STUDY REGARDING THE MICROENCAPSULATION OF FOOD INGREDIENTS IN ALGINATES

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Abstract
The technological tendencies concentrated on the production of functional food and restructuring active compounds such as anti-oxidants, vitamins, amino acids, minerals and even small molecules, such as cell, enzymes and probiotic microorganisms which are beneficial for the health, and thus the preservation in food during processing and storage. These advantages of recent technological tendencies of alginate fused together in the technique of microencapsulating, resulting in a final product which protects the compounds encapsulated by adversary factors, such as heat and moist, thus improving their stability and their bio-availability. To obtain these capsules are used as encapsulant material alginates, plant gums and other carbohydrates. The aim of this study was to review the alginate microencapsulation techniques for food applications. For preparing calcium alginate microcapsules into food applications, there are techniques such as: extrusion, emulsion and spray drying. The techniques of microencapsulation using alginates allow the protection of various active ingredients, such as proteins, amino acids, vitamins, extracts, flavours, enzymes and microorganisms which come into contact with the environment and thus are subject to degradation and loss of its nutritional properties and health benefits. Alginate is a polymeric material suitable for microencapsulation because the product is easy to handle and use, non-toxic and biocompatible. These aspects were described in the scientific literature underlining the prebiotic effect of alginates and the benefits of the daily contribution in fibres, with the purpose of reducing the level of blood cholesterol and sugar, as well as the capacity to extend the lifetime of products. The paper presents own research concerning the microencapsulation of strawberry juice and sea buckthorn oil in sodium alginate. The characterization of the obtained capsules was performed using electron microscopy (SEM).

Keywords: fruit juice, sea bucthorn oil, electronic microscopy

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1.INTRODUCTION

Alginates are used on a large scale encapsulation of enzymes, cells, bacteria, using ionotropic gelation technique. Systematic studies on the microencapsulation in alginates have begun to develop in the decades 7 and 8 of the twentieth century.
The special interest with respect to the microencapsulation of different substances resulted from the possibility of fabricating microcapsules with desired characteristics and properties and then us aging them in various fields such as medicine, pharmacy, biotechnology, agriculture, textile, paper, etc. (Augustin, 2003; Augustin & Sanguansri, 2006; Benita, 2006).
In the food industry, microencapsulation is a relatively new technology, which has grown bigger in the past 50 years. At first, the microencapsulation sought to cover only small particles of ingredients (acidifiers, sweeteners, flavors, dyes, oils, vitamins, minerals, antioxidants) or whole ingredients (raisins, nuts) with a view to protecting them against physico-chemical and biological aggression factors (Dima et al., 2009; Dulieu et al., 1999; Chandramouli, et al., 2004).
In this context, microencapsulation of ingredients and bioactive substances is a way of obtaining functional foods. Thus, can be encapsulated: polyunsaturated fatty acids ω3, phytosterols, probiotics, prebiotics and synbiotic, vitamins and minerals, peptides, proteins, aminoacids, polyphenols, antioxidants which provide protection against oxidative stress, lecithin, etc. (Pegg & Shahidi, 2007; Runge, 2004, King, 1995).

Recent research revealed the complexity of microencapsulation and focused on studies related to prolonged and controlled release of bioactive substances, as well as in diversifying applications that obtain food systems protected during the passage through the gastrointestinal tract, producing food for special nutrition, functional foods etc. (Vandamme, 2007; Thies, 2004).

Alginate is a hydrocolloid which shows gelling characteristics, stabilizing and thickening, thus presenting great interest for the food industry. The main uses of alginates are based on the following functional properties:

- thickening agent;
- food stabilizer systems, such as: ice cream stabilizer, beer foam stabilizer, emulsion stabilizer, stabilization of juices and natural fruit concentrates, stabilization of dairy products such as sour cream and cream etc .;
- gelling agent;
- forming of films and membranes;
- flocculation - clarification capacity of alginates (Gomeza et al., 2009; Dima et al., 2003, 2007)

Alginates are extracted from brown algae which is approx. 40% of the dry weight thereof. The most important industrial source is the Laminaria japonica species and Macroystis pyrifera. Products are easy to handle and use non-toxic, cheap and biocompatible (Caradin et al., 2003; Olivas et al., 2007, Poncelet et al., 1992, 1995, 2004; Kothimchenko, 2001).

The successful use of microencapsulation of ingredients and bioactive substances in food production requires knowledge of physicochemical and biological properties of both the substances encapsulated and the encapsulant material, or the respectively obtained microcapsules. Increased demand these foods, called functional foods, led on the one hand in testing and using new ingredients, mainly natural, and secondly the development of technologies to ensure adequate quality (Poncelet et al., 2007; Williams, 2006).

The paper presents own research concerning the microencapsulation of strawberry juice and sea buckthorn oil in sodium alginate.

It is known that fruit juices are rich in vitamins. Vitamins are essential components with a high structural diversity.

Most are sensitive to environmental factors during storage and processing. It is therefore recommended the microencapsulation of fruit juices and their use in various food products. Fruits and fruit juices are an excellent source of vitamin C for humans, but ascorbic acid has a very low stability during processing and storage. The known instability of freed ascorbic acid requires establishing stable forms that protect the encapsulated compounds from the path of factors such as heat and humidity, thus improving their stability and bioavailability. The main goal is to build a barrier between particles and medium components. This is a barrier protection against oxygen, water, and light, avoiding contact with other particles or ingredients (Mortazavian et al., 2007).

Microencapsulation in the alginates may be used to condition the oil in the form of water-soluble solid or extending their use in many other applications (Wandrey et al., 2003)

Sea buckthorn oil is a natural product obtained by cold pressing. Buckthorn berries contain natural antioxidants, including ascorbic acid (500 - 1400 mg / kg), tocopherols (1600 mg / kg) and carotenoids (150-430 mg / kg) (Häkkinen et al., 1999). The total content of vitamin E in the oil extracted from the seeds is 100-300 mg / 100g. Vitamin E is found in sea buckthorn fruit pulp and peel 70-80% of total tocopherols and tocotrienols, represented by α-tocopherol. The proportion of β- and γ-tocopherol and γ-tocotrienol is from 4-9%, 2-6% and 2-4%.

Sea buckthorn oil contains a high amount of essential fatty acids: linoleic and alpha-linolenic, which are precursors of other polyunsaturated fatty acids. The oils also contain carotenoids, sterols, free and esterified triterpenoids and isoprenoids (Kallio et al., 2002). The content of carotenoid varies depending on the source of the oil. To protect all these valuable compounds, the microencapsulation of sea buckthorn oil is recommended in alginates.

2. MATERIAL AND METHODS

In order to accomplish the experiments, the following materials were used:
- Matrices for encapsulation: sodium alginate;
- Juices of fruits: strawberries, apples, oranges, pineapple;
- Sea buckthorn oil;
- Calcium chloride.

Encapsulation techniques used.
Depending on the formation type of microspheres by gelling, two techniques of ionotropic gelation are known: external ionotropic gelation and internal ionotropic gelation. The technique selected for use in the encapsulation of ionotropic gelation of fruit juice is the external method.
The formation of alginate beads by external ionotropic gelation comprises: forming droplets of a solution mixed with the sodium alginate when the drop enters the solidification shell in a bath of calcium chloride (Fig.1).

The experimental data relates to the encapsulation of strawberry juice in alginate using as the binder a solution of calcium chloride. In order to obtain microcapsules were mixed 200 mL of strawberry juice with various concentrations of sodium alginate (3.2%, 2.4%, 1.6%). These data are shown in Table 1.
The sodium alginate used for the tests has the following physico-chemical characteristics: pH 6-8; viscosity 100-200 mPa · s (1% aqueous solution); guluronic acid content of 65-70% and mannuronic acid 25-35%. The resulting mixture is aspirated into a 10 mL syringe with needle of 0.8 × 40 mm and dripping through the needle thereof in a glass filled with $CaCl_2$ solution of 0.05 nmol / L. The trickling is made from a height of 10 cm above the liquid level. The microspheres thus obtained are maintained in the hardening solution for a few minutes, after which filtration takes place.
The $CaCl_2$ solution of 0.05 nmol / L contains free calcium ions linking the alginate chains in the particle surface forming the alginate gel.

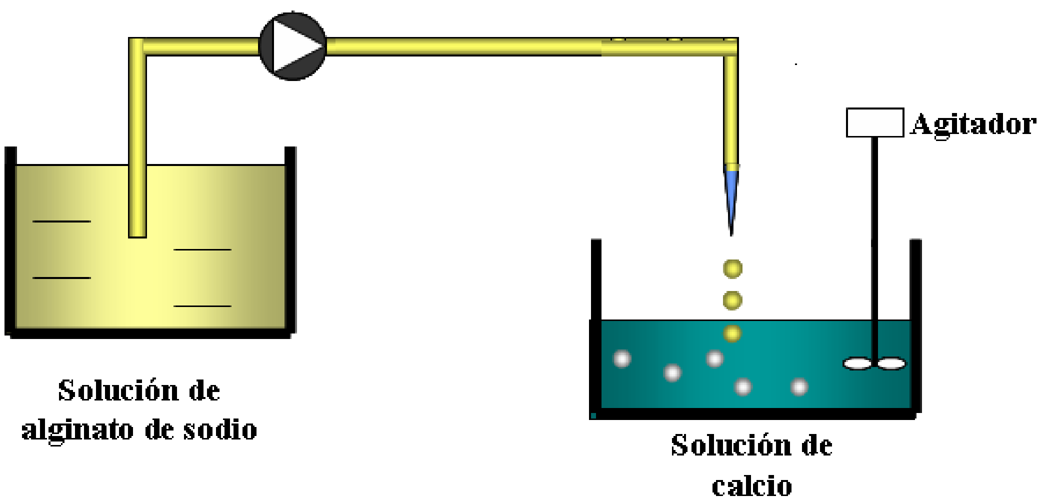

Fig.1. Creating microcapsules (Zuidam & Shimoni, 2010)

Table 1. Experimental data from obtaining strawberry microcapsules in sodium alginate

Sodium alginate (%)	Sodium alginate (g)	Strawberry juice (mL)	$CaCl_2$ (nMol/L)
3.2	3.20	200	0.05
2.4	2.40	200	0.05
1.6	1.60	200	0.05

Fig 2. Strawberry microcapsules in sodium alginate

It is dried in a stream of air at ambient temperature and are collected samples containing gelatin microcapsules, wet spherical in shape, having dimensions of between 3.5-4 mm.

For microencapsulation of sea buckthorn oil was used the method proposed by Dima *et al.* (2001), which is the internal ionotropic gelation, simultaneously with the emulsion process. By this method is obtained microcapsules more resistant to pressure and to a much smaller size distribution.

For encapsulation were used sea buckthorn oil extracted from sea buckthorn fruits collected from Carpathian areas of Moldova.

The experimental data relates to the encapsulation of sea buckthorn oil in alginate and 60°Bx sucrose as a curing agent using a solution of calcium chloride. Is added 1% sodium alginate at pH 7.9.

Fig.3. Sea buckthorn oil microcapsules

The resulting mixture is aspirated into a 10 mL syringe with needle of 0,8✕ 40 mm and dripping through the needle thereof in a glass with $CaCl_2$ solution of 0.05 nmol / L. The trickling is made from a height of 10 cm above the liquid level.

The microspheres thus obtained are maintained in the hardening solution for a few minutes, after which filtration takes place. It is dried in a stream of air at ambient temperature and are collected samples containing gelatin microcapsules, wet, spherical, with a size between 1.5-3.5 mm.

The $CaCl_2$ solution of 0.05 nmol / L contains free calcium ions linking the alginate chains in the particle surface forming the alginate gel.

3. RESULTS AND DISCUSSION

3.1. Microencapsulation of strawberry juice

Following experiments conducted and analysis of products, was achieved an optimal product version, the best encapsulation efficiency was achieved using sodium alginate concentration of 2.4%. (Figure 4).

Fig.4. Strawberry microcapsules with concentration of sodium alginate of 2.4%

Fig.5. Strawberry microcapsules with concentration of sodium alginate of 1.6% and 3.2%

3.2. Microencapsulation of sea buckthorn oil

In the case of sea buckthorn oil, the obtained concoction was subjected to microscopic analysis of SEM micrographs (Figure 6). Microcapsules observed are resistant to pressure and to a much smaller size distribution ranging from 1.5-3.5 mm. By SEM analysis can be visualized texture elements of the capsule wall: pores, cracks, holes, etc. The cells' core is homogeneous and the microcapsules' is heterogeneous, consisting of the matrix, blood or droplets of an O / W emulsion and which gives the appearance of vacuoles microporous seen through electronic microscopy (SEM).

The longer the particle is retained in the calcium chloride solution, the greater proportion of it is gellified, and it can be reached complete gelation.

In order to be deposited, the wet microcapsules are dried in a stream of ambient air for 72 hours at an ambient relative humidity of 36%. After this period, the particles reduce their size 2-4 times and do not retain their spherical shape.

4. CONCLUSIONS

The techniques of microencapsulation using alginates allow for the protection of various active ingredients, such as proteins, amino acids, vitamins, extracts, flavors, enzymes, and microorganisms that come in contact with the environment and thus are subject to degradation and loss of its nutritional properties and health benefits.

Alginate is a polymeric material suitable for microencapsulation because it is a product that is easy to handle and use, non-toxic and biocompatible. Several studies have shown that encapsulated compounds present bioavailability and, therefore, may maintain their functional activity during food processing and storage.

The characterization of the obtained capsules was performed using electron microscopy (SEM). By SEM analysis can be visualized texture elements of the capsule wall: pores, cracks, holes, etc. The cells' core is homogeneous, and the microcapsules' is heterogeneous, consisting of matrix, globules or droplets of an O / W emulsion and vacuoles, which give a microporous appearance seen through electronic microscopy (SEM).

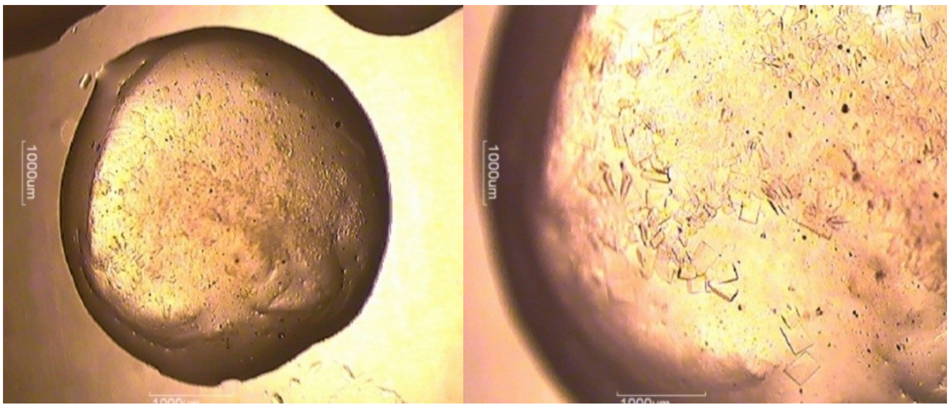

Fig.6. Microscopic image (SEM) of obtained microcapsules

Increasing matrices' concentration or matrices' complex leads to a better encapsulation efficiency. The best encapsulation efficiency was obtained when using alginate matrices in concentration of 2.4% in strawberry juice and 2% in the case of sea buckthorn oil.
In conclusion, microencapsulation remains an area in which researchers and technicians participate together, in a game of imagination and innovation from which are born newer and newer materials with special properties that come to meet the increasingly refined requirements of humanity.

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