The production and use of fruit and berry concentrates in combination with fermented milk products is attractive for many manufacturers because as a result it is possible to obtain unique recipes with a bright and attractive taste for consumers, and high functional properties. However, the use of fruit and berry concentrates in combination with fermented milk products leads to a reduction in the shelf life or absolute spoilage of products. Thus, after the initial analysis of modern technologies, the method of encapsulation of juice concentrates will create unique products – fruit and berry concentrates in the form of soft capsules for a safe combination with yogurt.

The creation of culinary delights of molecular cuisine is already using methods for preparing alginate capsules containing a juice-containing filler. However, there are no regularities for establishing a widespread production of capsules from alginate and a filler from the juice of fruits and berries to this day. In turn, it should be noted that this method makes it possible to obtain a product with high functional properties and pronounced taste.

The results of the research confirmed the successful possibility of mixing plant ingredients with yogurt and ultimately the possibility of obtaining a natural and healthy product with a pronounced and original taste.

The effect of capsules with fruit and vegetable extract on the organoleptic and structurally mechanical properties of yogurt was investigated. Recipes of fruit and berry concentrates were considered. In total, 3 varieties of one-component concentrates (apple, cherry, grape) were selected, which can be encapsulated in the alginate shell in their original form. 3 varieties of concentrates (raspberry, strawberry, currant) were obtained, which can be used as an additional component to the main ones to create a wide range of capsules for different age categories

Keywords: fruit and berry concentrates, yogurt, alginate, encapsulation, structure, adhesion force, strength

UDC 637.146.3

DOI: 10.15587/1729-4061.2023.272212

PRODUCTION OF YOGURT FROM GOAT AND SHEEP MILK WITH A FRUIT AND BERRY CONCENTRATE

Shukhrat Velyamov
PhD, Leading Researcher*

Assan Ospanov
Doctor of Technical Sciences, Professor, Corresponding Member of the National Academy of Sciences of the Republic of Kazakhstan, Head of the Research Group*

Dinara Tlevlessova
Corresponding author
PhD, Associate Professor
Department of Food Technology
Almaty Technological University
Tole bi str., 100, Almaty, Republic of Kazakhstan, 050012
E-mail: tlevlessova@gmail.com

Raushan Makeeva
Process Engineer*

Raushan Tastanova
Junior Researcher*

*Kazakh Research Institute of Processing and Food Industry
Gagarin ave., 238 G, Almaty, Republic of Kazakhstan, 050060

Received date 26.11.2022
Accepted date 03.02.2023
Published date 28.02.2023

***How to Cite**: Velyamov, S., Ospanov, A., Tlevlessova, D., Makeeva, R., Tastanova, R. (2023). Production of yogurt from goat and sheep milk with a fruit and berry concentrate. Eastern-European Journal of Enterprise Technologies, 1 (11 (121)), 23–30. doi: https://doi.org/10.15587/1729-4061.2023.272212*

1. Introduction

Interest in the production of yogurt from mixed milk and the milk of sheep and goats is increasing. Thus, 10 years ago there were only 3 articles in nacometric databases for such keywords as (sheep AND goat AND milk AND yogurt); in 2016, there were 5 papers; and in 2021, there were 7 articles. Papers about sheep's and goat's milk are replete with data on the usefulness of each type of milk. There is a direction for studying the processes in the production of products from the milk of sheep and goats compared to cow's milk [1].

The main raw material for the production of yogurt is cow's milk. Goat and sheep's milk is not a traditional raw material for more of the world's population. Yogurts with vegetable concentrate based on alginate capsules with yogurt from goat and sheep's milk are the original invention. Therefore, research on the development of healthy and live yogurts with the original filler, which is also a symbiotic, is relevant.

The advantage of raw materials is that in comparison with cow's milk, sheep's and goat's milk do not cause allergic reactions when consumed.

Sheep's and goat's milk are becoming increasingly popular as an alternative to cow's milk-based products because of its nutritional value and the less intensive farming methods required to raise these animals [2].

Goat's milk has been considered beneficial for decades because of its easy digestibility and less allergenic properties compared to cow's milk [3]. Sheep's milk is rich in minerals, protein, healthy fats, and is considered a good source of functional bioactive peptides [4]. Distinctive structures of triacylglycerols in sheep's milk fat have better digestibility compared to cow's milk fat and can quickly provide energy to infants or patients suffering from pancreatitis or cystic fibrosis [5].

Conducting research in this area will open up the potential of fermented milk products based on sheep's and goat's milk. Prerequisites for the creation of new original formulations of dairy products for functional purposes and these studies are of the greatest scientific interest. The combination of dairy products and fruit and berry fillers ensures mutual enrichment of ingredients for one or more factors. As a result, it becomes possible to create products of a balanced composition of the target varieties, increase the nutritional and biological value, as well as expand the range of yogurts, giving them functional properties.

2. Literature review and problem statement

A comparison was made with the acid gelling of low-fat cow's milk with the milk of sheep and goats previously brought to a standardized protein content. The microstructure, texture, and rheological properties of yogurts from different types of milk were studied and compared. Yogurt from cow's milk was taken as control, prototypes from sheep's and goat's milk were taken for comparison. The results show that goat yogurt, compared to cow and sheep yogurt, requires a longer fermentation and gelation time. Cooling led to an increase in the modulus of elasticity at different values for cow yogurt, as well as goat and sheep yogurt. Goat yogurt had a smaller particle size and a softer gel, which is associated with a more porous microstructure [2].

In the following work, plant material was added to yogurt in the form of essential oils (orange oil, vanilla oil, lemon). Overall organoleptic evaluations showed that dessert cow yogurts without probiotics (soft and classic starters) were more acceptable than yogurts with probiotics. Dessert yogurts made from goat's milk (classic and sour starters) were the opposite [3]. Yogurts were also enriched with whey proteins. The study used black carrots as a raw material to enrich them. An anthocyanin-rich black carrot concentrate (5 %) was encapsulated by an emulsion method to produce thermally induced whey protein-based microcapsules, for use as an enricher and dye for yogurt at the same time [4].

In work [5], the extract Tragopogon Collins (TPE) was used, which was obtained by ultrasound and encapsulated using the maltodextrin- whey protein system. Further, the encapsulated extract was added to yogurt and the effect on the probiotic properties of yogurt was investigated. Samples with the addition of encapsulated extract had a low pH, less syneresis compared to control, and in addition, in these samples, the viability of probiotic bacteria during storage was higher. Investigation of the effect of polymerized whey protein from goat's milk on the physicochemical properties and microstructure of recombined yogurt from goat's milk. Scanning electron microscopy of recombined goat's milk yogurt with PGWP revealed a compact protein network. The results showed that PGWP made directly from raw milk could be a new protein-based thickener for making real goat's milk yogurt. At the same time, the viability of bacteria remained at 10^6 at 8 weeks of storage under refrigerated conditions [6]. The addition of a mixture of wheat fibers and plantain caused a decrease in pH and an increase in the acidity of yogurts. In accordance with these results, the best effects on improving the quality of yogurts were obtained: reducing syneresis, increasing viscosity, and a good effect on the growth of microorganisms for all samples. In general, the use of fiber and protein with a concentrate can improve quality characteristics and have good potential for use in various foods [7]. Also, pectin-containing extracts were added to yogurts to improve the structure and enrichment with dietary fiber [8].

Lime juice increases the bioavailability of calcium from yogurt snacks made from whey minerals and proteins.

Lime juice was used in yogurt to increase calcium availability. The availability of calcium was checked in the In vitro system (GI TIB simulation). The results showed that whey minerals, a waste product of cheese production, can be used in snacks, improving the bioavailability of calcium when combined with lime juice [9]. Consumption of food for functional purposes based on spirulina does not cause doubts about the usefulness but the specific taste and smell repels the consumer. In order to eliminate this drawback, scientists decided to encapsulate spirulina. Alginate and whey protein were used for encapsulation. With the help of a scanning electron microscope, the morphology of microcapsules and their average particle size of 52 µm were investigated, and the electrostatic interaction between the wall materials was illustrated using infrared spectroscopy with Fourier transform. The complete release of spirulina from microcapsules was observed in the simulated intestinal fluid, which is favorable for the growth of Lactobacillus in the human intestinal tract. The results showed an obvious effect of encapsulation on the physicochemical properties of yogurt-containing breakfasts. Organoleptic evaluation showed that encapsulation in general can increase customer satisfaction. It can be argued that masking the color and taste of microalgae by microencapsulation can be used to enrich dairy products with microalgae [10].

Gelatinized microspheres coated with alginate have been manufactured to encapsulate the probiotic Bifidobacterium Teenis 15703T to improve survival under adverse gastrointestinal conditions. The gelatinous microspheres were crosslinked with non-cytotoxic genipine and coated with an alginate crosslinked with Ca^{2+} from external or internal sources. The alginate coating prevented pepsin-induced degradation of gelatin-induced microspheres in artificial gastric juice (pH 2.0, 2 h), resulting in a significant (P<0.05) greater number of survivors due to the buffering effect of intact microspheres. After sequential incubation in artificial gastric (1 h) and intestinal juices (pH 7.4, 4 h), the number of surviving cells was 7.6 and 7.4 log CFU ml^{-1} for alginate-coated microspheres. Internal and external Ca^{2+} source methods. For cells in uncovered gelatinous microspheres and free cells, 6.7 and 6.4 log CFU ml^{-1}, respectively, were obtained. This study presents a new microencapsulation method that protects probiotic bifidobacteria under adverse environmental conditions [11].

The type of encapsulating material also affects the viability of probiotics during storage, processing, and in the gastrointestinal tract. The effectiveness of any material depends not on its capsule-forming ability, strength, and increased viability but on its cheapness, availability, and biocompatibility. Thus, additional convenience and reduced packaging costs can also be used to offset the cost of encapsulating one or more ingredients. Encapsulated forms of ingredients provide a longer shelf life of the product [12].

There are various techniques of encapsulation of juices or concentrates (hydrophilic fillers) into polymers of natural origin and the drip method, in this case, is the most promising [13]

Work [14] notes the relevance of the drip method for obtaining capsules but this work is associated with the production of gelatin capsules.

In [15], a method for producing particles encapsulated in sodium alginate flavor "feijoa" is proposed. Feijoa sodium encapsulated in alginate has supramolecular properties. Thus, the claimed technique makes it possible to obtain dried microcapsules, which is significantly different from the proposed direction of research, in particular the production of food capsules.

The closest to the proposed encapsulation technique of juice concentrates is the method reported in [16], which offers encapsulation of liquid water-containing products into semi-permeable capsules, but the fundamental difference is the method of capsule formation and the technological mode.

Given the above, the task is to identify the conditions under which the filling of the capsules remains liquid, and to determine the shelf life with stable characteristics of the capsule filling in terms of rheology.

3. The aim and objectives of the study

The purpose of the study is to develop a technology of yogurt from goat and sheep milk with a fruit and berry concentrate. This will make it possible to improve the organoleptic characteristics of yogurts and, with the help of concentrates, provide a symbiotic system for lactic acid bacteria.

To accomplish the aim, the following tasks have been set:

– to substantiate the choice of the main zoned raw materials for the production of concentrates;

– to substantiate the technological mode of production of concentrates and to study the physicochemical parameters of prototypes;

– to investigate the structural-mechanical indicators of alginate capsules;

– to determine the influence of experimental batches of concentrates on the structural, mechanical, and organoleptic properties of yogurt.

4. The study materials and methods

The object of our study is the technology of yogurt from goat and sheep's milk, the subject of the study is encapsulated concentrate. The hypothesis of the study assumes the possibility of producing capsules from fruit and berry raw materials with their impact on the structure and organoleptic evaluation of yogurts. Assumption as capsules were chosen alginate capsules, as they are more pleasant to the taste, burst on the tongue. During the study, organoleptic analyzes were carried out and it was decided not to use gelatin capsules, because they cause unpleasant associations when used together with yogurt.

The most common and affordable varieties of fruits and berries growing in Republic of Kazakhstan were chosen as the main raw materials.

For the normal formation of alginate capsules with a water-containing concentrate, the active acidity of the filler should not be in the range of 4.0–4.5 units, sodium citrate was used to reduce the acidity of concentrates. The concentration of sodium alginate should be no higher than 1 %, and the concentration of calcium salt – 1 %.

For the preparation of concentrates, direct-pressed juices from apples, cherries, grapes, currants were used as recipe components, strawberries and raspberries. Pre-prepared fruit concentrates with a dry matter content in the range of 20–22 % and an active acidity of 4.0–4.5 units were mixed with sodium alginate. Next, to remove excess air from the mixture, they were left in the refrigerator for 1–2 hours until the bubbles were completely removed.

To prepare samples of soft seamless alginate capsules measuring 10 mm, a pipette with the appropriate size was used. Using a pipette, a solution of concentrate with sodium alginate was immersed in drops in a 1 % solution of calcium salt (calcium chloride or calcium lactate).

The active acidity of the filler was determined by the ionometric method using the pH meter PB-10 of Sartorius (Germany), which was calibrated according to the standard pH buffer values.

The method of studying the textural properties of capsules is carried out by analogy with the technique presented in [17–20], the textural properties of capsules (strength, adhesion force) were studied using the CT 3 texture analyzer (Brookfield, USA). The CT3 texture analyzer is designed to measure the load created by the probes when compressing the tested sample, as well as the height of the probe movement when determining physical and mechanical properties, such as strength, adhesion force, etc. The principle of operation of the analyzer is based on the conversion by the sensor of the load applied to the test sample into an analog electrical signal that changes in proportion to this load. The tests are carried out by a single exposure to the test sample by compression. During the test, at each point in time, the force that must be applied for deformation is measured, up to the specified moment of the end of the test. The resulting dependences allow you to evaluate the textural properties of the product. Samples in the form of a sphere with a diameter of 10 mm were used for research.

The textural properties of the capsules were studied on the first day of preparation and after 7 days, due to the maximum shelf life of live yogurt with which it is planned to use capsules in combination.

Statistical processing of the data was carried out using descriptive statistics.

5. Results of studies on the possibility of using alginate capsules with a concentrate in yogurt technology

5. 1. Selection and research of the main zoned raw materials for the production of concentrates

As the main raw materials, the most common and affordable varieties of fruits and berries growing in Republic of Kazakhstan were selected, the results of studies of the selected raw materials are given in Table 1.

Table 1

Physical and chemical indicators of zoned raw materials

No. of entry	Name and brief description	Vitamin "C", mg/%	Total sugar, %	Total titrated acidity, %	Soluble solids, %	The content of nitrates, mg/kg norm – 60.0 mg/kg
1	Cherry "Lyubskaya"	10.03±0.02	9.72±0.08	1.28±0.09	16.5±0.5	35±0.1
2	Grapes "Kibray early"	4.0±0.01	18.2±0.08	0.60±0.02	19.2±0.4	40±0.1
3	"Golden Delicious" Apple	12.8±0.1	12.91±0.05	0.74±0.05	15.2±0.2	37±0.99
4	Black currant "Minay Shmyrev"	124.7±0.09	7.42±0.1	3.26±0.05	12.4±0.5	29±0.1
5	Strawberries "Zenga-Zengana"	20.65±0.12	5.87±0.05	1.07±0.02	8.0±0.2	32±0.1
6	Raspberry "News Kuzmina"	26.45±0.02	6.41±0.06	1.02±0.01	9.50±0.8	38±1

The analysis of the physicochemical parameters of the zoned raw materials indicates the suitability of their use as the main raw material for the manufacture of juice concentrates. For the study, cherries "Lyubskaya", grapes "Kibray early", apples "Golden Delicious", black currant "Minay Shmyrev", strawberries "Zenga-Zengan", raspberries "News Kuzmina" were selected. The zoned raw materials were examined for the content of vitamin C, the content of total sugar, the total content of titratable acids, the content of dry soluble substances, the limit level of nitrites.

5. 2. Technological mode of production of concentrates and study of physicochemical parameters of prototypes

For the manufacture of concentrates from grapes, apples, and cherries, a technique of direct pressing of juice from vegetable raw materials was used; the technological scheme is shown in Fig. 1.

This technique is selected in connection with the possibility of full-fledged squeezing of juice from the specified raw materials with a minimum pulp content.

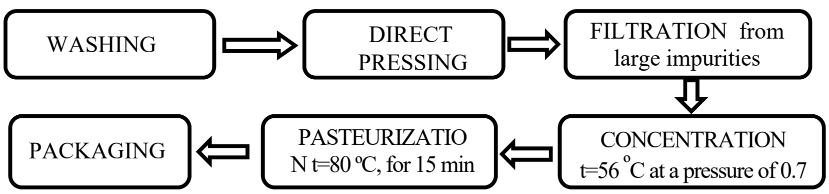

Fig. 1. Technological scheme of preparation of grape, apple, and cherry concentrates

For the manufacture of concentrates from currants, raspberries, and strawberries, due to the laboriousness and high cost of obtaining juice with a minimum pulp content, the homogenization method was adhered to; the technological scheme is shown in Fig. 2.

Homogenization of plant raw materials with the addition of hydro module makes it possible to perform a full extraction of soluble solids and effectively get rid of small stones and impurities. At the output, a thick concentrate with pulp was obtained, which can be used as an additional component to the juices of apples, cherries, and grapes.

According to the above schemes, trial batches of concentrates were produced, with the characteristics given in Table 2.

Thus, 2 techniques of manufacturing concentrates from fruits and berries in accordance with the specificity of raw materials have been worked out.

Table 2

Physicochemical parameters of the resulting concentrates

Concentrate from	Vitamin "C", mg/%	Total sugar, %	Total titrated acidity, %	Soluble solids, %	
				Up to concentration	After concentration
Cherry "Lyubskaya"	13.8	12.96	1.70	16.5	22.0
Grapes "Kibray early"	4.06	26.4	0.82	19.2	25.0
"Golden Delicious" Apple	14.2	20.8	1.17	15.2	24.0
Black currant "Minay Shmyrev"	140.4	14.4	1.40	12.4	24.0
Strawberries "Zenga-Zengana"	24.5	14.8	2.54	8.0	20.0
Raspberry "News Kuzmina"	48.0	14.0	2.12	9.50	20.0

5. 3. The structural mechanical properties of alginate capsules

When examining the textural parameters of alginate capsules (on the CT 3 Brookfield texture analyzer), their strength was judged by the magnitude of the shear stress at the time of destruction of the capsule wall (shell rupture). The applied load generated by the analyzer deforms the tested sample. The value of this load is also measured. Processing of the obtained experimental data is carried out using the specialized software Texture PRO CT [20, 21].

For the experiment, 3 samples of capsules were prepared from various formulations of concentrates, but with the same active acidity, dry matter content (their indicators are summed up to the indicators specified in the research methods). Alginate roe capsules were taken as a control sample as no similar products are sold in the markets. The results of the study of textural indicators (strength and strength of adhesion) of prototypes of alginate capsules with a filler from a concentrate of juices of fruits and vegetables are given in Table 3.

Fig. 3 shows photographs of the obtained capsules from apple concentrate (yellowish color) and capsules from apple-cherry concentrate (red color).

Next, the capsules and yogurt were packed in double cups and sealed with foil. In this form, they were provided for tasting to experts.

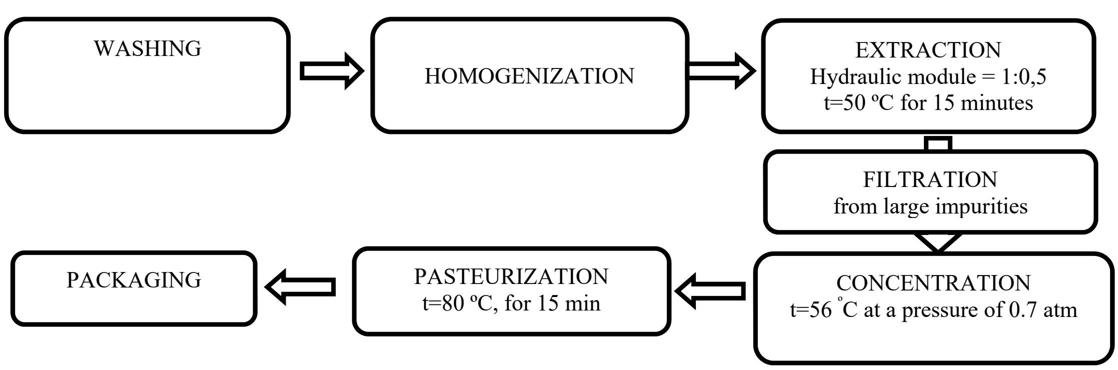

Fig. 2. Technological scheme of preparation of currants, raspberries, strawberries

Table 3

Results of studies of textural indicators (strength and strength of adhesion) of prototypes of alginate capsules with a filler from a concentrate of fruit and vegetable juices

Sample, formulation	Strength, MPa	Adhesion force, N
On the 1st day of preparation of capsules		
Control, alginate roe	0.99±0.01	0.058±0.001
No. 1, 70 % apple juice + 30 % beet juice	0.86±0.01	0.052±0.001
No. 2, 70 % grape juice + 30 % beet juice	0.88±0.01	0.056±0.001
No. 3, 50 % apple juice + 50 % carrot juice	0.87±0.01	0.054±0.001
After 7 days of refrigerated storage		
Control, alginate roe	0.99±0.01	0.058±0.001
No. 1, 70 % apple juice + 30 % beet juice	0.72±0.01	0.034±0.001
No. 2, 70 % grape juice + 30 % beet juice	0.75±0.01	0.036±0.001
No. 3, 50 % apple juice + 50 % carrot juice	0.74±0.01	0.035±0.001

a *b*

Fig. 3. Samples of alginate capsules obtained by drip method: *a* – a sample with apple juice; *b* – a sample of apple-cherry concentrate

5. 4. Investigation of the influence of experimental batches on the structural, mechanical, and organoleptic properties of yogurt

The concept of the project involves packing capsules and yogurt in various containers. In this regard, to determine the basic structural and mechanical properties of yogurt after mixing it with capsules, the method of sensory assessment of the quality and texture of food products according to Bourne was used. Table 4 gives the results of a sensory assessment of the quality and texture of yogurt from OKM mixed with Bourne capsules.

Thus, in the laboratory, the technological mode for the manufacture of alginate capsules by the drip method was worked out. Prototypes have been developed that are stable if they are immersed in a neutral environment of the filler during storage.

6. Discussion of results of the study of alginate capsules with a fruit and berry filler

Functional ingredients that are unstable in a low-pH environment will be massively released in the stomach and inactivated before delivery to the small intestine and absorption, which will reduce the effectiveness of their oral delivery. These disadvantages limit the use of this system for oral delivery. Alginate hydrogel is stable in a low pH environment, it is also an ideal carrier for oral delivery of functional ingredients that are unstable in the environment of gastric juice. Using a combined method of electrospraying followed by pipette administration, millimeter-sized calcium alginate capsules were prepared for encapsulation of probiotics, which improved the survival of encapsulated probiotics against the antibiotic [22].

The betacyanin extract from the peel of Hylocereus polyrhizus has the potential for staining and antioxidant activity, it was encapsulated. A simple method of ionic gelation using an alginate matrix was applied to study the effect of microencapsulation on increasing the stability of labile betacyanins. A study of the release characteristics of the optimal extract of the microencapsulated extract was improved by more than 2 times compared to the unencapsulated betacyanin extract and commercial betanin solution (control). A heat treatment study showed that microencapsulation of betacyanin extract also had a significant effect ($p<0.05$) on improving the half-life ($T_{1/2}$) of the pigment extract compared to the unencapsulated extract and betanin solution [23]. There is also speculation that there may be a problem with bacterial viability and shelf life can be solved by encapsulating the yogurt itself. Along with this, the article also suggests that the problem with bacterial viability and shelf life can be solved by encapsulating the yogurt itself. Along with this, the article contains differences in food standards in different countries of the world that may hinder the production and adoption of yogurt [24].

Consumption of omega-3 fatty acids and phytosterol helps reduce cholesterol levels but such compounds are susceptible to oxidation, which makes them difficult to use. It was decided to encapsulate and add to a widely consumed product – yogurt. Yogurt containing microcapsules had a pH range of 3.89 to 4.17 and a titratable acidity range of 0.798 to 0.826 % with good sensory perception. It was possible to use microcapsules in yogurt without deterioration of rheological properties and physicochemical stability of the product [25].

Table 4

Results of sensory assessment of the quality and texture of yogurt from OKM mixed with Bourne capsules

Parameter	Evaluation
Taste	The combination of the taste of the capsule filler with the neutral taste of yogurt from OKM, reveals when consumed, in particular when biting the capsules and the release of the filler
Smell	When mixed, yogurt acquires the smell of filler ingredients
Color	When mixed, yogurt is dyed in a neutral color of the filler
Texture	Evaluation
Tactile assessment	Yogurt does not change its consistency, but when consumed, there is a feeling of granularity from the capsules, and fibrousness and juiciness of the taste of the filler after biting the capsule
Kinetic evaluation	Separately, the consistency of yogurt and the consistency of jelly-like capsules with filler are felt
Auditory assessment	When consumed, a slight crunch of capsules appears
Visual assessment	The structure changes, the yogurt takes the form of a yogurt filled with capsules. Yogurt is not spoiled due to the neutral environment of the capsules

In addition, using a combined method of uniaxial dispersion electrospray and ion-tropic gelation, multinucleated capsules of calcium alginate filled with millimeter-sized fish oil were also produced, with controlled shapes and sizes, using the method of uniaxial dispersion electrospraying and external gelation [26]. In these works, a gel system is formed inside the capsule nucleus, which is not yet homogeneous inside. The task of the study was to create capsules with liquid filling for 7 days. The shelf life of yogurt from goat or sheep's milk is 10–14 days, capsules made using this technology after 7 days inside are gelatinized. On the 10^{th} day, a gel is formed inside, on the 14th day, a gelled composition is formed inside the capsules. Thus, the shelf life of yogurt with capsules is justified by 7 days. The data obtained in this study are reproducible, in the future it is planned to investigate the strength of the capsule shell and the production of hydrophilic capsules with a longer period.

Table 1 indicates the physicochemical parameters of the zoned raw materials; this is necessary to determine the possibility of using as fillers for alginate capsules. In connection with the purpose of obtaining capsules with liquid filling, the technology illustrated in Fig. 1, 2 was developed. Table 2 gives the physicochemical indicators of the results obtained. Gentle methods of manufacturing concentrates made it possible to preserve the content of especially unstable vitamin C as much as possible and to obtain technologically suitable for encapsulation raw materials with an excellent presentation of bright taste and aroma. The results of studies of textural indicators (strength and strength of adhesion) of prototypes of alginate capsules with a filler from a concentrate of juices of fruits and vegetables are given in Table 3, compared with control. Alginate roe was taken as control. According to the results of sensory assessment of the quality and texture of yogurt from OKM mixed with capsules according to Bourne Table 4, it can be concluded that mixing the homogeneous structure of yogurt with capsules has a positive effect on the taste range, the product acquires a new look and taste, while not losing its quality.

The contents of the capsules, in particular the formulation of juice concentrates, do not affect the strength of the capsules in any way if the active acidity and dry matter content are observed normally.

With a period of 7 days of storage of capsules, there is a slight weakening of the strength of the capsules but these circumstances do not cause a significant decrease in their quality.

The results obtained in the capsule study are limited by the experimental plan.

The direction of development of the study is to work out the modes of encapsulation and identify conditions under which the filling will remain liquid inside the capsule for a longer time. Yogurt from sheep's and goat's milk is stored for more than 10 days, the purpose of further research is to prolong the timing of the hydrophilic filling of capsules to at least 10 days. The results of the study of the technological mode of encapsulation of the filler from fruit-berry concentrates into the alginate shell obtained in the laboratory are necessary for the further formulation of a full-factor experiment for the production of capsules in a capsulator used in production.

7. Conclusions

1. The zoned raw materials were examined for the content of vitamin C, the content of total sugar, the total content of titratable acids, the content of dry soluble substances, the limit level of nitrites. The results of the analysis of the physicochemical parameters of the zoned raw materials allow us to assert the suitability of their use as the main raw material for the manufacture of juice concentrates.

2. Due to the specificity of plant raw materials, 2 prop duction techniques of juice concentrates have been worked out. For raw materials with a high moisture content and a dense fiber structure (apples, grapes, cherries), a technological mode for the manufacture of concentrates based on direct pressing of juices has been determined, and for raw materials with a loose fiber structure and a lower moisture content (currants, strawberries, raspberries), a method for producing concentrates based on homogenization of plant raw materials and water extraction has been worked out.

As a result of laboratory production of concentrates manufactured according to the described techniques, 3 varieties of one-component concentrates (apple, cherry, grape) were obtained, which can be encapsulated in the alginate shell in their original form. 3 varieties of concentrates (raspberry, strawberry, currant) were obtained, which will be used as an additional component to the main ones to create a wide range of capsules for different age categories.

3. The structural and mechanical properties of alginate capsules with fruit and berry concentrate are close to control but the control sample is stronger due to the oil filling. For comparison, the strength of fish roe is 37 kPa, and the strength of the powdered alginate shell of the capsules was 33.9 kPa. Another problem is the gelling of the filling. The study showed that on the 7^{th} day the strength does not change, therefore, the filling remains liquid.

4. The addition of alginate capsules to live yogurt affects the organoleptic parameters of yogurt but does not affect the change in structural and mechanical parameters. The taste and aftertaste improve, the color does not change, the consistency of yogurt remains unchanged. The disadvantage is the shelf life of yogurt due to the introduction of alginate capsules. The shelf life of yogurt is up to 28 days without loss of quality under refrigerated conditions, the shelf life of capsules with a hydrophilic shell is 7 days, then the filling is gelatinized.

Conflicts of interest

The authors declare that they have no conflicts of interest in relation to the current study, including financial, personal, authorship, or any other, that could affect the study and the results reported in this paper.

Funding

Grant financing of the Ministry of Education and Science of the Republic of Kazakhstan No. AR 08855775 "Development of live yogurt technology based on milk of small cattle with encapsulated fruit and berry concentrate".

Data availability

The data will be provided upon reasonable request.

References

1. Akbulut Çakır, Ç., Teker, E. (2021). A comparison of the acid gelation properties of nonfat cow, sheep, and goat milk with standardized protein contents. Journal of Food Processing and Preservation, 46 (6). doi: https://doi.org/10.1111/jfpp.16014
2. Boukria, O., El Hadrami, E. M., Sameen, A., Sahar, A., Khan, S., Safarov, J. et al. (2020). Biochemical, Physicochemical and Sensory Properties of Yoghurts Made from Mixing Milks of Different Mammalian Species. Foods, 9 (11), 1722. doi: https://doi.org/10.3390/foods9111722
3. Clark, S., Mora García, M. B. (2017). A 100-Year Review: Advances in goat milk research. Journal of Dairy Science, 100 (12), 10026–10044. doi: https://doi.org/10.3168/jds.2017-13287
4. Mohapatra, A., Shinde, A. K., Singh, R. (2019). Sheep milk: A pertinent functional food. Small Ruminant Research, 181, 6–11. doi: https://doi.org/10.1016/j.smallrumres.2019.10.002
5. Teng, F., Reis, M. G., Broadhurst, M., Lagutin, K., Samuelsson, L., Ma, Y. et al. (2020). Factors affecting levels of volatile 4-alkyl branched-chain fatty acids in sheep milk from 2 contrasting farming systems in New Zealand. Journal of Dairy Science, 103 (3), 2419–2433. doi: https://doi.org/10.3168/jds.2019-17192
6. Nguyen, H. T. H., Afsar, S., Day, L. (2018). Differences in the microstructure and rheological properties of low-fat yoghurts from goat, sheep and cow milk. Food Research International, 108, 423–429. doi: https://doi.org/10.1016/j.foodres.2018.03.040
7. Papaioannou, G. M., Kosma, I. S., Dimitreli, G., Badeka, A. V., Kontominas, M. G. (2022). Effect of starter culture, probiotics, and flavor additives on physico-chemical, rheological, and sensory properties of cow and goat dessert yogurts. European Food Research and Technology, 248 (4), 1191–1202. doi: https://doi.org/10.1007/s00217-021-03955-z
8. Ersus Bilek, S., Yılmaz, F. M., Özkan, G. (2017). The effects of industrial production on black carrot concentrate quality and encapsulation of anthocyanins in whey protein hydrogels. Food and Bioproducts Processing, 102, 72–80. doi: https://doi.org/10.1016/j.fbp.2016.12.001
9. Maleki, M., Ariaii, P., Sharifi Soltani, M. (2021). Fortifying of probiotic yogurt with free and microencapsulated extract of Tragopogon Collinus and its effect on the viability of Lactobacillus casei and Lactobacillus plantarum. Food Science & Nutrition, 9 (7), 3436–3448. doi: https://doi.org/10.1002/fsn3.2250
10. Tian, M., Cheng, J., Wang, H., Xie, Q., Wei, Q., Guo, M. (2022). Effects of polymerized goat milk whey protein on physicochemical properties and microstructure of recombined goat milk yogurt. Journal of Dairy Science, 105 (6), 4903–4914. doi: https://doi.org/10.3168/jds.2021-21581
11. Javidi, Y., Goli, M. (2021). Investigation of physico-chemical and microbial properties of low fat yogurt enriched with whey protein concentration, milk protein concentration, and wheat-psyllium fiber. Food Science and Technology, 18 (112), 247–260. doi: https://doi.org/10.52547/fsct.18.112.247
12. Nabiyeva, Z., Zhexenbay, N., Iskakova, G., Kizatova, M., Akhmetsadykova, S. (2021). Devising technology for dairy products involvinglow-esterified pectin products. Eastern-European Journal of Enterprise Technologies, 3 (11 (111)), 17–27. doi: https://doi.org/10.15587/1729-4061.2021.233821
13. Wang, J., Aalaei, K., Skibsted, L. H., Ahrné, L. M. (2020). Lime Juice Enhances Calcium Bioaccessibility from Yogurt Snacks Formulated with Whey Minerals and Proteins. Foods, 9 (12), 1873. doi: https://doi.org/10.3390/foods9121873
14. Nourmohammadi, N., Soleimanian-Zad, S., Shekarchizadeh, H. (2020). Effect of Spirulina (Arthrospira platensis) microencapsulated in alginate and whey protein concentrate addition on physicochemical and organoleptic properties of functional stirred yogurt. Journal of the Science of Food and Agriculture, 100 (14), 5260–5268. doi: https://doi.org/10.1002/jsfa.10576
15. Annan, N. T., Borza, A. D., Hansen, L. T. (2008). Encapsulation in alginate-coated gelatin microspheres improves survival of the probiotic Bifidobacterium adolescentis 15703T during exposure to simulated gastro-intestinal conditions. Food Research International, 41 (2), 184–193. doi: https://doi.org/10.1016/j.foodres.2007.11.001
16. Riaz, Q. U. A., Masud, T. (2013). Recent Trends and Applications of Encapsulating Materials for Probiotic Stability. Critical Reviews in Food Science and Nutrition, 53 (3), 231–244. doi: https://doi.org/10.1080/10408398.2010.524953
17. Derkach, S. R., Voron'ko, N. G. (2000). Pat. No. 2223014 RU. Modificirovannaya zhelatinovaya osnova dlya kasulirovaniya mnogokomponentnyh pishchevyh dobavok na osnove rybnyh zhirov.
18. Zaval'niy, M. A. (2002). Pat. No. 2179845 RU. Sposob inkapsulirovaniya zhidkih vodosoderzhashchih produktov v polupronicaemye kapsuly.
19. Krolevec, A. A. Pat. No. 2567341 RU. Sposob polucheniya chastic inkapsulirovannogo v al'ginate natriya aromatizatora «feyhoa», obladayushchego supramolekulyarnymi svoystvami.
20. Ivanova, N. A. (2013). Razrabotka tekhnologii proizvodstva myagkih zhelatinovyh kapsul s gidrofil'nymi napolnitelyami rotacionno-matrichnym metodom. Perm', 26.
21. All about hard gelatine capsules. Firm «Capsugel» (1994). Basel: Switzerland, 47.
22. Bueno, A. G., Nozal, R. R. (2010). Innovation vs. tradition: the election of an european way toward pharmaceutical industrialisation, 19th-20lh centuries. An. R. Acad. Nac. Farm., 76 (4), 459–478. Available at: https://www.academia.edu/41005445/Innovation_vs_tradition_the_election_of_an_european_way_toward_pharmaceutical_industrialisation_19_th_20_th_centuries
23. Chiwele, I., Jones, B. E., Podczeck, F. (2000). The Shell Dissolution of Various Empty Hard Capsules. Chemical and Pharmaceutical Bulletin, 48 (7), 951–956. doi: https://doi.org/10.1248/cpb.48.951

24. Nepovinnykh, N., Petrova, O., Belova, N., Yeganehzad, S. (2019). Physico-Chemical and Texture Properties of Gelatin-Free Jelly Desserts. Food Processing: Techniques and Technology, 49 (1), 43–49. doi: https://doi.org/10.21603/2074-9414-2019-1-43-49
25. Muratova, E. I., Smolihina, P. M. (2013). Reologiya konditerskih mass. Tambov: FGBOU VPO «TGTU», 188.
26. Li, Y., Liang, M., Dou, X., Feng, C., Pang, J., Cheng, X. et al. (2019). Development of alginate hydrogel/gum Arabic/gelatin based composite capsules and their application as oral delivery carriers for antioxidant. International Journal of Biological Macromolecules, 132, 1090–1097. doi: https://doi.org/10.1016/j.ijbiomac.2019.03.103
27. Fathordoobady, F., Jarzębski, M., Pratap-Singh, A., Guo, Y., Abd-Manap, Y. (2021). Encapsulation of betacyanins from the peel of red dragon fruit (Hylocereus polyrhizus L.) in alginate microbeads. Food Hydrocolloids, 113, 106535. doi: https://doi.org/10.1016/j.foodhyd.2020.106535
28. Chan, Y. L., Jamalullail, N. A., Tan, C. P., Abdul Manap, M. Y., Lai, O. M. (2019). Development of bio-yoghurt chewable tablet: a review. Nutrition & Food Science, 50 (3), 539–553. doi: https://doi.org/10.1108/nfs-07-2019-0202
29. Comunian, T. A., Chaves, I. E., Thomazini, M., Moraes, I. C. F., Ferro-Furtado, R., de Castro, I. A., Favaro-Trindade, C. S. (2017). Development of functional yogurt containing free and encapsulated echium oil, phytosterol and sinapic acid. Food Chemistry, 237, 948–956. doi: https://doi.org/10.1016/j.foodchem.2017.06.071
30. Tao, L., Xu, J., Chen, J., Liu, L., Zhang, T., Tao, N. et al. (2022). Preparation and characterization of internal gelation-based electrosprayed multicore millimeter-sized fish oil-loaded calcium alginate-stabilized capsules. Food Hydrocolloids, 128, 107599. doi: https://doi.org/10.1016/j.foodhyd.2022.107599