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ΠΑΝΕΛΛΗΝΙΑ
ΕΝΩΣΗ
ΤΕΧΝΟΛΟΓΩΝ
ΤΡΟΦΙΜΩΝ



ΣΧΟΛΗ
ΤΕΧΝΟΛΟΓΙΑΣ
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Producing stable emulsion by ultrasound with emphasis on the use of Taguchi statistical methodology: a new approach

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Abstract

High power ultrasound has the potential to be used in various chemical/physical processes. It can cause/initiate changes that usually take place under extreme conditions and hence has been increasingly gaining interest. This work was aimed at using ultrasound in preparation of stable oil-in-water emulsion. The effect of pH, ionic strength, pectin and xanthan gum as well as the time of sonication on the stability, droplet size distribution and creaming index of the emulsion was investigated. The experimental data were analyzed with Taguchi method and optimum conditions were determined. The results showed that increasing sonication time narrowed the range of droplets size. However, excessive sonication resulted in emulsion breakdown. Pectin and xanthan enhanced the stability of emulsion, although they had different impacts on the emulsion stability when used individually or together. These observations can be attributed to viscosity change, formation of multiemulsions and electrostatic interactions arising from variation in pH and ionic strength.

Keywords: Ultrasound, emulsification, Taguchi method, droplet size distribution, xanthan, pectin

Introduction

Many food products such as milk, cream, beverages, dressings, dips, sauces, batters and desserts are oil-in-water emulsions that consist of small lipid droplets dispersed in an aqueous medium (Friberg and Larsson, 1997; McClements, 1999; Stauffer, 1999). These products are thermodynamically unstable. One type of stability loss is formation of cream, in which buoyant emulsion droplets tend to rise to the top of a container. It is the same process as sedimentation, but in the opposite direction. Therefore, it is of importance for manufacturers to produce food emulsions of high stability with no or minimal changes in the structure or consistency during storage. Stability of an emulsion depends on many parameters of which size of droplets is of crucial. This has been studied for many years leading to development of new concepts and technologies.

It has long been known that ultrasound is capable of making fine emulsions (Abismaïl *et al.*, 1999; Mujumdar *et al.*, 1997; Neduzhii, 1961a and b, 1962, 1965). However, yet it has not been widely used in the food industry for some reasons. The disintegration effect of ultrasound is due to the bubbles collapsing at the interface of two immiscible liquid, disrupting one phase into another.

In the present work the rate of creaming was measured and the stability was monitored as a

function of sonication time, ionic strength and pH of aqueous phase, surfactant and stabilize concentration and the optimum conditions to make emulsions with reasonable stability were determined using Taguchi's robust design method. It was first introduced by Dr. Genichi Taguchi, which is a process/product optimization method based on 8 steps of planning, conducting and evaluating results of matrix experiments to determine the best level of control factors on characteristic properties and hence optimal conditions for any complex process (Ross, 1988). It has been used in many areas of manufacturing since the 1960s with many discrete product engineering and manufacturing companies using it to great effect (Fowlkes and Creveling 1995). This technique is an alternative to standard factorial designs. Since it reduces the number of experiments, it is easier to use, faster and at the same time accurate and reliable saving time and cost (Ross, 1988). Taguchi method can determine the experimental conditions having the least effect on the desired characteristic by calculating a term called signal to noise (S/N) ratio. The experimental conditions having the maximum S/N ratio are considered to be the optimal condition as the experimental variables are inversely proportional to the S/N ratio (Roy, 1990).

Materials and Methods

Materials

Sodium chloride, glacial acetic acid and soy bean lecithin were purchased from Merck Co, Germany. Xanthan from *Xanthomonas campestris* and pectin from citrus peel were supplied by Sigma Chemical Co, Germany. Sun flower oil was obtained from local market.

Experimental procedure

Preparation of aqueous phase

Aqueous phase was prepared by dispersing 1g lecithin and different proportions of xanthan, pectin and NaCl in distilled water adjusted to pH 3 or 4 by glacial acetic acid. Table 1 shows proportion of each constituent in the aqueous phase for various formulas used in the experiment.

Table 1. Constituents of various formulas used for emulsion making (w/w %)

Compound	Formula 1	Formula 2	Formula 3	Formula 4	Formula 5	Formula 6
Xanthan	0.0	0.0	0.0	0.4	0.0	0.4
Pectin	0.0	0.0	0.4	0.4	0.4	0.0
NaCl	0.0	0.4	0.4	0.4	0.0	0.0
Water	59.0	58.6	58.2	57.8	58.6	58.6
Oil	40.0	40.0	40.0	40.0	40.0	40
Lecithin	1.0	1.0	1.0	1.0	1.0	1.0

Preparation of emulsion

The aqueous phase and sunflower oil was mixed together in a beaker. 5 ml aliquot of the mixture was introduced into a round bottom glass tube of 14 mm internal diameter and 100 mm length. Sonication was carried out using a Dr. Hielscher ultrasonic processor, Model UP 50H, Germany, with the operating frequency of 30 KHz and power output of 50W. A tapered titanium sonotrode of 3 mm in diameter was used for sonication. The tip of sonotrode was placed 1 cm below the surface of mixture. All samples were sonified in ice water for 60 and 120 seconds.

Determination of droplet size distribution

Drop size distribution of samples was measured immediately after making and also after one month storage at 4°C using Fritsch laser diffraction analyzer, Model Analysette 22, Germany.

Determination of creaming rate

5 ml of each sample was stored in a round bottom glass tube at 4°C for a month and the height of creaming layer was measured.

Experimental design

Taguchi L8 orthogonal array design was used to screen the effect of pH, sonication time and concentration of xanthan, pectin and sodium chloride on droplet size distribution of samples.