International Journal of Innovative Technology and Exploring Engineering (IJITEE)
ISSN: 2278-3075 (Online), Volume-8 Issue-4, February 2019

Design of Equipment for Probiotics Encapsulation

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***Abstract*: This paper describes the construction and operating principle of the probiotics encapsulation equipment. The capsules were obtained by drop-by-drop method with different concentration of alginate (0.5, 1.0 and 1.5%) and gelatin. The viscosity of gelling liquids was measured at different temperatures. The most optimal option is the composition of capsules containing 1% alginate and 1% gelatin, the solution should be used at a temperature of 30-50 ° C. Capsules made from this composition have a rounded shape, equal size, soft texture, stable for physical impact.**

***Index Terms*: encapsulation, probiotic, alginate, capsule, installation**

I. INTRODUCTION

The systematic inclusion in the diet of probiotic products and dietary supplements that contain microorganisms that regulate the processes of intestinal absorption, becomes a very effective tool in the prevention and treatment of nutritional diseases.

In connection with the most intensive absorption of microorganisms in the small intestine, not in the stomach, the question arises of obtaining enteric capsules, and therefore the development of equipment for encapsulation.

The equipment allows obtaining a granular product, which is a homogeneous granulometric composition of the capsule with an elastic gel-like structure.

For the selection of an adapted version of the method of producing microcapsules in the laboratory of the "Standardization and Biotechnology" department of Shakarim State University of Semey, we conducted preliminary experiments, on the basis of which the drip method of encapsulation was chosen [1].

Drip technology consists in the introduction of alginate solution / suspension containing the active ingredient in a bath with a solution of calcium chloride in the form of drops [2].

A 2 ml medical disposable syringe and a 1 ml insulin syringe with modified needles were used as a forming device. When using a disposable syringe, larger capsules were obtained than when using insulin. This is due to the difference in diameter of the needles of the used syringes [3].

Alginate with the addition of gelatin was selected as the gelling composition, and calcium chloride was used as a formative liquid.

Alginate hydrogels are widely used in encapsulating cells [4] and calcium alginate is preferable for encapsulating probiotics because of its ease of use, non-toxicity, biocompatibility and low cost [4, 5].

The properties of alginates were used to form microcapsules using an extrusion process. The extrusion process involves forcing an alginate solution of a certain concentration through a forming aperture (most used in probiotic encapsulation technology — through a needle aperture) into the calcium chloride solution; cations diffuse into the alginate particle and form a gel alginate matrix. This method is called the “diffusion method” or the “external gelation” method [6].

Insitu Gelation, or internalgelation, allows the use of water-insoluble calcium salts, such as $CaCO_3$, that are mixed with an alginate solution. Calcium ions are subsequently released from the alginate phase by lowering the pH of the solution and/or increasing the solubility of the original calcium as a result of the formation of the alginate gel [6].

There are also disadvantages of using alginate in encapsulation technology:

1. The process of scaling is very difficult;
2. Microparticles have a porous structure, which is a disadvantage in the protection of cells;
3. Alginate microcapsules are sensitive to acidic medium.

However, these disadvantages can be compensated by mixing alginates with other polymeric compounds, coating capsules with a film, or applying structural modifications of alginate [7].

II. MATERIALS AND METHODS

Equipment description

On the basis of the conducted preliminary experiments, an experimental setup was developed and manufactured. Principle of the inkjet printer was taken as the basis. The installation for encapsulation was made at the expense of a grant from the Ministry of Education and Science of Republic of Kazakhstan on the topic “Scientific and practical justification for the use of encapsulated synbiotic preparations with immunostimulating activity in the production of dairy products” at the Siberian Research Institute of Cheesemaking in Barnaul (Fig. 1).

Manuscript published on 28 February 2019.
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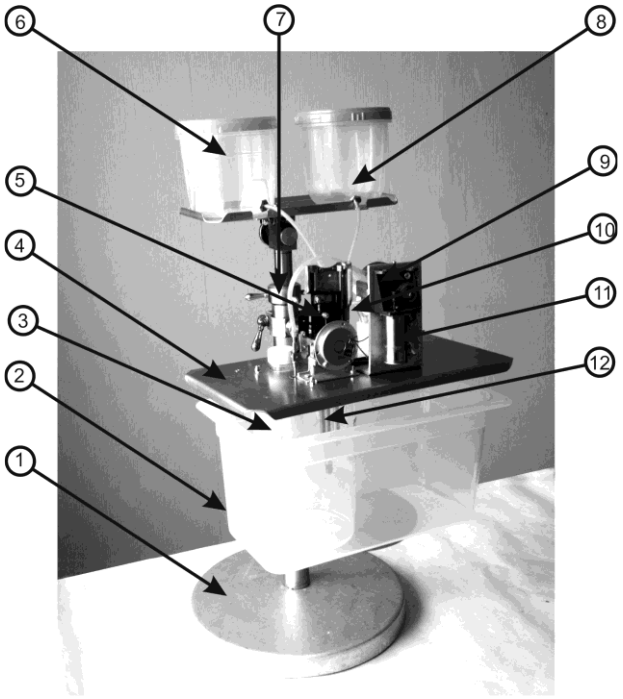

Figure 1: The installation for encapsulation of biologically active supplements

The working unit includes a tripod (1), on which two consoles are mounted with the possibility of movement. The lower console is designed to accommodate the tank (2) for the cooling solution (water with ice). On the second console panel actuators are mounted (4).

In the upper part there is a panel for placing containers with a mixture for encapsulation and a solution for washing the installation system (6 and 8). The panel can be adjusted in height by the adjusting nut (7) (Fig. 1).

On the actuators panel there are: a circulating pump, a peristaltic pump with a rotor position sensor of the peristaltic pump, a vibrator with a system of guides and die mounting. The piping of the circulating pump and a temperature sensor of cooling solution for encapsulation (CaCl2) are also located on the panel in which they are immersed. The immersion level of the tubes is set in accordance with the conditions of the experiment. The liquid level in the working tank is set by the slope of the overflow pipe located in the side of the working tank. Overflow pipe is designed to maintain the level of liquid in the tank in a predetermined position. When filling the tank with capsules, the level of the liquid will increase, while the excess of it will merge into the container with the cooling solution.

Viscosity determination

On the basis of the laboratory of the "Standardization and Biotechnology" pilot experiments were carried out to obtain capsules with measuring the viscosity of the gel-forming liquid.

The viscosity of the gelling fluid was determined with a Brookfield RVT Rotary Viscometer.

For selection of the temperature regime for the production of capsules, the viscosity was measured at various temperatures (30 ° C, 40 ° C, 50 ° C) of the liquid.

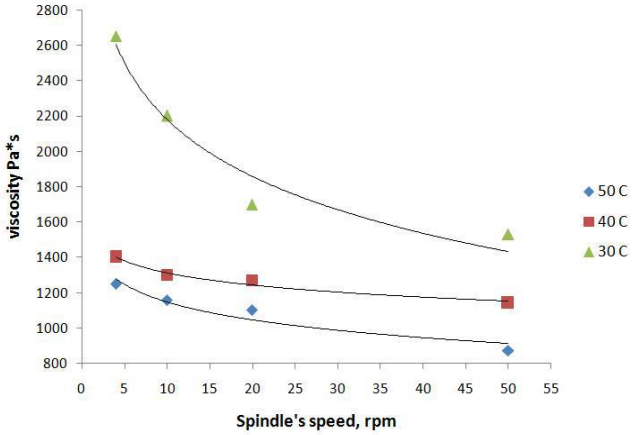

Figure 2: 1.5% alginate containing liquids viscosity depending on spindle's speed of viscometer

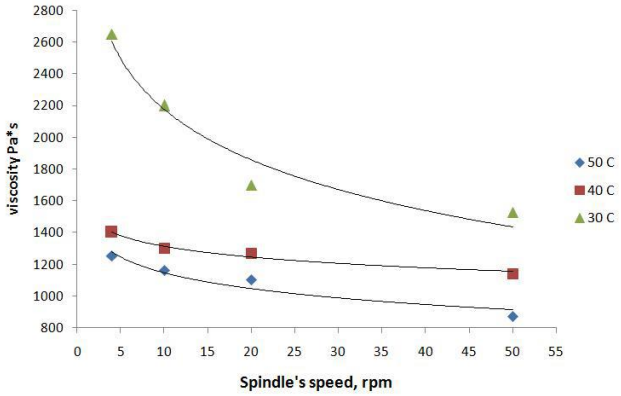

Figure 3: 1.0% alginate containing liquids viscosity depending on spindle's speed of viscometer

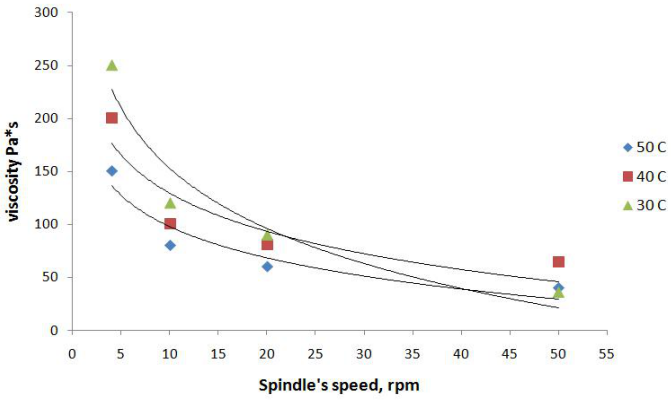

Figure 4: 0.5% alginate containing liquids viscosity depending on spindle's speed of viscometer

III. RESULTS AND DISCUSSION

It can be seen from the graphs that, at a temperature of 50 ° C, the viscosity of the gel-forming liquid is less than at 30 ° C and 40 ° C, the lower viscosity of the gel-forming liquid allows obtaining stable dimensions and correct shape of the capsules. To select the percentage of the composition of the gelling solution, we took 1% gelatin and changed the percentage of alginate to obtain the optimal size and shape of the capsules.

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Capsule images were taken using LOMO optical microscope, against the background of a metal ruler. As a result, in the background of photos millimeter risks from the ruler are visible, which allows determining the approximate size of the capsules.

In the first case, 0.5% alginate and 1% gelatin were taken (Fig.5).

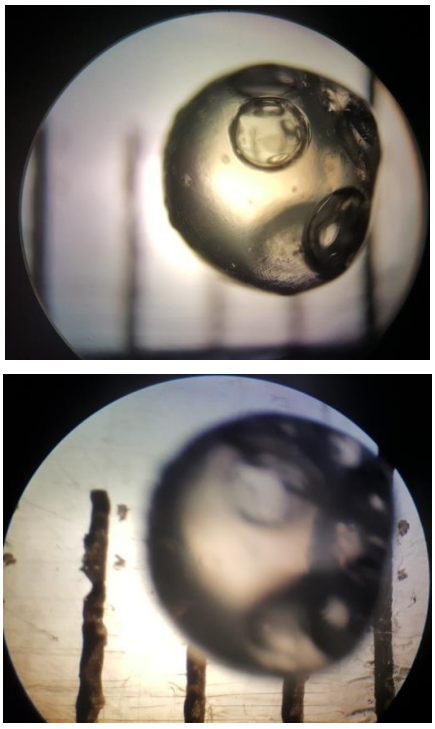

Figure 5: Capsules with 0,5 % alginate

Obtained capsules have an irregular shape and heterogeneous structure, soft texture, easily destroyed by physical exposure. Capsule size is in the range of 1.8 - 2.5 mm.

In the second case, 1% alginate and 1% gelatin were taken (Figure 6).

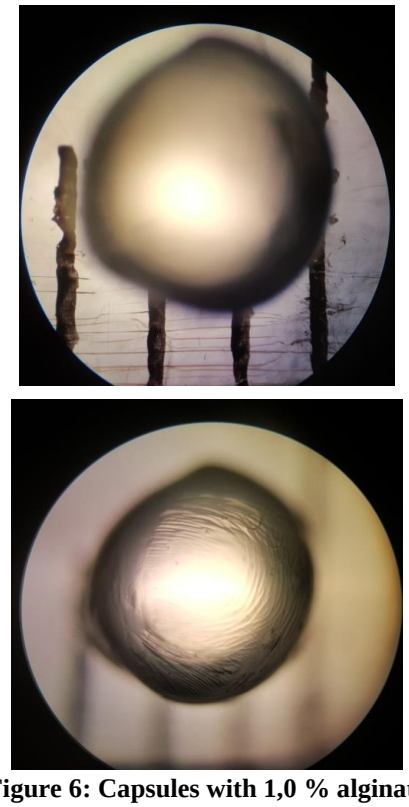

Figure 6: Capsules with 1,0 % alginate

Obtained capsules have a rounded shape and a uniform structure, are resistant to physical effects and have a size of 2.7 - 3 mm.

In the third case, 1.5% alginate and 1% gelatin were taken (Fig. 7).

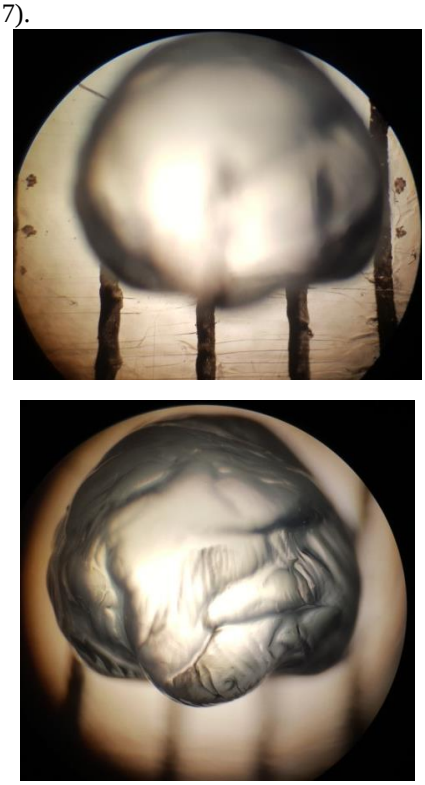

Figure 7: Capsules with 1.5 % alginate

Capsules turned out to be elastic to the touch, with a solid multi-layered shell, have an irregular shape and heterogeneous structure. The size is 3.0-3.4 mm.

IV. CONCLUSION

On the basis of the conducted experiments, we can conclude that the most optimal option is the composition of capsules containing 1% alginate and 1% gelatin, the solution should be used at a temperature of 30-50 °C. Capsules made from this composition have a rounded shape, the same size, soft texture, but stable for physical impact. At the moment, a priority conclusion on invention No. 2018 / 0285.2 dated 04.24.2018 has been received for the construction of installation.

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