat and low-fat ice creams made with micro fluidized milk exhibited slower meltdown rates [16]. It has been found that thermally-denatured whey proteins can be partially or fully solubilized through Micro fluidization and it can minimize the sedimentation of heat treated whey proteins [17]. It has been discovered that Dynamic High Pressure Micro fluidization can influence the antigenicity of β-Lacto globulin in Bovine milk which was brought about by changes in SH groups and particle size and β strand content [18].

3. High pressure processing

High pressure processing uses water as a medium to transmit pressures between 100 and 1000 MPa to the products. It has been found that when applied to milk, high pressure processing can denature whey proteins, affect the activity of native milk enzymes, and produce changes in casein micelles [19, 20]. Processing at high pressures was believed to improve functional and sensory properties of low-fat and nonfat dairy products, as well as high-fat dairy products [21]. When High Pressure Processing was carried out to whey proteins it resulted in denaturation of whey proteins, mainly β lacto globulin and immunoglobulin G and a change in structure of the casein micelle was observed. High Pressure Processing at 600 MPa could cause protein aggregation, mainly β lacto globulin and κ-casein, using thiol disulphide interactions but α-Lactalbumin was least denatured [21]. When micellar protein concentrates were subjected to High Pressure Processing changes of casein micelles, as well as denaturation of serum proteins could be observed. Calcium-binding α_{S1}- and α_{S2}-casein levels have been increased after pressure treatments. Pressurization up to 350 MPa has increased soluble calcium and phosphorus levels, whereas treatment at 450 MPa has reduced soluble Ca and P levels. This could be due to casein micelle destabilization as a result of pressure treatment. Treatment of 10% micellar casein concentrate and 10% milk protein concentrate samples at 450 MPa resulted in weak, physical gels, which featured aggregates of uniformly distributed, casein substructures of 15 to 20 nm in diameter. Serum proteins were significantly denatured by pressures above 250 MPa [22]. It was found that high pressure treatment prior to cheese-making directly affects the final composition and yield of cheeses. Results from previous research show that HP treatment at 10 ^{0}C could significantly increase the cheese yield and protein retention, and some of the rheological parameters compared to cheeses made from raw or pasteurized milk. It was also found that the use of slightly higher pressurization temperatures increased moisture retention in cheese. High pressure treatment of milk at 676 MPa at 10 ^{0}C was found to increase the adjusted yield compared to pasteurization treatment [23] A previous study showed that processing by HPP up to 900 MPa did not produce significant changes to the lipid classes or fatty acid composition of milk fat and permits a better maintenance of the vitamin C in milk and the same levels of preservation of fatty acid proportions and tocopherols [24]. The results of a previous study showed that the tertiary structure of Lactoferin B was significantly modified with increased intensity of high pressure processing, indicating partial denaturation and aggregation of Lactoferin B. The decrease in the unordered structure indicated that high pressure processing resulted in a looser secondary structure of Lactoferin B. and it was found that high pressure processing also improved the solubility, foaming and emulsifying properties of Lactoferin B [25].

4. Conclusion

When studying the previous research works done on the application of non-thermal technologies such as Ultrasonication, Micro fluidization and High pressure processing to milk, it could be identified that different alterations of milk components could be done by those techniques and several alterations could be brought about in the final dairy products. Finally it could be concluded that certain processing treatments become beneficial in dairy industry but at certain conditions negative effects are also possible.

5. References

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