New Dairy Technology

Cavitation processing is an emerging technology in food processing. When cavitation passes through a liquid, bubble nuclei present in the liquid grow by bubble coalescence and rectified diffusion. When these bubbles reach a critical size range, they collapse under near-adiabatic conditions generating extreme conditions within the bubbles and in the surrounding liquid that include intense shear forces, turbulence and microstreaming effects. These cavitation-induced physical effects are finding increasing use in food and dairy processing, in applications such as the enhancement of whey ultrafiltration, extraction of functional foods, reduction of product viscosity, homogenization of milk fat globules, crystallization of ice and lactose and the cutting of cheese blocks.

CAVITATION/ HOMOGENIZATION OF MILK

Milk is an emulsion that is homogenized to reduce the average particle size, which improves its consistency and extends shelf life. The homogenization process is expensive and by utilizing cavitation it can improve quality process, can improve quality of the milk and consistency and reduce operating costs.

Milk is a very complex food containing over 100,000 different molecular species. Cow's milk is composed of 87% water, 3.5% protein, 3.7% fat, 4.9% lactose, and 0.7% salts. The main components of interest are protein and fat globules.

The proteins, referred to as casein particles combine together with calcium and phosphate to form aggregates with a well-defined structure. Their typical size is in the range of 100 nm. They are white, tasteless and odorless and are used to make food, paint, and adhesives. In contrast, the fat globules in raw unhomogenized milk are between 1-10 µm, while in homogenized milk the size range is 0.2-2 µm.

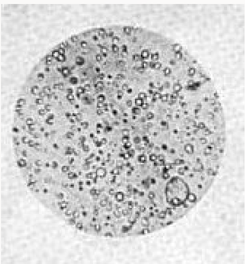
Milk is an oil-in-water emulsion, with the fat globules dispersed in a continuous phase of skim milk. If raw milk were left to stand the fat globules would form a cream layer and rise to the surface. Cavitation is a mechanical process used to reduce the size of the fat globules in the milk.

The net result of this process is a decreased creaming rate according to Stokes' Law, reduced clustering during creaming, and better density matching with the continuous phase.

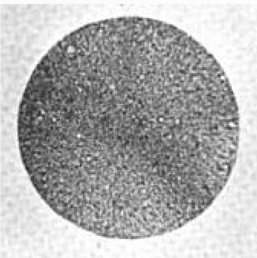
The cavitation process reduces the globule size by passing milk under high pressure through a Nano Reactor.

The cavitation/homogenization phenomenon is completed before the fluid leaves the reactor area.

The main goal of cavitation/homogenization is to break up the large fat globules and create a stable emulsion that has an increased shelf life, a better taste, and improved mouth feel.



Fat globules before Cavitation



Fat globules after Cavitation

Effect of Cavitation treatment on production of Cheese

Cheese is one of the most demanded products around the world. Each year, the cheese industry reports considerable sale increases. Varieties of this dairy product with the highest demand include cheddar, colby, monterey jack, mozzarella, ricotta. The main processing steps of cheese making include the clotting or curdling of the milk, removal of whey, acid production, salting, shaping, and ripening. The essential step during cheese processing is the formation of the curd that occurs by enzymatic and microbial activity. Many environmental conditions such as temperature, enzyme concentration, or microbial load are very important during the process to generate a firm curd in a specific time. One of the desirable aspects in cheese making is to reduce the curdling time and increase the yield, because the final yield of cheese is around 10%.

CTI's Nano cavitation reactors can be applied in cheese making in order to improve these aspects while at the same time improve the overall **quality** of cheese.

When cavitation was applied to milk to study the proteolytic activity of the enzymes related to curdling, the main observable effect was that cavitation speeds up the hardening of the curd and the final product showed a better firmness because of the activity on the chymosin, pepsin, and other related enzymes. When cavitation is used to enhance the extraction not only the yield and enzyme activity were increased considerably, but also extraction times were much shorter than without cavitation.

The reason for that could be attributed to the distraction of cellular structure because of the action of cavitation, increasing the activity of the substance contained in the cells and the migration of proteins and minirals from cells to the solution. The activity of the chymosin increased with cavitation and the nitrogen content of the extract decreased at the same time.

Other uses of hydrodynamic cavitation in the cheese-making industry are in the flavor arena. In addition to all of the benefits of the cavitation technology, cavitated milk showed better characteristics, such as whiter color, better texture (hardness), higher

Effect of Cavitation treatment on the stabilization of cocoa particles in milk

Prevention from physical instability of chocolate milk is an important challenge in food science, particularly dairy industries.

According to the findings, the increase of power intensity and exposure time led to a significant increase on the degree of homogenization, and subsequently a paramount decrease in the size of cocoa particles. The cocoa particle diameters of chocolate milk which sonicated at 65ºC were smaller than the other temperatures whereas the milk phase volume of one treated at 45ºC was less than the other temperatures. κ-carrageenan at the highest applied concentration (0.02%) effectively prevented from phase separation and sedimentation after 30 days. Colour measurements also showed higher *L** values for cavitated samples where with the increase of power intensity and exposure time led to a significant increase on *L** value. Overall acceptance of treated samples had no significant difference against control.

Based on the findings it seems that cavitation is an effective processing method for reducing the particle size of cocoa and increasing of chocolate milk stability. In addition, it showed some effects on the degradation of κ-carrageenan network and at higher temperatures these effects were more pronounced.

EFFECT OF CAVITATION TREATMENT ON THE YOGURT

Fat globules are routinely homogenized (prior to inoculation of milk with yogurt starters) to improve yogurt consistency and to prevent serum separation in the final product . These effects are not only due to fat globule size reduction but also to the effects of pressure on other milk constituents, mainly proteins.

Cavitation homogenization of milk has been studied. It has been reported the ability of cavitation to homogenize fat globules. By using cavitation treatment prior to starter inoculation improved, yogurt viscosity, its attributed to the milk cavitation homogenization effects. It is also found that fermentation time could be reduced by cavitation treatments prior to

Yogurt is one of the most consumed dairy products. Flavor and consistency are its main quality parameters. Consistency of yogurt is dependent on its structure, a protein network formed by casein micelles strings and/or clusters entrapping serum and fat globules. Complex interactions can be established between these three components.

This network is relatively weak and it is formed by acidification of milk by a mixed culture of *Streptococcus thermophilus* and *Lactobacillus delbruekii* ssp. *bulgaricus*, although proteolytic processes could also be involved.

As cavitation has been shown to affect fat globule size and dairy protein denaturation, it is expected that yogurt structure, which is highly dependent on fat globule size and denaturation and aggregation state of proteins, is also affected.

Effect of cavitation in ice cream making

Cavitation can be is used for making milk more stable against creaming and for giving the product a richer mouth feel due to a slight increase in viscosity. Cavitation is also can be used in ice cream making. The Cavitated/homogenized mix gives a creamier product, when the mix is frozen. However, experienced ice cream makers know, that it is beneficial to store homogenized ice cream mix a few hours at low temperature (4°C) before freezing.

This aging process permits any added emulsifying agent (glycerol mono- and di-stearates) to partially displace some of the casein submicelles from the fat surfaces. The reason, this is beneficial, is not well understood, and is still a subject of research.

Other Uses of CTI's Nano reactors in Dairy Industry

Edible films is an interesting topic for many researches in food preservation worlwide; however, some specific characteristics of the films are required in order to be used in food, as well as their mechanical properties. Sodium caseinate and whey proteins can be used for manufacturing edible films and their mechanical properties are improved by using cavitation

Considerable reduction of vibrations and absence of pulsation of processed liquid allows to simplify and reduce the price of design, to increase trouble-free operation term, to guarantee high quality of process for the whole operation period.

Effect of Cavitation Treatment on Production of Margarine

Emulsions

Emulsions find a wide range of application in industry and daily life. In the pharmaceutical industry lipophilic active ingredients are often formulated in the disperse phase of oil-in-water emulsions. Milk, butter, and margarine are examples of emulsions in daily life. To facilitate the selection of an emulsification system, the influence of the most important parameters of the emulsion formulation on the resulting mean droplet diameter in the most prevalent continuous emulsification system.

Cavitation emulsification provide extended shelf stability, improved smoothness, body and color for a vast array of dairy applications including milk, ice cream, cream, yogurt, desserts, sour cream, cheese and condensed milk, process mayonnaise emulsions, salad dressings, margarine and butter emulsions, mustards and much more.

Epolymorphic transformation

Cavitation can be utilized for the control of solidification in liquids. The liquid to be solidified is subjected to cavitation in order to control the steps of nucleation and/or crystal growth of the solidification process.

Accelerating the polymorphic transformation of edible fat compositions. Such compositions when undercooled by at least 4° C. are exposed to cavitation for a time and at a frequency sufficient to induce nucleation of stable polymorph crystals without exceeding the melting point of those crystals. Typical fats to be treated by this method are butter fat and the fats used in ice cream, chocolate, margarine and yogurt.

Processes for the preparation of edible emulsion spreads which may be either water continuous or fat continuous. The most common spreads such as margarine have a continuous fat phase and a dispersed aqueous phase. Such spreads are traditionally prepared by passing a mixture of the aqueous phase and the oil phase through a series of one or more scraped-surface heat exchangers and pin stirrers.

The oil phase of those mixtures is eventually crystallized by cooling under such shear that a W/O-emulsion is obtained in which a lattice of fine fat crystals provides the desired consistency and stabilizes the dispersed aqueous phase.

Alternatively the process of spread preparation may start with a continuous aqueous phase emulsion and includes a cavitation step in order to impart fat continuity to the emulsion spread.

The lattice of fat crystals in the spread necessarily consists of solid saturated fat. For reasons of healthy nutrition and economy of raw materials the content of such saturated fat preferably is restricted to the minimal functional amount. Cavitation has shown to have such a beneficial influence on nucleation and eventually on the strength of the crystal lattice that even at relatively low solid fat levels a spread product with a good consistency, texture and stability is obtained.

Alternatively, cavitation further provides a process for preparing a W/O-emulsion spread comprising the steps of;

A. preparing an O/W-emulsion having a continuous aqueous phase containing dispersed fully liquefied fat, cooling the emulsion to cause partial crystallisation of the fat, so obtaining a dispersion of partially crystallized fat in a continuous aqueous phase,

B. inverting the O/W-emulsion into a fat continuous emulsion in the usual way,

C. working and cooling the fat continuous emulsion to cause further partial crystallisation of the fat until a desired consistency and texture is obtained,

For present spread manufacturing processes the cavitation is most beneficial for the preparation of emulsion spreads which are fat continuous. Proper fat crystallisation plays, however, also a role in the preparation of spreads in which fat is the dispersed phase.

A since long acknowledged benefit of cavitation is its potential influence on the habitus of the crystallized fat. The formation of one fat polymorph may be promoted over another one. Since some polymorphs possess preferred properties, cavitation provides a tool for improving the properties of the resulting fat and indirectly for improving the properties of food products containing those triglyceride fats.

Another benefit of cavitation in production of margarine, is a pretreatment of oil or fat trough cavitation prior to hydrogenation process. Pretreated oil will react much quicker with introduced nickel or other catalyst used in the process.