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FACTORS INFLUENCING THE OBTAINING AND THE STABILITY OF DOUBLE EMULSIONS MADE OF CORN OIL

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An emulsion containing a solution of potassium chloride as the aqueous phase and food oil as oily phase was made. The emulsion was obtained using sorbitan monooleat and sorbitan monolaureat as surfactants. Double emulsions were prepared both in the presence and absence of a hydrophilic surfactant. The double emulsions were destroyed by outside coalescence of the drops of internal phase in a few minutes. The stability of double emulsions depends on the concentration of saline solution. The stability of the emulsions increases with the addition of hydrophilic surfactant.

Keywords: double emulsion, lipophilic surfactant, hydrophilic surfactant, stability, coalescence

1. Introduction

Double emulsions are considered as multiple emulsions – type of disperse mediums. The obtained direct double emulsion was formed by reverse emulsion corpuscles dispersed into an external aqueous phase, in presence of a hydrophilic surfactant (Bibette, 1997). The reverse emulsion corpuscles were formed by internal aqueous phase drops dispersed into an oily phase, using a lipophilic surfactant. These systems were destroyed by passing an aqueous phase from the reverse emulsion corpuscle interior to the aqueous phase outside them (Leal-Calderon et al., 2007).

The double emulsions are very important in the pharmaceutical area, and are used to introduce by oral way the encapsulated drugs, such as insulin (Garti et al., 1998). They are both used in the food industry or food made by this way providing the organoleptic properties of the product as well as its stability (Bilati et al., 2005). Given the importance of direct double emulsions for the pharmaceutical industry (Matsumoto et al., 1989) and food industry (Benichou et al., 2004), we tried to prepare the double emulsions using as an oil phase corn oily food. The corn oil is rich in poly-unsaturated fatty acids (Vintilă, 2002) and very useful in the treatment of several nutritional and cardiovascular diseases.

Until now, the double emulsions have been prepared as model systems (Bibette et al., 1999), using a hydrocarbon oil phase (Pays et al., 2000). On account of the applications of these systems, it is necessary to use non-toxic pattern, such of edible oils.

2. Materials and Methods

In this work, emulsions on water or a potassium chloride solution, as the aqueous phase, were prepared, the salt being provided by the firm *Reactivul* – Bucureşti (România). The oily phase relied on corn, provided by the firm *Ulvex* – Buzău (România). As lipophilic surfactant sorbitan monooleate was used, (Span 80) provided by *Aldrich* Company – Taufkirchen (Germany). As hydrophilic surfactant monolaureat sorbitan (Span 20) was used provided by the *Aldrich* Company. The concentrations used are shown in Table 1.

The emulsion type was determined by means of Sudan Red dye type (Binks, 1998).

The emulsions obtained were examined under an optical microscope, multiplied 7 times by the ocular magnification and 1000 times by the objective magnification. The images were selected by Video-Enhanced Microscopy (VEM). During a later stage, the images were interpreted using the computer, working on a WinFast PVR program (Zgherea et al., 2008).

To prepare the emulsions, all the components were carefully mixed for five minutes, by means of the single step method (Figure 1.). To do this, we used the Ultraturax T-25 homogenizer provided by Janke and Kunkel (Germany) (Stoian, 2000).

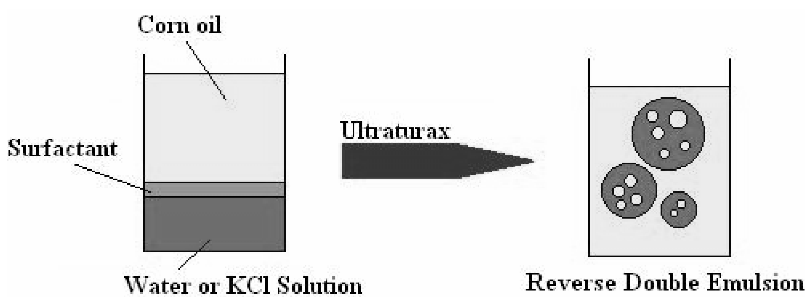

Figure 1. Scheme to obtain the emulsions

Table 1. The materials and their concentrations

Phase	Materials used		Composition
Water phase	- Water - KCl solutions, of concentrations: 0.2 N; 0.4 N; 0.6 N; 0.8 N; 1 N		25%(v)
Oil phase	Corn oil		75%(v)
Surfactant	Lipophilic	Span 80	1%(m) from the oil phase
	Hydrophilic	Span 20	No Span 20, Span 80 : Span 20 = 2:1, Span 80 : Span 20 = 1:1, Span 80 : Span 20 = 1:2

The evolution of emulsions was observed by VEM microscopy. The period during which the emulsion was destroyed was also macroscopically determined (Stoian et al., 2002).

3. Results and Discussions

In the first stage, only Span 80 a lipophilic character was used as surfactant. The emulsion components are presented in Table 1. It was found by VEM microscopy that the obtained emulsions were not the primary inverse emulsions, but the double emulsions (Figure 2. a). The dispersed particles are almost spherical. The resulting emulsions are polydispersed. The emulsions retain the appearance of double emulsions in the presence of both surfactants (Span 80 and Span 20) (Figure 2. b). To determine the double emulsions type, the method of emulsion colouring by means of Sudan Red dye was used. Reverse double emulsions (oil/water/oil) were prepared. The obtaining of reverse double emulsions shows that in the system there exists a hydrophilic surfactant such as phospholipids of the plant oil material or traces of soaps of the oil refinery process (which is of a hydrophilic character).

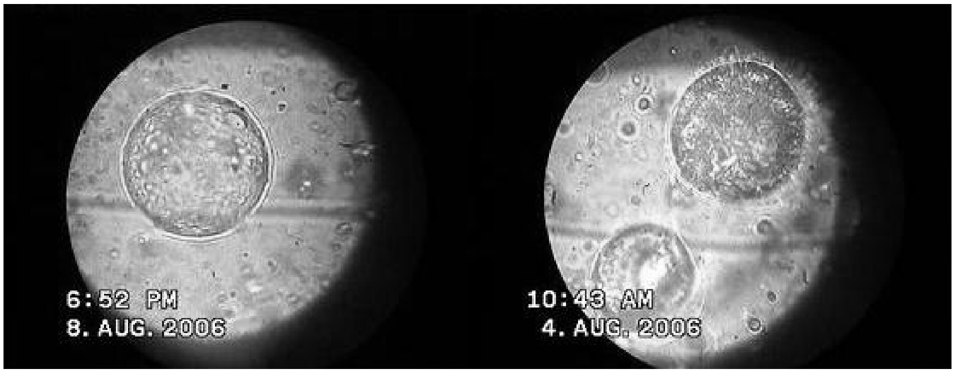

Figure 2. Double emulsions containing Span 80 (1%) obtained in the absence of Span 20: a) Water: oil corn germ = 3:1 (v.), b) 0.4 N KCl solution: oil of corn germ = 1:1 (v.)

The evolution of emulsions was very fast and the increase in particles a few tens of seconds was recorded. It was noted that the manner of destabilization is a complex process of coalescence (Fig. 3.).

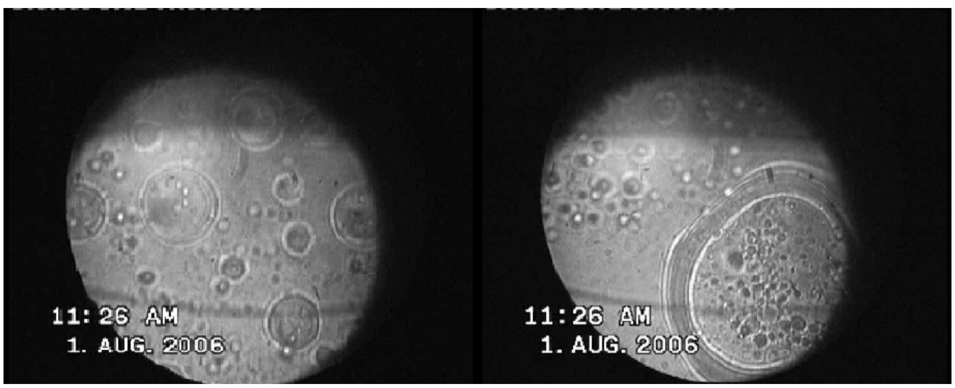

Figure 3. Appearance of the emulsion containing 25% (v) 1 N KCl solution and 75% (v) corn oil in the presence of 1% (m) Span 80: a) kinetics at the beginning of the reaction, b) after a few dozen seconds

This coalescence process takes place in two stages. During the first stage, the coalescence takes place among the small internal oil droplets. At the end of this stage, the internal oil large drops are formed. In the second stage, the coalescence takes place between large oil internal droplets formed in the previous stage, arrived in the vicinity of the walls near of the particle wall that contains them; the coalescence takes place between the droplets and the particle. As a result, the particle is reduced and, finally, the double emulsion is transformed into a primary emulsion (Figure 4).

This very rapid coalescence during a few seconds and further up to an hour enhances a slow process of creaming, which can last more than a month during which the separation of the phases occurs. The process of destruction takes place, also, by the coalescence of the globules. Because the emulsions are polydispersed, they are also destroyed by Ostwald ripening.

Through macroscopic variation, the stability of double reverse emulsions was studied, in function of the concentration of hydrophilic surfactant added (Figure 5.). The phase separation time was measured. The most stable emulsions were found to be those in which the lipophilic surfactants concentration is placed in front of double hydrophilic surfactants; the most unstable emulsions are emulsions that do not contain the hydrophilic surfactant (as expected).

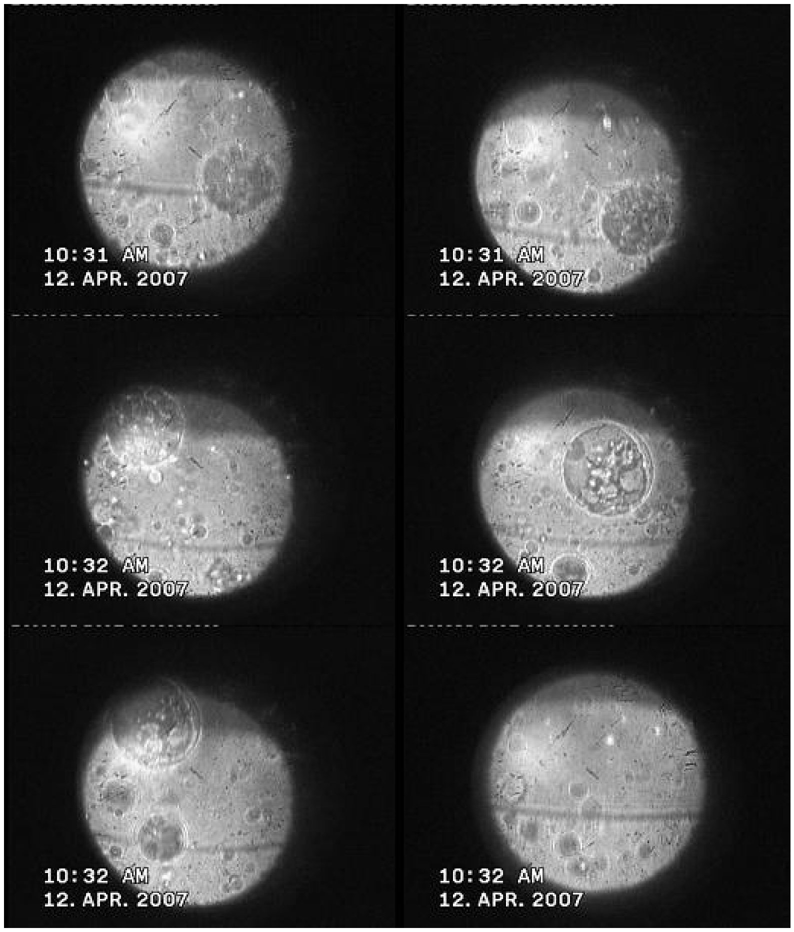

Figure 4. Stages in the evolution of reverse double emulsions

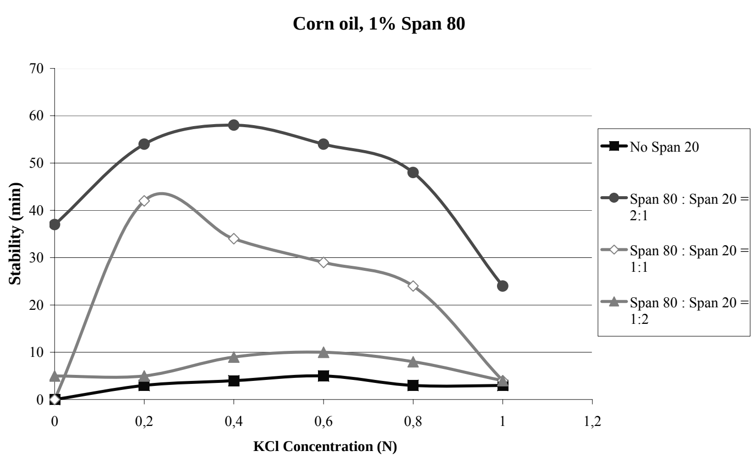

Figure 5. Stability of reverse double emulsions versus the concentrations of KCl, in relation with the ratio between the concentrations of Span 20 and Span 80

Considering the stability depending on the salt concentration we found that it was related to each of the parameters rated as a maximum (Fig. 5.). This is due to the dual structure of the double emulsions: the increase in salt concentration enhancing on the one hand, the stabilization of the reverse emulsion (the overall one); while, on the other hand, increasing the concentration of KCl determines the destabilization of the direct emulsion (the primary one). Depending on the cumulative effect of these two effects presented, the double emulsions are more or less stable. The maximum stability is obtained for a salt concentration of 0.2 N.

4. Conclusions

This work allows some important conclusions obtained on emulsions using oil as an oil phase support, such as sesame oil:

1. The edible oils such as corn oil are complex systems. These systems contain not only fat but also many other plant substances the oil is extracted from or related to the process of oil obtaining. Among these substances, mention must be made of the surfactants that can stabilize, for a short period of time, the emulsions prepared with the respective oil.
2. Despite the use of a single surfactant (lipophilic), we can prepare double emulsions, because the corn oil contains phospholipids, which are hydrophilic surfactants.
3. The emulsions prepared this way are reverse double emulsions.
4. These double emulsions get destroy in few minutes by coalescence. The rapid process of coalescence is followed by a very slow rate process of creaming.
5. Following the complex process of coalescence, the primary reverse emulsions result.
6. The stability of the emulsions increases with the addition of hydrophilic surfactant. The most stable emulsions are those in which the concentration surfactant is Span 80: Span 20 = 2:1. The most unstable emulsions are those which do not contain the Span 20.
7. The stability of the double emulsions depends on the concentration of the saline solution. The stability of the emulsions is minimal for low and high concentrations of KCl, but it has a maximum concentration of 0.2 N.

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