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Application of Microfluidization in the Food Industry

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Abstract:

Microfluidization is a high-pressure homogenization technique that applies a number of forces such as high impact force, shear force, sudden pressure drop, and cavitation force in order to subdivide the particles into smaller sizes. The technology of micro fluidization is based on a double-acting intensifier pump and an interaction chamber. The intensifier pump creates the pressure required to force the raw material into the interaction chamber. It is widely used in the food industry for a variety of applications, including the formation of micro- and nano-sized emulsions, the encapsulation of easily degradable bioactive compounds, and the enhancement of functional properties of proteins, polysaccharides, and dietary fibers. It was first used to emulsify milk products before being used in other food products such as fruit juices, proteins, gums, cereals, and cereal by-products.

Key words: Microfluidization; Food Industry; bran

Introduction

Microfluidization is becoming more and more popular in a variety of industries, especially in the food industry. It is a processing method that combines rapid hydrodynamic cavitation, high shear rates, ultrahigh pressure, an immediate pressure drop, high impact forces, and high frequency vibration (McClements and Rao 2011). Due to high shear stress and turbulence, the fluid flowing in a channel of a microfluidizer is divided into two or more microstreams. As a result, the microstreams are mixed by colliding into one another and the wall at speeds of up to 400 m/sec, which leads to the creation of fine emulsions and fine particle distribution (Mccrae 1994; Mert 2012). After that, the product has been successfully cooled and is ready to be collected in the output reservoir. The fluid undergoing the microfluidization process expands due to an instantaneous pressure drop at the exit of the interaction chamber, which causes the particles' tightly packed architecture to lose some of its integrity. As a result, cavitation or pores emerge inside the fluid. The system has the ability to deal with a variety of food materials, including fluids and products with high solid content and viscosities. The delivery of a consistent process pressure profile is accomplished by the combination of an intensifier pump and fixed geometry. When the product is continuously applied for the majority of the compression strokes, it passes through the microfluidizer at the target pressure, resulting in smaller particles and a narrower size distribution. When no food is fed into the system or processed through the interaction chamber during the suction strokes, the zero pressure section is also used, which has no impact on the final quality of food (Su and Mesite 2016). In the dairy industry, it is used to make nanoemulsions for processing a variety of milk-based products, including infant formula,yoghurt, cheese, and ice cream. These applications in various food products show that microfluidized milk has smaller emulsion particles than homogenised milk. Due to the amount of intact or partially intact micelles forming on the surface of the fat globule in milk treated with a microfluidizer is less. Microfluidization significantly reduced the amount of fat separation that occurred in milk during storage (Cobos, Horne, and Muir 1995; Dalgleish, Tosh, and West 1996). This method was also applied to the creation of nonfat or low-fat ice creams, which melted more slowly (Olson, White, and Richter 2004). In cereals, the phenolic compounds present are exposed due to the size reduction thereby increasing the bioavailability. Also microfluidization is used to create fibrous structures from bran of cereals.

Cereal & Cereal Products

Microfluidization has many advantages over conventional milling methods. It helps in reducing the size of cereal fibres into very smaller units, thereby increasing many functional properties such as improvement in water holding capacity, swelling capacity, porosity, oil-holding capacity, cation-exchange capacity. They also help in improving the surface areas and the exposure of phenolic compounds, thereby increasing the antioxidant property (Mert, I. D,2019).Bran is the outer most layer in cereal grains and is highly nutrient rich. It contains various vitamins, minerals, dietary fiber, antioxidants, phenolic lipids, phytosterols and other phytochemicals (Ozkaya et al.2017., Mert,I.D.2019). Due to the higher content of minerals and fibre, wheat bran is incorporated in various food products .It is reported that eating a diet high in dietary fibre has a number of health benefits such as reduced risk of colon cancer,diabetes, insulin sensitivity, cardiovascular disease and coronary heart disease. It is reported that particle size affects on functional and physicochemical properties of wheat bran (Suriano et al.2018). In this context , microfluidization is used as an effective method in reducing the particle size of wheat bran as the conventional milling methods are not suitable because of soft structure and relatively low density of wheat bran. The reduction of mean particle size of corn bran and the increase of surface area were reported by Wang et al.,2013. According to various studies, cereal brans provide some significant, distinctive, functional and nutritional features in terms of colour, texture, shelf life, cooking performance, and their dietary fibre content. wheat bran can be milled using microfluidization to create a highly branching fibrous structure (Mert et al.,2014).

Dairy products

Microfluidization has made a notable impact on the dairy industry. The homogenization of cream liqueur to increase shelf life was the first documented study utilising microfluidization in a process. Because it reduces particle size and improves stability, it has enormous promise for the creation of liquid emulsions.

Milk

Microfluidization produced substantially smaller fat globule sizes (0.22 m) in milk than conventional homogenization due to its higher homogenization efficiency. The amount of fat separation during storage is reduced by microfluidization, and it has been shown that UHT milk that has undergone this process can stay stable for up to nine months on the shelf without separation, as opposed to two to three months for UHT milk that has undergone conventional homogenization (Hardham et al., 2000; Tobin et al., 2015). Regardless of the prior heating treatments like pasteurization, thermization, or UHT, microfluidization did not appreciably alter the level of the majority of volatile chemicals.In particular, butanoic, n-decanoic, and carboxylic acid concentrations remain unchanged.

Yoghurt

Milk gels prepared by microfluidization and conventional valve homogenization have similar properties to those produced by stirring yoghurts. Temperatures, solids content, heat treatment and incubation temperature are the main factors controlling rheological properties of milk gels (Cobos et al.,1995; Ciron et al. 2010). Micro fluidization at 150 MPa for fat-free yoghurts had a negative impact on product quality and increased syneresis while decreasing hardness, cohesiveness, and viscosity. Low-fat yoghurt exposed to the same process did not significantly differ in terms of texture or water retention from that created by traditional homogenization (Tobin et al., 2015).

Cheese

Bucci et al., 2018 examined the effects of 4 micro fluidization temperature and pressure combinations on 3.0% milk. Longer coagulation durations and weaker gels were visible in the milk's coagulation properties after treatment at 54°C and 125 or 170 MPa. The gels created by a microfluidizer were observed under a microscope to have a dense matrix and evenly scattered fat-protein droplets. As a result, milk that has been micro-fluidized at a pressure of 75 MPa can be used to create cheeses with short curds and high moisture content.

Conclusion

Microfluidization is one of the emerging processing technology, which is used to create particles of smaller sizes. The microfluidizer changed the structure of the food by producing high cavitation, shear, velocity impact, and turbulence forces, which significantly improved the physicochemical, functional, nutritional, rheological, and sensory qualities of food products without changing their original flavour. These particular alterations have been made due to the reduction in particle size and subsequent increase in surface area. Additionally, by increasing their exposure, micro fluidization increased the bioavailability and bio accessibility of food products. The creation of stable emulsions and suspensions, encapsulation, and nanoparticles are among the uses of microfluidizers. Additionally, it has demonstrated its ability to create fibrous structures from the bran of cereals. Also, micro fluidization is applied in various dairy products such as yogurt, ice cream, milk, etc.

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