УДК 636.934

Научная статья

Открытый доступ

DOI: 10.32634/0869-8155-2022-365-12-149-153

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Поступила в редакцию:
24.06.2022

Одобрена после рецензирования:
25.10.2022

Принята к публикации:
21.11.2022

Разработка технологии кисломолочных продуктов для детского питания

РЕЗЮМЕ

Восполнение макро- и микроэлементов при их дефиците у детей является ведущей задачей современной диетологии и основополагающим фактором здорового развития детей. Решить эту задачу может разработка новых видов продуктов питания. В данной статье представлена разработка технологии производства кисломолочного продукта для детского питания. Экспериментально исследован вариант введения водоросли спирулины в кисломолочный продукт. На основании физико-химических, реологических и органолептических показателей установлено, что введение 2% спирулины позволяет получить продукт с приемлемыми физико-химическими и реологическими характеристиками. Органолептический профиль корректировали добавлением фруктового наполнителя в объеме 20% от массы сырья. Проведенные исследования позволили разработать кисломолочный продукт для детского питания, позволяющий удовлетворить 10–16% суточной потребности в пищевых элементах, обладающий высокими потребительскими характеристиками.

Ключевые слова: кисломолочный продукт, микро- и макроэлементы, *Spirulina platensis*, сбалансированное питание, органолептические исследования

Для цитирования: Воробьев Д.И. и др. Разработка технологии кисломолочных продуктов для детского питания. *Аграрная наука*. 2022; 365 (12): 149–153. https://doi.org/10.32634/0869-8155-2022-365-12-149-153 (In English).

Research article

Open access

DOI: 10.32634/0869-8155-2022-365-12-149-153

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Received by the editorial office:
24.06.2022

Accepted in revised:
25.10.2022

Accepted for publication:
21.11.2022

Development of technology for the fermented milk products for child nutrition

ABSTRACT

Replenishment of macro- and micronutrients in case of their deficiency in the children is the leading task of modern dietetics and a fundamental factor in the children's healthy development. The development of new types of food products can solve this task. This article presents the development of technology for production of fermented milk product for children nutrition. The option of introducing spirulina algae into a fermented milk product was experimentally investigated. On the basis of physical and chemical, rheological and organoleptic characteristics it was defined that the introduction of 2% of spirulina allows obtaining a product with acceptable physical, chemical and rheological characteristics. The organoleptic profile was corrected by adding fruit filler in volume of 20% from the raw material mass. The conducted research made it possible to develop a fermented milk product for child nutrition, which can satisfy 10–16% of the daily demand for nutritional elements, and which features high consumer-oriented characteristics.

Key words: fermented milk product, micro- and macroelements, *Spirulina platensis*, balanced nutrition, organoleptic studies

For citation: Vorobyev D.I. et al. Development of technology for the fermented milk products for child nutrition. *Agrarian science.* 2022; 365 (12): 149–153. https://doi.org/10.32634/0869-8155-2022-365-12-149-153

Введение / Introduction

In recent decades, among the population of various countries, including Russia, WHO has recorded a nutritional deficiency in the children's diet, which leads to metabolic disorders, delayed mental and physical development, and also increases the chance of various diseases onset [1–5].

Food must satisfy the demand of a child's body not only for nutrients, not only be balanced in proteins, fats, carbohydrates, but it must also contain the recommended amount of macronutrients and micronutrients, essential amino acids, vitamins, essential fatty acids, dietary fiber and other functional components.

The current living conditions of mankind do require the daily diet to not only consist of traditional food products, but also to include functional products, assigned to satisfy the nutritional demands of various population groups, depending on the risks of diseases and on features of population groups that suffer from deficiency of one or more micro- and macronutrients [6–10].

These are prophylactic dietary food products that additionally contain functional food ingredients and essential nutrients [11–15].

Материал и методы исследования / Materials and method

The object of the research in this work was the blue-green alga Spirulina platensis.

The subjects of the research were:

- milk used to produce fortified fermented milk product for children nutrition;
- fermented milk products produced with starter cultures and spirulina added;
- fermented milk products produced with starter cultures, spirulina and fruit filler added.

During the research the physical and chemical, microbiological and organoleptic methods of tests were used.

To obtain a fermented milk product, pasteurized milk was used with fat content of 3.2%. The milk was preheated to a temperature of 43°C, the ferment was added in amount of 5% from the volume of fermented milk; and dry spirulina algae was thoroughly admixed in volume of 1%, 2% and 5% of the fermented milk. Samples of the fermented milk product were obtained by the thermostatic method, by their fermentation at a temperature of 42±1°C.

In laboratory conditions the following samples of a fermented milk product for children nutrition were developed:

- Sample C is a fermented milk product obtained with lactic acid bacteria (control smaple). For this, liquid starter culture of pure cultures in volume of 5% from fermented milk was added to 100 cm^3 of pasteurized milk with temperature of 43°C. The starter – 3 cm^3 of *Streptococcus salivarius thermophilus* strain and 2 cm^3 of *Lactobacillus delbrueckii subsp. bulgaricus* strain.
- Sample No. 1 is a fermented milk product obtained with lactic acid bacteria and spirulina, added in volume of 1% (experiment No. 1). For this, 5% of starter culture (3 cm^3 of *Streptococcus salivarius thermophilus* strain and 2 cm^3 of *Lactobacillus delbrueckii subsp. bulgaricus* strain) and 1% of spirulina (1 g) were added to 100 cm^3 of pasteurized milk heated to a temperature of 43°C.
- Sample No. 2 is a fermented milk product obtained with lactic acid bacteria and spirulina, added in volume of 2% (experiment No. 2). For this, 5% of starter culture (3 cm^3 of *Streptococcus salivarius thermophilus* strain and 2 cm^3 of *Lactobacillus delbrueckii subsp. bulgaricus* strain) and 2% of spirulina (2 g) were added to 100 cm^3 of pasteurized milk heated to a temperature of 43°C.
- Sample No. 3 is a fermented milk product obtained with lactic acid bacteria and spirulina, added in volume of 5% (experiment No. 3). For this, 5% of starter culture (3 cm^3 of *Streptococcus salivarius thermophilus* strain and 2 cm^3 of *Lactobacillus delbrueckii subsp. bulgaricus* strain) and 5% of spirulina (5 g) were added to 100 cm^3 of pasteurized milk heated to a temperature of 43°C.

Результаты и обсуждение / Results and discussion

At the initial stage it was found that the starter culture, which consisted of *Streptococcus salivarius thermophilus* and *Lactobacillus delbrueckii subsp. bulgaricus* with addition of 1%, 2% and 5% spirulina formed a curd in the milk in 5 hours, while the control sample (without spirulina) got fermented in 6 hours.

The titratable acidity in the samples 1–3 after 5 hours was (74–80)°T. In the control samples (in triplicate) at the end of fermentation the titratable acidity was (72–75)°T.

Fermented samples of fermented milk products were cooled down to a temperature of 4±2°C.

The obtained samples of fermented milk products after cooling were tested by the following parameters: physical and chemical, rheological and organoleptic parameters. The results are presented below in table 1. The results of tests for titratable acidity are presented below in table 2.

The samples of the ready fermented milk product with spirulina formed a uniform dense curd within 5 hours. The control samples formed the curd within 6 hours. The samples No. 1, 2, 3 of fermented milk product have higher values of titratable acidity than in the control samples due to adding of spirulina in various amounts. In samples with spirulina the titratable acidity values are increased proportionally to the added amount of spirulina in the ready product.

Table 1. **Physical and chemical indicators of samples of fermented milk product with spirulina for children nutrition**

Parameter	Characteristics of parameters				Norm
	control	sample No. 1	sample No. 2	sample No. 3	
Mass fraction of fat, %	3,2±0,1	3,2±0,1	3,2±0,1	3,4±0,1	From 1,4 till 4,0
Mass fraction of protein, %	3,0±0,1	3,5±0,1	4,1±0,1	5,0±0,1	2,0–5,0
Mass fraction of carbohydrates, %	4,7±0,1	4,8±0,1	5,0±0,1	5,6±0,1	Not more than 16
Mass fraction of SNF, %	10,0±0,1	10,0±0,1	10,0±0,1	10,5±0,1	Not more than 7,8
Phosphatase	Absent	Absent	Absent	Absent	Not allowed

The moisture-holding capacity of the curd formed by lactic acid bacteria was determined by the centrifugation method. The results are shown in figure 1 below.

As it can be seen from the diagram, the samples with spirulina (No. 1 and 2) have a similar moisture-holding capacity with control sample. The sample No. 3 has less dense curd structure.

The organoleptic indices of the samples of a fermented milk product of a functional orientation with spirulina were evaluated in 5-point rating scale. The results are shown in figure 2 below. Sensory profiles were drawn up to compare samples of fermented milk product, obtained with liquid starter culture and spirulina added in various quantities.

According to the results of the taste evaluation of fermented milk product samples with added spirulina, it was defined that spirulina changed the taste and smell of the products. However, the addition of 1% spirulina did not change the smell, it remained the same. This fermented milk product also retained the taste of pure fermented milk, but at the same time the aftertaste of this component appeared.

When 2% of spirulina was added, the texture was still the same as in the control sample, but the increased ratio of spirulina to fermented milk influenced the taste and smell of the product. A slight taste of "algae" appeared in the sample No. 2. The sample No. 3 turned to be unfit for consumption because of strong taste and smell of algae. When evaluating the appearance of the obtained product, it was found that the control samples and samples No. 1 and 2 had a dense curd and were scored the maximum number of points – 5. The sample No. 3 had a less dense curd and scored less points – 4 in the 5-score rating system.

The control sample had a pure fermented milk taste and smell, without any foreign aftertastes.

During the sensory analysis, sample No. 1 with 1% of spirulina showed the best result in all aspects, but this experimental sample had only 8% of the physiological demand for iron in children from 3 to 7 years old. That does not meet the requirements for fortified foods. The sample No. 2 had a more expressed taste and aroma of algae in comparison with the sample No. 1.

The obtained samples of a fermented milk product with spirulina, developed for baby food, have a specific taste and aroma, that is not appropriate for traditional food products, including food for children nutrition.

To impart flavor (taste and smell), to improve the consumers' perception of the functional product, it was proposed to add a fruit filler "Green apple – lemon balm" (sugar, water, concentrated juices (apple, lemon), thickener – pectins, natural flavoring "Green apple", natural extract of lemon balm).

The fruit filler was added in volume of 10, 15 and 20% of the fermented milk:

– Sample No. 1 – 10% of fruit filler;
– Sample No. 2 – 15% of fruit filler;
– Sample No. 3 – 20% of fruit filler.

The prepared samples were placed into thermostatic chamber at temperature of 42±1°C. The fermentation was controlled by titratable acidity of the fermented base. The titratable acidity in the formed milk after 5 hours was (73–76)°T. Fermented samples of fermented milk products were cooled down to the temperature of 4±2°C.

The produced samples of fermented milk products after cooling were tested by following parameters: physical, chemical

Table 2. **Titratable acidity in the samples of fermented milk probiotic personalized food product**

Sample	Titratable acidity, °T		
	fresh milk	fermented milk, 5–6 hours	finished product
Control sample	17±1	72±1	85±1
	16±1	73±1	86±1
	17±1	75±1	84±1
Sample No. 1	17±1	75±1	87±1
	17±1	74±1	86±1
	16±1	74±1	86±1
Sample No. 2	16±1	74±1	87±1
	17±1	75±1	88±1
	17±1	76±1	86±1
Sample No. 3	17±1	79±1	89±1
	16±1	78±1	90±1
	16±1	80±1	91±1

Fig. 1. Moisture-holding capacity of the test samples of fermented milk products with spirulina for baby food

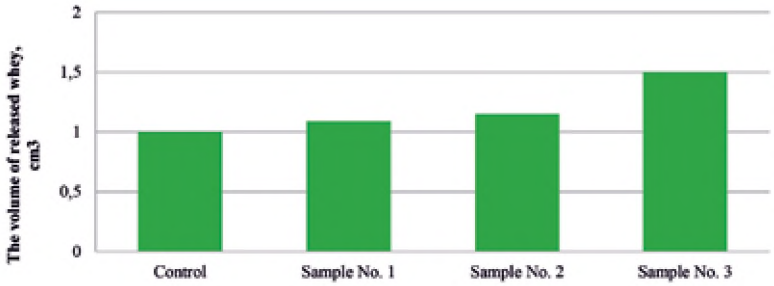
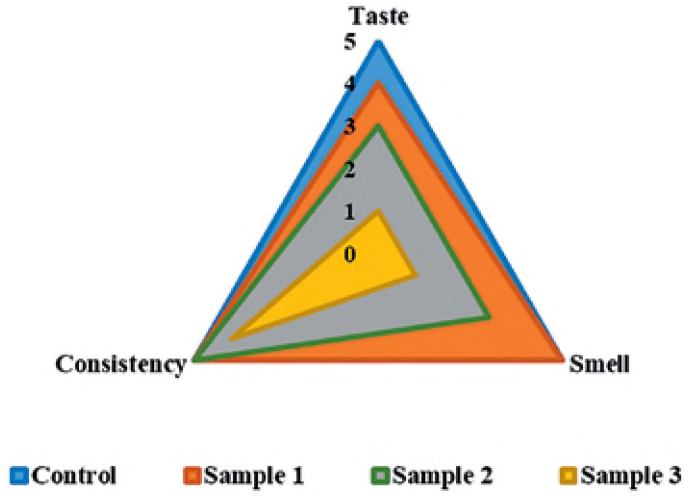


Fig. 2. Organoleptic profile of samples of fermented milk product with added spirulina



and organoleptic, the results are presented in table 3.

The results of titratable acidity tests are presented in the table 4.

The organoleptic parameters of the samples of the fermented milk functional product were evaluated in a 5-point rating scale. The results of evaluation are shown in figure 3.

The organoleptic analysis of the obtained data showed that sample No. 1 with 10% of fruit filler got the smallest score in terms of "taste" and "smell". The sample with 10% of fruit filler featured the taste of algae; that proved insufficient quantity of the fruit filler. In sample No. 2 the flavor was mixed, i.e. green apple flavor was expressed, but the sample had algae aftertaste.

The sample No. 3 turned to be the best sample in all aspects and regards. The smell conformed to the fruit filling. The taste of sample No. 3 changed, the taste was dominated by "green apple" and "lemon balm". The texture of all three samples scored the maximum number of points, the obtained curd was dense.

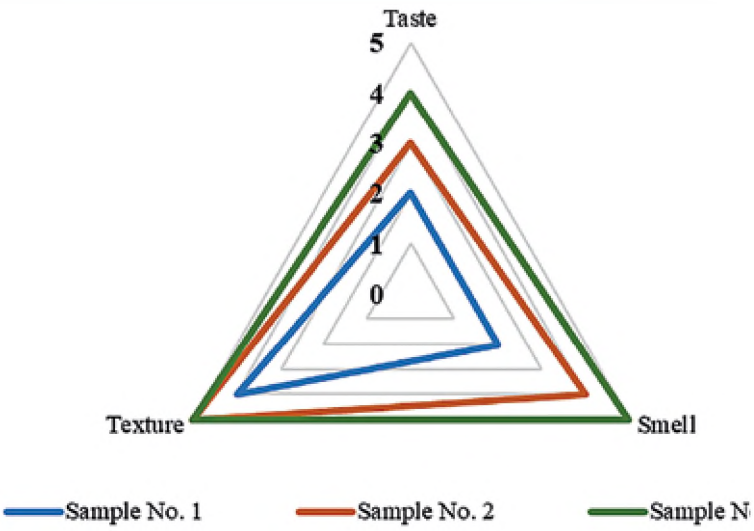
Table 3. **Physical and chemical parameters of samples of a fermented milk functional product with spirulina and fruit filling "Green apple – lemon balm"**

Parameter	Characteristics of the parameters			Norm
	sample No. 1	sample No. 2	sample No. 3	
Mass fraction of fat,%	2,7±0,1	2,6±0,1	2,6±0,1	From 1,4 to 4,0
Mass fraction of protein,%	3,4±0,1	3,5±0,1	3,2±0,1	2,0–5,0
Mass fraction of carbohydrates, %	10,0±0,1	10,0±0,1	10,0±0,1	Not less than 7,8
Mass fraction of SNF, %	9,0±0,1	11,2±0,1	13,4±0,1	Not more than 16,0
Phosphatase	Absent	Absent	Absent	Not allowed

Table 4. **Titratable acidity in the finished samples of fermented milk product with spirulina (2%) and fruit filler**

Sample	Titratable acidity, °T			
	fresh milk	fermented milk, 5–6 hours	finished product	finished product with filler
Sample No. 1	17±1	73±1	87±1	90±1
	16±1	73±1	87±1	91±1
	17±1	75±1	88±1	91±1
Sample No. 2	17±1	75±1	87±1	92±1
	17±1	74±1	89±1	93±1
	16±1	74±1	88±1	92±1
Sample No. 3	16±1	74±1	88±1	94±1
	17±1	75±1	89±1	95±1
	17±1	76±1	89±1	93±1

Fig. 3. Organoleptic profile of fermented milk product samples with spirulina and fruit filling



Выводы / Conclusion

The production and further analysis of the samples with spirulina showed that the texture of the experimental samples corresponded to the control sample, but increase in ratio of spirulina to fermented milk changed the taste and smell.

A slight taste of algae was detected in the sample No. 2. The sample No. 3 was not suitable for consumption because of overexpressed taste and smell of algae. The assessment of the fermented milk product appearance revealed, that the control samples and the samples No. 1 and 2 had a dense curd and scored the maximum number of points – 5, the sample No. 3 had a less dense curd and scored less points (4) in 5-point rating scale.

The assumption was confirmed that the fruit filler would neutralize the effect of spirulina on organoleptic characteristics of the product. During the analysis, the data of organoleptic test were obtained. The sample No. 1 with 10% of fruit filler scored the least number of points in terms of "taste" and "smell". In the sample with 10% of fruit filler, the taste of algae was clearly noticeable. That witnessed the insufficient quantity of fruit filler. The sample No. 2 featured the mixed flavor with distinct taste of green apple, but algae aftertaste was also expressed.

The sample No. 3 proved to be the best sample in all regards. The aroma corresponded to the fruit filling. The taste of sample No. 3 changed, as its taste was dominated by "green apple" and "lemon balm". The texture of all three samples scored the maximum number of points; the obtained curd was dense.

Thus we have determined the best ratio of base to fruit filler – 80:20. When 2% of spirulina powder is added, the iron content in the finished product corresponds to 10–16% of the physiological demand, which helps to satisfy the iron deficiency in a child's body.

As a result of the conducted research it is possible to conclude that use of spirulina in the production of fermented milk products for children nutrition can reduce iron deficiency in a child's body.

Все авторы несут ответственность за свою работу и представленные данные.
Все авторы внесли равный вклад в эту научную работу.
Авторы в равной степени участвовали в написании рукописи и несут равную ответственность за плагиат.
Авторы заявляют об отсутствии конфликта интересов.

All authors bear responsibility for the work and presented data.

All authors have made an equal contribution to this scientific work.
The authors were equally involved in writing the manuscript and bear the equal responsibility for plagiarism.
The authors declare no conflict of interest.

БИБЛИОГРАФИЧЕСКИЙ СПИСОК / REFERENCES

1. Torshina O. et al. Simulation methods as an effective tool for solving healthy applied and theoretical problems. *International Journal of Pharmaceutical Research.* 2019; 11(4):286–290.
2. Smolnikova F., Khayrullin M., Pasko O., Zhukovskaya S., Zubtsova Y., Yakunina E. Main Problems Of School Nutrition. *International Journal Of Scientific & Technology Research.* 2020; 9(02):1105–1108.
3. Kulushtayeva B., Rebezov M., Igenbayev A., Kichko Y., Burakovskaya N., Kulakov V., Khayrullin M. Gluten-free diet: Positive and negative effect on human health. *Indian Journal of Public Health Research and Development.* 2019; 10(7):889–892. DOI:10.5958/0976-5506.2019.01690.5
4. Okuskhanova E. et al. Functional and physical properties of oil-in-water emulsion based on sodium caseinate, beef rumen and sunflower oil and its effect on nutritional quality of forcemeat. *Journal of Dispersion Science and Technology.* 2021. DOI:10.1080/01932691.2021.1950008
5. Suychinov A., Rebezov M., Maksimyuk N., Khairullin M., Kulikov D., Konovalov S., Konovalova O., Penkova I., Moldabaeva Zh. Vitamins and their role in human body. *International Journal of Pharmaceutical Research.* 2019; 11(3):1246–1248.
6. Rauf A. et al. Recent advances in the therapeutic application of short-chain fatty acids (SCFAs): An updated review. *Critical Reviews in Food Science and Nutrition.* 2021. DOI:10.1080/10408398.2021.1895064
7. Abu-Izneid T. et al. Nutritional and health beneficial properties of saffron (Crocus sativus L): a comprehensive review. *Critical reviews in food science and nutrition.* 2020. DOI:10.1080/10408398.2020.1857682
8. Rebezov M. et al. Role of beetroot as a dietary supplement in food products: *Review. Plant Cell Biotechnology and Molecular Biology.* 2020; 21(57–58):8–16.
9. Mitra S. et al. Potential health benefits of carotenoid lutein: An updated review. *Food and Chemical Toxicology.* 2021; 154. DOI:10.1016/j.fct.2021.112328
10. Islam M.N. et al. Superoxide dismutase: An updated review on its health benefits and industrial applications. *Critical Reviews in Food Science and Nutrition.* 2021. DOI:10.1080/10408398.2021.1913400
11. Omari N.E. et al. Natural Bioactive Compounds Targeting Epigenetic Pathways in Cancer: A Review on Alkaloids, Terpenoids, Quinones, and Isothiocyanates. *Nutrients.* 2021; 13. https://doi.org/10.3390/nu13113714
12. Vaskovsky A.M., Chvanova M.S., Rebezov M.B. Creation of digital twins of neural network technology of personalization of food products for diabetics. *4th Scientific School on Dynamics of Complex Networks and their Application in Intellectual Robotics DCNAIR.* 2020; 251–253. DOI:10.1109/DCNAIR50402.2020.9216776
13. Friday O.A. et al. Influence of pro-vitamin -a- cassava flour and cashew nut flour supplementations on physico-chemical properties of wheat based bread. *Journal of Microbiology, Biotechnology and Food Sciences.* 2021; 11(1):1–6. DOI:10.15414/jmbfs.4843
14. Bouyahya A. et al. Sources, health benefits, and biological properties of zeaxanthin. *Trends in Food Science and Technology.* 2021. https://doi.org/10.1016/j.tifs.2021.10.017
15. Nile S. et al. Soybean Processing Wastes: Novel Insights on Their Production, Extraction of Isoflavones, and Their Therapeutic Properties. *Journal of Agricultural and Food Chemistry.* 2021. https://doi.org/10.1021/acs.jafc.1c04927

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