Agronomy Research **12**(3), 759–768, 2014

Fermented sauces for child nutrition from age three

L. Nadtochii* and A. Koryagina

ITMO University, Lomonosova Street 9, 191002 Saint-Petersburg, Russia; *Correspondence: l.tochka@mail.ru

Abstract. One of the directions in modern food science is the development of diets for children of different age groups based on their physiological needs and psycho-emotional activity. One of the approaches to solving this problem is functional product design. Such products are not medicaments, but help to prevent the diseases and ageing processes of the human organism.
The purpose of our research was to develop fermented sauce compositions based on milk and plant ingredients for child nutrition.
Mass fractions of pumpkin and banana purée, berry syrup and stabilizing additives were experimentally determined.

Key words: Fermented sauces, child nutrition, fruit and vegetable purées, berry syrups, corn starch.

INTRODUCTION

The creation and launching of functional food products is one of the directions of the human nutrition program initiated by the UN. Even in the developed countries there is a deficit in biologically active substances, macronutrients and micronutrients, and ballast substances in the diet. Functional food products which are not medications help to prevent diseases and ageing. 65% of the modern market of functional food products consists of dairy products (Zakharova & Mazeeva, 2010).

One of the priorities in the field of healthy eating is the existence of a varied range of products for functional purposes. Vegetable raw materials with a wide range of biologically active substances (vitamins, minerals, dietary fiber, antioxidants, etc.) are currently widely used. The presence of these ingredients improves many physiological processes in the body and improves the immune system. One of the most accessible ways to create products with such qualities is the development of technology for the production of functional foods with a complex mineral composition. The creation of multicomponent products is mainly aimed at the regulation of amino acids, lipids, carbohydrates, minerals and vitamins in human diet. (Tikhomirova, 2009). Children and elderly people have become an increasingly important segment of the consumers and such products are aimed specifically at these two groups (Murray et al., 2001).

The present study focuses on the development of safe functional foods intended for children. A balanced diet is one of the conditions for the normal development of resilience in children, helping to cope with exposure and infection. Baby food plays a significant role in ensuring children access to balanced products, the production of

which is possible only in the conditions of specialized modern enterprises. The most important are the products included in the daily diet. A special group of them is sauces. Due to the presence of extractive, aromatic and flavoring substances stimulating the secretion of digestive glands, sauces are a good source of key components in food (Tarasova & Taghiyev, 2009).

At present, various types of sauces and soups are extremely popular in the consumer market because of the significant expansion of the average consumer basket. However, not all products in this category, available now in the market, are ideal for the children. The abundance of these products is unacceptable for children because of their content of additives, stabilizers, preservatives, and artificial dyes. That is why the study is so important in the current situation in the food market, as regards children of pre-school and school age. According to the Institute of Nutrition of Russian Academy of Medical Sciences, a broad-scale monitoring of the nutritional status of school-age children has shown a shortage of high-grade proteins (30–70%), fat (10–40%), and vitamins (40–70%). The vast majority of pupils (about 80%) are eating at school cafeterias and buffets during school hours. Due to deficient school meals, according to the I.M. Sechenov Moscow Medical Academy, 37% of children regularly experience hunger and 39% from time to time. Because of considerable mental stress at school, the well-being of pupils depends on regular meals and a high-calorie diet. Childhood and adolescence is characterized by relatively high energy consumption. Thus, the energy consumption of children 7–10 years of age constitutes about 80 kcal kg^{-1} of body weight, 13–16 year old adolescents 50–65 kcal kg^{-1}, and adults 45 kcal kg^{-1}.

The recommended consumption rates of basic nutrients for children and adolescents by age and gender according to the Institute of Nutrition and the sanitary standard 2.4.5.2409-08 'Hygienic requirements for catering pupils in general educational institutions, institutions of primary and secondary professional education' are shown in Table 1.

Table 1. Recommended consumption rates of basic nutrients for children and adolescents according to age

Poultry nutrition	Quantity, per day	
	7–11 years	11–18 years
Protein, % of calories	14	13
Fat, % of calories	30	30
NLC, % of calories	10	10
Sugar, % of calories	10	10
Calcium, mg	1,100	1,200
Vitamin C, mg	80	100
Energy value, kcal	2,400	2,800

Feeding children of school and pre-school age is an important task. In fact, it has become increasingly difficult to work out a balanced and safe diet for the children due to the abundance of the latest developments of food industry filling the store shelves. Not all of these innovations are suitable for children, but the children prefer such products because of their pleasant organoleptic properties. However, there is a way out. The new products can be both useful and valuable in terms of nutritional value, but at the same time tasty foods with health benefits that babies could drink every day. The

younger generation is fond of sweet dairy desserts. Therefore, one solution to the shortage of dairy products in the diet of children of pre-school and school age may be the development of new functional milk based products, which could easily be combined with their taste preferences. Sauce could be ideal as such a product, as it is both fashionable and popular.

MATERIALS AND METHODS

A study on the development of composition and technology of fermented sauces for three year old infants was conducted in the laboratory of technology of milk and food biotechnology at Institute of Refrigeration and Biotechnology of Saint Petersburg National Research University of Information Technologies, Mechanics and Optics.

The objects of research were:

- skimmed milk powder with a fat content of 1.25%;
- homogenized mashed pumpkin 'Umnitsa' for early childhood (Ivanovo plant of baby food);
- homogenized banana purée for early childhood (Ivanovo plant of baby food);
- blueberries, sugar free syrup 'Huckleberry' ('Petrodiet');
- viburnum berry syrup ('Vifiteh');
- corn starch premium sort ('Starch-center');
- sourdough of pure cultures of viscous *Streptococcus thermophilus*.

Milk powder was used in the experiment with the aim of eliminating differences in physical and chemical indicators of raw milk. However, at the implementation of fermented sauce into production, it is recommended to use raw milk as a base.

Raw materials for the manufacturing of fermented sauces must meet the microbiological requirements presented in Table 2. The milk used for manufacturing baby food products should not be below the first grade. Manufactured fillers comply with microbiological criteria, as do products for babies from 6–10 months.

Table 2. Acceptable levels of bacteria and somatic cells in raw milk

Product milk, grade	KMAFAnM	Weight of the product, which is not allowed		Max content of somatic cells
		Coliform bacteria	Pathogens, including *salmonella*	
Supreme	$1*10^5$	–	25	$4*10^5$
the first	$5*10^5$	–	25	$1*10^6$
the second	$4*10^6$	–	25	$1*10^6$

Integrated study design adopted these methodologies:

1. Determination of active acidity;
2. Determination of dry matter and mass fraction;
3. Definition of syneresis properties.

Determination of active acidity

Potentiometric method is based on the measuring of voltage between two electrodes (electrode measurement and comparison). Electrodes couple before the measurement and should be placed in a glass with a solution of hydrochloric acid molar concentration of 0.1 mol/dm^3 in intervals between measurements. Electrodes are washed by distilled water before tests and sediment particles must be removed through filter paper.

We poured a 40 ± 5 cm^3 sample of milk or liquid product in a glass with a capacity of 50 cm^3 at the temperature 20 ± 2°C and dipped in the lead pair. After that we took the readings.

The measurement of pH in each sample is repeated twice, each time removing the electrodes from the sample and immersing them into the product.

The immersion depth of the electrode pair into the glass during the trial shall be not be less than 30 mm and that of combined electrodes no less than 16 mm. It is not allowed to touch the electrodes or the glass of the temperature compensator bottom and sides.

After the measurement of each sample of milk or dairy products, an electrode couple should be rinsed with distilled water at the temperature 30–40°C and the sediment particles in the distilled water must be removed through filter paper.

The final results of the measurement of active acidity in milk and dairy products are obtained by taking the arithmetic mean of the results of two parallel determinations.

Determination of moisture and dry matter content in sauces

It is necessary to put a doubled cheesecloth in an aluminum weighing bottle, then to exsiccate the content with an open lid at 105°C for 20–30 min, after that to cool it in the desiccator for 20–30 min by closing the lid, and then to weigh the content.

3 ml of the investigated product should be taken into a prepared aluminum weighing bottle pipette, distributed at regular intervals over the entire surface of the doubled cheesecloth and weighed after closing the lid. Then open aluminum container and lid in the oven at 105°C for 60 min, after which the aluminum container is closed, cooled and weighed. Drying and weighing continue during 20–30 min until the difference in mass between two successive weighings is no more than 0.001 g.

Definition of syneresis properties

The study of syneresis properties of clots was conducted as follows: a 10 ml test sample was placed into a measuring tube and centrifuged for 30 min, noting every 5 min the precipitated serum volume. By results of the research the rate of sample syneresis was found out and the ability of serum clotting was concluded.

Research organization

In the course of this study, we carried out experiments on pumpkin and banana puree and syrup percentage, as well as on the doses of stabilizer for a product with high organoleptic properties and a texture typical of this type of products. The control sample of sauce No 1 was prepared on the basis of raw milk without the addition of plant fillers and was produced from banana purée; the control sample of sauce No 2 was prepared from pumpkin purée.

All samples of sauces were made on the basis of skimmed milk, reduced to a mass fraction of solids 16%, fermented together with pure cultures of lactic acid of viscous *Streptococcus thermophilus*. Before developing, all the samples were subjected to intensive mixing in a blade mixer at the speed of 800 RPM to prevent stratification of the foundations and filler. Further samples were put in a thermostat at the temperature 44 ± 2°C and fermented for 4–6 hours. The finished product was sent ripening to the holding room at 4 ± 2°C.

RESULTS AND DISCUSSION

The dynamics of decreasing the acidity of sauce samples during the process of fermentation was studied.

In the first stage of the research the effect of doses of applied plant fillers on the fermentation of samples was investigated. Fig. 1 shows the use of different doses of pumpkin purée added in the amount of 15, 30, 45% of the mass of the initial mixture.

Fig. 1 shows that the fermentation all samples lasted for approximately six hours. It should be noted that the change in acidity was faster in the control sample, as skimmed milk is a suitable environment for the development of starter microflora. The graph also shows the reduction in active acidity depending on the doses of filler: the higher the dose, the slower pH decreases. This may be due to the presence of large quantities of organic acids in samples with high filler content, which impede the rapid multiplication of the microflora of the leaven. However, adding a filler up to 30% of the amount had a slight effect on the fermentation of the mixture, which is why further investigation used a dose of about 30% for making a plant component.

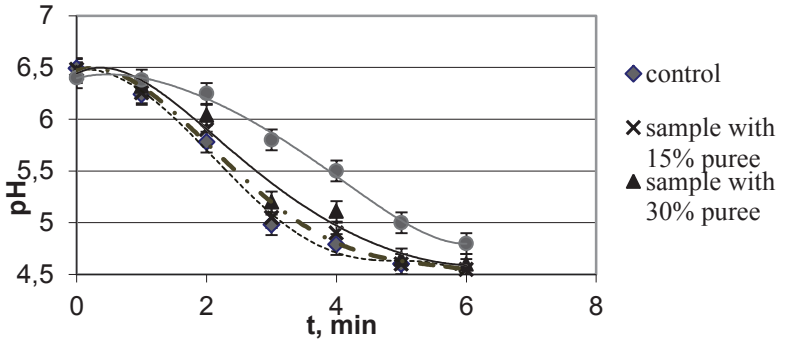

Figure 1. Change in the active acidity of samples with different doses of added pumpkin purée.

Banana and pumpkin purée were selected as plant components. Fig. 2 shows the variation in the active acidity of the selected samples in comparison with the control sauce.

The initial values of the active acidity of the samples with fillers are lower than in the control sample. But the development of the starter microflora occurs rapidly in the control sample as noted previously. However, after 6 hours of fermentation, samples reach similar values of active acidity. This allows establishing the necessary time for the fermentation of all samples, which is 6 hours.

The study should also figure out how to affect the process of fermentation by adding viburnum syrup as a sweet component of the recipe. Fig. 3 shows the effect of

syrup (in an amount of 9%) on the fermentation process of the sample with pumpkin purée.

Fig. 3 shows that the decrease in active acidity is faster in the sample without syrup. It is obvious that a high content of sugar and organic acid does not make the microflora of the starter culture evolve quickly and seamlessly in the sample with syrup, and as a result, the fermentation occurs at a slower speed compared to the sample without syrup. It should be noted that samples obtained in both the first and second experiments had a good flavour and taste but the sauces lacked the required consistency. At the end of the fermentation the samples had the sleek, glossy clot, but a heterogeneous structure: when mixing, there was a small separation of the serum that affected the consistency of the product.

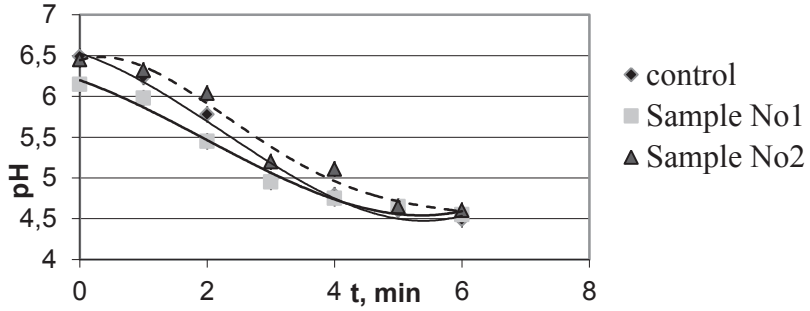

Figure 2. Change in the active acidity of samples with different fillers.

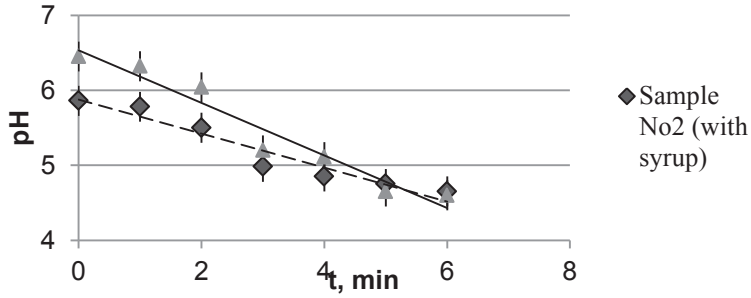

Figure 3. Change in the active acidity of samples with addition of syrup and without syrup.

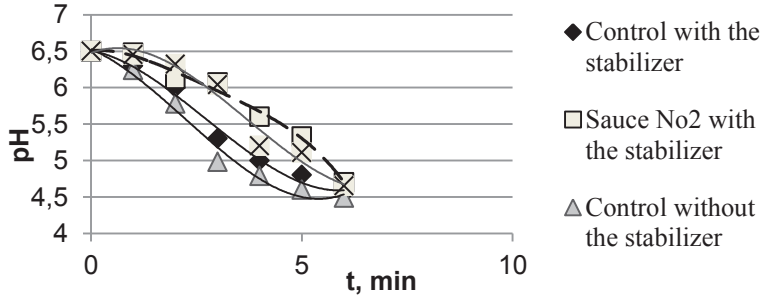

Figure 4. Change in active acidity of samples with and without stabilizer.

Consequently, it appears to be necessary to add a stabilizer in the manufacturing process of the fermented sauces. Fig. 4 presents diagrams of decrease in active acidity during fermentation of samples (control sauce and sample No2) with different fillers with and without a stabilizer. The stabilizer was added according to the recommendations in the amount of 2.7%.

On comparing these graphs we can say that the presence of the stabilizer does not affect the fermentation of the samples significantly. However, with the introduction of the stabilizer, we are reaching the desired consistency and structure of samples. Thus, the inclusion of a stabilizer in the formulation of sauces is appropriate.

Study on syneresis properties of samples.

Syneresis properties are an important quality indicator in the production of fermented products. It is required that the allocation of serum during centrifugation be minimal (V, %).

As a result of this experiment, the following data presented in Fig. 5 were obtained.

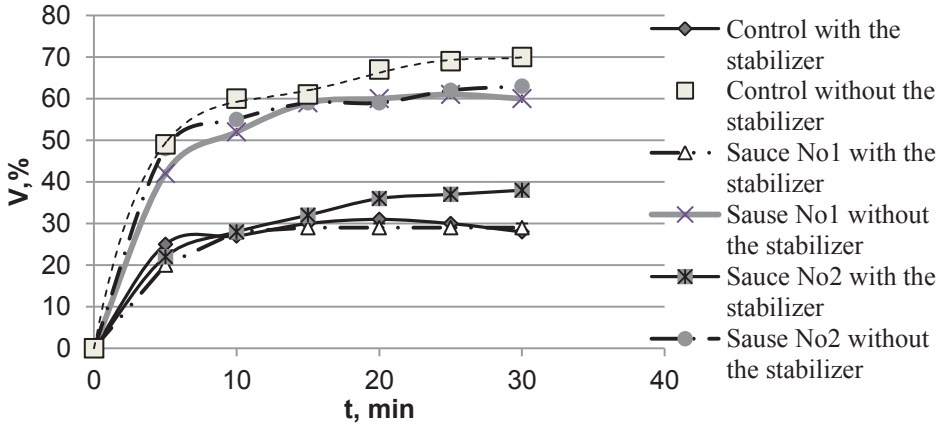

Figure 5. Syneresis properties of sauce samples with and without stabilizer.

Fig. 5 shows the syneresis properties of test samples with and without stabilizer. The graph shows the apparent stabilizing effect of structure with stabilizer: samples with the stabilizer separated the serum significantly less than samples without the stabilizer.

Samples No1 and 2 without the stabilizer are more resilient than the control sauce without the stabilizer. This may be due to the stabilizing quality of dietary fiber, which is part of banana and pumpkin purée.

Composition and properties of developed sauces

While working out the sour sauce recipe, it was decided to use 34–37% of plant component ingredients of the total weight of the finished product. Such a filler dose provides the necessary organoleptic qualities and functionality without violating the regulations for child nutrition products.

In order to obtain the desired consistency of the product of this type and the stabilization of the system, it was decided to introduce corn starch in the amount of 2.7% of the total weight of the sauce as a stabilizer.

Recipes for cooking sauces No 1 and No 2 for 1,000 kg of product are presented in Tables 3, 4.

Table 3. Recipe of sour sauce No 1 with banana purée for 1,000 kg of product (excluding losses)

Component	Weight, kg
Water	515.0
Banana purée	283.0
Skimmed milk powder	69.0
Blueberry syrup	61.0
Sourdough (viscous thermopile *Streptococcus*)	45.0
Stabilizer (corn starch)	27.0

Table 4. Recipe of sour sauce No 2 with pumpkin purée for 1,000 kg of product (excluding losses)

Component	Weight, kg
Water	496.0
Pumpkin purée	273.0
Skimmed milk powder	68.0
Viburnum syrup	91.0
Sourdough (viscous thermopile *Streptococcus*)	45.0
Stabilizer (corn starch)	27.0

The moisture content of the dry matter is an important characteristic of the finished product. The data obtained are summarized in Table 5.

Table 5. Moisture content of dry matter in sauce samples

Samples	Dry matter content, %	Moisture content, %
Control sample	14.9 ± 0.2	85.1 ± 0.2
Sauce No 1	17.1 ± 0.2	82.9 ± 0.2
Sauce No 2	14.2 ± 0.2	85.8 ± 0.2

The present study also examined the organoleptic parameters of the samples.

Children have been documented to have different taste thresholds than adults (Glanville et al., 1964; Hermel et al., 1970). It is apparent that children have different dietary habits and preferences than adults. Whether this is a result of differences in perception *per se*, familiarity, a learned behaviour or a combination of these, is not yet clear. It may therefore be desirable to train children for descriptive profiling or investigate these implications more thoroughly (Moskowitz, 1994; Chen & Resurreccion, 1996; Baxter et al., 1998).

As it was not possible to teach children sensory analysis in the present study, organoleptic evaluation of the received sauce samples was carried out by a group of 8 people from the academic staff working at the Department of Milk Technology and Food Biotechnology. The panelists were trained in accordance with the ISO 8586-1: 1993.

Preparation and use of samples for sensory analysis was carried out according to the recommendations (Seon-Suk et al., 2012). The evaluation was conducted for each indicator on a five-point system. Samples were served with a glass of water after they were left at the room temperature for 10 min. Samples were presented at the same time in each session. Sensory evaluation of samples in each analysis was carried out 2 times. The control points of organoleptic evaluation were taste, colour, and consistency. Results of the evaluation are summarized in Tables 6 and 7 and displayed on the chart.

Table 6. Results of organoleptic evaluation of fermented sauces with different fillers

Samples	Points			
	Sour milk taste	Taste filler	Colour	Consistency
Sample No 1	4.25	4.88	4.13	4.75
Sample No 2	4.38	4.88	4.88	4.88

Sample No 2 got the highest score in organoleptic evaluation of the best consumer properties; however, sample No 1 received high praise too, particularly for its sour milk taste, taste filler and consistency, losing only in colour. The latter is not substantial enough to discard the sample from further research. The samples must meet the requirements shown in Table 7.

Table 7. Organoleptic characteristics of fermented sauces with different fillers

Organoleptic characteristics	Sauce with mashed banana and blueberry syrup	Sauce with pumpkin purée and cranberry syrup
Taste and flavor	Sour milk, sweet, with a strong banana taste and flavour of blueberries	Sour milk, sweet, with a pronounced taste of pumpkin and cranberry flavour
Consistency	Homogeneous, viscous	Homogeneous, viscous
Appearance	Homogenous mass	Homogenous mass
Colour	Beigish-grey	Bright orange

Table 8. Microbiological safety indicators for sauces

The microorganisms identified	Sauces for children's and dietary nutrition
Spore *mesophilic* aerobic and facultative anaerobic-team *B.subtilis*.	Meet the requirements of the industrial sterility. In the case of determining the number of these micro-organisms, it should be no more than 11 cells in 1 g (cm^3) of the product
Mesophilic Clostridium	Do not meet the requirements of the industrial sterility detected in 10 g product (cm^3)

Fermented sauces must meet the requirements 'Hygienic requirements for safety and nutritional value of foods. Public health regulations 2.3.2.1078-01' shown in Table 8.

CONCLUSION

The study was carried out to develop the composition and technology of fermented sauces for children from age three. Based on the results of the research we can make the following conclusions:

1) The possibility of using filling materials of plant origin for the production of fermented sauces was proved: it is possible to use banana and pumpkin purée and berry syrup for this purpose in an amount of 34–37% of the total weight of the finished product. It also provides a perspective for enlarging the assortment of fermented sauces by introducing other combinations of fruit or vegetable purées and berry syrups;

2) The viscous thermopilus culture of Streptococcus (*Streptococcus thermophilus*) promotes the clot formation of moderately viscous consistency with a pleasant sweet taste of fermented sauces;

3) The use of corn starch as stabilizer allows to achieve the desired consistency and structure of sauces: samples with added starch separated almost 2 times less whey than samples without stabilizers;

4) The requirements for fermented sauces with various fillings were identified. The organoleptic characteristics: taste of fermented milk with a pronounced taste of fillers, aroma with a pronounced flavour of fillers; consistency is homogeneous, viscous.

ACKNOWLEDGEMENTS. This work was partially financially supported by the government of the Russian Federation, Grant 074-U01.

REFERENCES

Baxter, I.A. & Jack, F.R. & Schro der, M.J.A. 1998. The use of the repertory grid method to elicit perceptual data from primary school children. *Food Qual. Prefer.* **9**(2), 73–80.

Chen, A.W. & Resurreccion, A.V. (1996). Age appropriate hedonic scales to measure food preferences of young children. *J. Sens. Stud*. **11**, 141–163.

Dobrynina, E.S. & Lomovskij, O.I. 2010. Development of new formulations of sauces and dressings functional purpose. *Food industry.* 54–55.

ISO 8586-1: 1993 (Sensory analysis. General guidance for the selection, training and monitoring of assessors, Part 1. Selected assessors.

Glanville, E.V., Kaplan, A.R. & Fischer, R. 1964. Age, sex and taste sensitivity. *J. Gerontol*. **34**, 834–840.

Hermel, J., Schonwetter, S.V. & Samueloff, S. 1970. Taste sensation and age in man. *Journal of Oral Medicine*. **25**, 39–42.

Moskowitz, H.R. 1994. Children versus adults. Food concepts & products. *CT: Food & Nutrition Press*. 293–331.

Murray, J.M., Delahunty, C.M. & Baxter, I.A. 2001. Descriptive sensory analysis: past, present and future. *Food Res. Int*. **34**: 461–471.

Seon-Suk J., Seung-Joo L., Palanivel G. & Hae-Soo K. 2012. Comparative Study of Flavor, Texture, and Sensory in Cream Cheese and Cholesterol-removed Cream Cheese. *Food Sci. Biotechnol*. **21**(1), 159–165.

Tarasova, L.I. & Taghiyev, T.G. 2009. Sauces and mayonnaises-is there a difference. *Oil and fat industry*. 7. (In Russian).

Tikhomirova, N.A. 2009. Current state and prospects of development of functional food products. *The dairy industry*, 5–6. (In Russian).

Tikhomirova, N.A. 2009. Healthy eating for students. *The dairy industry*.78–79. (In Russian).

Tikhomirova, N.A. & Churakov, M.M. 2007. Functional fermented sauces. *The dairy industry*. **3**, 59–60. (In Russian).

Zakharova, L.M. & Mazeeva, I.A. 2010. Technology of new functional foods milk based. *Storage and processing of agricultural raw materials*. 63. (In Russian).

.