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Establishing the regularity of the emulsification process

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Abstract. The study is aimed at assessing the influence of the degree of quantitative content of vegetable oil in an aqueous-oily medium on the emulsification process. Safflower oil was chosen as the main ingredient of the oil phase. The degree of quantitative content of safflower oil varied from 20 to 80% in relation to water. The stability of emulsions depends on many factors, including the degree of ultrasonic action, the stability of water-oil emulsions is ensured only if a film forms on the interfacial surface that mechanically prevents the aggregation of particles of the dispersed phase. It is the stabilizing adsorption film, and not the low interfacial tension, that exclude the possibility of fusion of particles of dispersed phases. The production of water-oil emulsions based on various oils, including emulsions used in perfumery, food, petrochemical and other industries. The disadvantage of the above analogues is that the influence of quantitative parameters on the emulsification process has been established and they do not have a set of functional and technological properties necessary for the production of new types of food products. This paper presents the results of the influence of the quantitative parameters of the components on the formation of a water-oil emulsion based on safflower oil under ultrasound exposure. The process of formation of a water-oil emulsion largely depends on the quantitative parameters of the components and the parameters of ultrasonic exposure - the frequency and amplitude of ultrasound, as well as its power. Therefore, establishing the regularity of the emulsification process of a water-oil mixture based on safflower oil using ultrasonic exposure is an urgent task. In connection with the expansion of the scope of ultrasound in the production of various types of emulsions, studies are being conducted on the influence of quantitative parameters of components in the process of ultrasonic treatment on the physico-chemical and rheological parameters of the final product.

1 Introduction

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Many common food products are emulsions (mayonnaise, coffee cream, salad dressings, etc.), so a better understanding of the regularity of the formation of emulsions is crucial for the development, production and storage of appropriate food products [1].

The study is aimed at assessing the influence of the degree of quantitative content of vegetable oil in an aqueous-oily medium on the emulsification process. Safflower oil was chosen as the main ingredient of the oil phase. The degree of quantitative content of safflower oil varied from 20 to 80% in relation to water. The stability of emulsions depends on many factors, including the degree of ultrasonic exposure.

Ultrasonic processing of materials is widely used in various industries, such as medicine, food and pharmaceutical, mechanical engineering and oil and gas industries [2,3]. It is known that ultrasound has a significant effect on the speed of various processes in the food industry [4,5]. The use of ultrasound makes it possible to speed up food processes, thereby reducing the cost of processing, obtaining a more homogeneous mass and improving the quality of the final product. One example of the use of ultrasound in the food industry is the creation of water-oil emulsions based on vegetable oils. [6].

When liquids are homogenized, the interface between the phases increases, which leads to an increase in the free energy reserve of the system [7,8]. And as you know, according to the second law of thermodynamics, the surface energy tends to a minimum by reducing the interface of phases. As a result, there is a decrease in the interfacial surface due to the union of two phase droplets. I.e., we observe a spontaneous process of fusion of phase particles that does not require energy expenditure. This process of merging particles of two or more phases ensures the subsequent creation of a stable structure of emulsions [9,10,11].

The stability of water-oil emulsions is ensured only if a film forms on the interfacial surface that mechanically prevents the aggregation of particles of the dispersed phase. It is the stabilizing adsorption film, and not the low interfacial tension, that exclude the possibility of fusion of particles of dispersed phases. The production of water-oil emulsions based on various oils, including emulsions used in perfumery, food, petrochemical and other industries is based on this principle. [12,13].

The oxidative and physical stability of oil-in-water emulsions containing n-3 fatty acids (25 wt. % oil, 2.5 wt. % of whey protein, pH 3.0 or pH 6.0), and their subsequent inclusion in meat products. The physical stability of fish oil emulsions was excellent, no coalescence or aggregation occurred during storage. Oxidative stability was better at pH 6.0 compared to pH 3.0, probably due to antioxidant proteins with a continuous phase [14]. The introduction of fish oil emulsions into pork sausages led to an increase in oxidation compared to sausages without the addition of fish oil emulsion. Confocal microscopy of pork sausages with fish oil emulsions showed that the droplets eventually merged in the meat matrix, which could contribute to a decrease in oxidative stability [15].

To assess the effect of vegetable oils on the stability of the emulsion, palm olein (POo), olive oil (OO), safflower oil (SAF), grape seed oil (GSO), soybean oil (SBO) and sunflower oil (SFO) with varying degrees of saturation were selected as the main ingredient of the oil phases. All emulsions were stored at 4°C, 27°C and 40°C for 35 days and subjected to all stability tests, including temperature change, centrifuge test, cyclic test, pH and melting point of the slip. The results showed that POo has the greatest stability, followed by SAF, OO, GSO, SFO and SBO. In addition, the results imply that the degree of saturation of vegetable oils does have a significant effect on the stability of the emulsion, based on testing on a centrifuge with an approximate oil usage level of 30% [16].

When emulsifying natural honey with colloidal particles, such as precipitated CaCO 3 (Socal R1E FG, Calofort U and Calofort SV), the mixtures gave stable emulsions of vegetable oil in honey. It was established that Socal R1E FG and Calofort U represent unmodified CaCO 3.particles, and Calofort SV is modified (coated with 3% stearic acid). The functional properties (namely, droplet size and resistance to delamination and coalescence) of these emulsions were determined. The oil droplets in the emulsions were several microns in size, and after an initial small degree of coalescence, the emulsions remained stable for up to one year without delamination and further coalescence. Emulsions from Socal R1E FG had greater stability compared to emulsions from Calofort U and Calofort SV. The results obtained can be used for both the food and pharmaceutical industries. For example, since honey is sweet by nature, these emulsions can be used in new food formulations without the addition of sweeteners. In addition, these emulsions can be used for microencapsulation of food products and pharmaceutically active ingredients. [17,18].

The authors believe that the stability of emulsions can be improved through the use of natural polymer additives. The influence of various parameters, such as pH, oil content, emulsifier content, hydrophilic-lipophilic balance of the emulsifier mixture, additive concentration and temperature, on the stability of the cosmetic emulsion has been studied. [19,20]. The "compatibility with the skin" of the developed emulsions has been confirmed and are stable at neutral pH. Xanthan gum proved to be the most effective additive compared to other natural polymers. The emulsions showed "pseudoplastic" fluidity.

A "Method for producing emulsions containing oil bodies and active components" has been developed, where the active ingredient is distributed in the oil body. This development can be used in the production of an emulsion using hydrophobic, or samphipathic biologically active components. The invention presents methods for producing emulsions containing active components distributed in oil bodies, where they are stabilized and easily accessible for long-term storage. Accordingly, the present invention provides a method for distributing the active component into oil bodies, including: a) dissolving the active component in the first solvent; b) mixing the dissolved component with the second solvent; c) contacting a mixture of solvents with oil bodies to distribute the active component in oil bodies [21]. A method for producing oil-fat paste is known. The material suitable for use as a fat mixture for spreading contains 7-55% of the fat substitute isolated from palm fats [22]. In the "Method for obtaining a plastic fat composition", when preparing a plastic composition with a high content of polybasic unsaturated aliphatic acids, 10 g of solid palm oil with an upper melting point of 50 ° C and 90 g of liquid oil with 65-70% of polybasic unsaturated aliphatic acids are mixed. A mixture of 20% is taken separately. solid oil and 80%. liquid palm oil, transesterification is carried out in both mixtures and 15-25% is mixed. the first product of transesterification, 60-70%. the second product of transesterification, 5-10%. solid oil and 5-10%. liquid palm oil. The prepared composition contains aliphatic acids in an amount of ≥50% of the mass of all aliphatic acids, has good ductility and good preservation [23,24].

The disadvantage of the above analogues is that the influence of quantitative parameters on the emulsification process has been established and they do not have a set of functional and technological properties necessary for the production of new types of food products. The closest in terms of technical essence and the achieved result is a water-fat emulsion, including red palm oil and an emulsifier stabilizer [25].

Water-oil emulsion containing red palm oil "Carotino", drinking water, emulsifier, stabilizer. At the same time, soy lecithin and fatty acid monoglyceride are used as an emulsifier, and xanthan gum is used as a stabilizer. The invention makes it possible to obtain a food system - a water-oil emulsion containing red palm oil, which serves as a vitamin-containing additive to meat products for baby food. The components for the stabilization of the water-oil emulsion were selected in such a way that they possessed both a complex of functional and technological properties and carried out possible protective properties for additional protection of the fat emulsion from oxidation not only during the production of the water-fat emulsion, but also during the production of food products [26,27].

Methods for preparing water-oil emulsions emulsions are divided according to the mixing sequence: (emulsifier + oil) + water; (emulsifier + water) + oil; emulsifier + (water + oil) Table 1.

Table 1. Methods of preparation of water-oil emulsions.

Food emulsions	Emulsion type	Preparation method	Stabilizer
Cream cream	water/oil	Homogenization	Gelatin
Margarine	water/oil	Homogenization	of Lecithins, phosphatides
Mayonnaise	water/oil	Homogenization	of pectin (E440)
Sauces	water/oil	Homogenization	Starch
Fat emulsions	water/oil	Homogenization	FOLS-1, starch

To increase the stability of water-oil emulsions (physical, chemical and microbiological), it is necessary to increase physical stability, the introduction of hydrophilic solvents, stabilizers and qualitative homogenization, etc. [28,29]

Due to the expansion of the field of ultrasound application in the production of various types of emulsions, studies are being conducted on the influence of quantitative parameters of components in the process of ultrasonic treatment on the physico-chemical and rheological parameters of the final product [30,31].

This paper presents the results of the influence of the quantitative parameters of the components on the formation of a water-oil emulsion based on safflower oil under ultrasound exposure. The process of formation of a water-oil emulsion largely depends on the quantitative parameters of the components and the parameters of ultrasonic exposure - the frequency and amplitude of ultrasound, as well as its power. Therefore, establishing the regularity of the emulsification process of a water-oil mixture based on safflower oil using ultrasonic exposure is an urgent task.

The purpose of this work is to establish the regularity of the emulsification process of a water-oil mixture based on safflower oil. To achieve this goal, it is necessary to solve the following tasks: to determine the quality indicators and the fatty acid composition of safflower oil; to establish the regularities of the formation of water-oil emulsion at different ratios of ingredients.

2 Materials and methods of research.

Generally accepted methods were used to determine the qualitative indicators and fatty acid composition of safflower oil [25]. Determination of the fatty acid composition of safflower oil was carried out by gas-liquid chromatography.

To study the regularity of ultrasonic emulsification, a laboratory stand was developed, where the ultrasonic homogenizer Omni Sonic Ruptor 4000, consisting of an electronic generator and an emitter with an immersion titanium waveguide having a mushroom-shaped working end, serves as a source of ultrasonic action. The device provides for the possibility of vertical movement of the working body in order to implement various modes of exposure. The appearance of the ultrasonic emitter is shown in Fig. 1.

Fig.1. Ultrasonic homogenizer Omni Sonic Ruptor 4000

Since, according to the generalization of the known results of theoretical and experimental studies, the maximum efficiency of cavitation is provided at a frequency of 20 kHz, the main attention is paid to identifying the intensity of ultrasonic vibrations necessary to obtain emulsion droplets of the required diameter in a specific frequency range. Food emulsions of the "vegetable oil-water" type were used as objects of research. Safflower oil was used as vegetable oil.

For the experiment, food emulsions with different ratios of ingredients were used: – the first option – 20% vegetable oil + 80% water; – the second option – 50% vegetable oil + 50% water; – the third option – 80% vegetable oil + 20% water. The time of ultrasonic exposure varied from 4 to 30 minutes, and the exposure power was 400 watts. The temperature of the food emulsion before ultrasonic exposure was 25 ° C.

3 Results

Qualitative indicators (Table.1) and fatty acid composition (Table.2) was determined in an accredited laboratory of the Scientific Research Institute of Food Safety of Almaty Technological University (Kazakhstan). The results of the studies are presented in Table 1.

Table 1. Quality indicators of safflower oil.

The name of the indicator, unit of measurement	**By Indicators**
Colour	Yellow with a brown tinge
Taste and smell	Peculiar to safflower
Transparency	Transparent without a cloudy shade
Iodine number, g J/100g	142
Acid number, mg KOH/g	3.5
Density at 20 °C, g/cm3	0.919

Table 2 shows the fatty acid composition of safflower oil

Table 2. Fatty acid composition of safflower oil.

The name of the indicator	**The value of the indicator**
Saturated fatty acids,%	8.0
Monounsaturated fatty acids, %	10.6
Polyunsaturated fatty acids, %	81.3
Linoleic acid content, %	76

There are several ways to obtain water-oil emulsions. In recent years, the creation of water-oil emulsions using ultrasound has become popular [15].

Figure 2 shows the results of ultrasonic treatment of safflower oil at different ratios of components: – the first option is 20% vegetable oil + 80% water; – the second option is 50% vegetable oil + 50% water; – the third option is 80% vegetable oil + 20% water.

Fig.2. Ultrasonic treatment of a water-oil composition based on safflower oil.

where: a-20% vegetable oil + 80% water; b-50% vegetable oil + 50% water; c- 80% vegetable oil + 20% water;

4 Discussion

The obtained results confirm the possibility of creating water-oil emulsions at different water-oil ratios using ultrasonic exposure. The regularity of the viscosity of emulsions is also established. The more water in relation to the oil (Fig.2 "a"), the viscosity of the water-oil emulsion is higher. This pattern is explained by the formation of a large number of particles of the dispersed phase. With a small volume of water (Fig.2 "c"), a sufficient number of dispersed phase particles are not formed in relation to the oil due to insufficient water to form an adsorption film around the dispersed phase particles. The stabilizing adsorption film around the dispersed phase particles, rather than the low interfacial tension, exclude the possibility of fusion of dispersed phase particles.

5 Conclusion.

Qualitative indicators are determined (Table.1) and fatty acid composition (Table.2) safflower oil. The content of polyunsaturated fatty acids is more than 80%.

The regularities of the creation of water-oil emulsions at different water-oil ratios using ultrasonic exposure have been established. Ultrasonic treatment of the water-oil composition in the ratio of water and oil -80/20% (Fig.2 "a") allowed to obtain a homogeneous substance. It is established that the viscosity and stability of the resulting emulsion depends on the number of particles of the dispersed phase.

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