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STUDY OF EFFICIENCY AND QUALITY OF DRY MILK MIXTURES FOR BABY NUTRITION IN THE STORAGE PROCESS

K. Belinska[1], Ph.D
N. Falendysh[2], Ph.D, Assistant Professor
T. Marusei[1], Ph.D, Assistant Professor
[1]Department of tourism and hotel and restaurant business
Kamianets Podilskyi National Ivan Ohiienko University
Suvorova str., 52, Kamianets Podilskyi, Ukraine, 32300
[2]Department of Bakery and Confectionary Production
National University of Food Technologies
Volodymyrska str., 68, Kyiv, Ukraine, 01601

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Correspondence:

K. Belinska
E-mail: kristina 0612@ukr.net

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Abstract. Many children are unable to receive natural nutrition for various reasons. In this case, children are transferred to artificial feeding. Artificial feeding is provided by dry milk formulas. Most powdered milk formulas on the market are made from cow's milk. But the chemical composition of cow's milk in many respects does not correspond to human milk. It is proposed to use mare's and sheep's milk to develop mixtures for baby food. Milk collected from farms in Eastern, Western and Central Ukraine was used. Powdered milk was obtained by spray drying. The calculation of formulations was performed by optimizing the chemical composition using the standard Simplex program. Dry milk formulas based on Ligans mare's milk and Agnus sheep's milk have been developed for feeding children from birth to 6 months. Studies of microbiological parameters of the mixtures have shown that during 12 months of storage in cardboard packs with an inner package of combined polymeric material, the obtained products retain quality. During this period, the content of vitamins that can break down during storage is also normal. Assessing the tolerability of Ligans and Agnus mixtures, it was found that with the use of mixtures, the incidence of colitis and flatulence began to decline rapidly. A decrease in the total level of IgE by 88–90% in the blood of children indicates the hypoallergenic properties of mixtures of Ligans and Agnus. The initial content of sIgA in coprofiltrates of breastfed infants has been shown to be almost indistinguishable from that of infants consuming Ligans and Agnus. Developed mixtures are recommended to increase the body's resistance. The effectiveness of the mixtures has been confirmed by medical and biological studies.

Key words: baby food, dry mixes, sheep's milk, mare's milk.

Introduction. Formulation of the problem

Breast milk is considered the «gold standard» of infant nutrition and protects the baby's body from infections and inflammation, promotes immunity and accelerates the maturation of organs [1,2]. But for various reasons, many children around the world are deprived of breastfeeding.

Despite the implementation of WHO/UNICEF initiatives since 2003 and the active promotion of breastfeeding, today only 36% of children under 6 months of age are breastfed. Other children receive adapted formula. [3,4]

To date, most infant formulas in the first year of life are highly adapted and as close as possible to the basic characteristics of breast milk [5]. However, there are some differences in the structure and composition of protein, oligosaccharides, carbohydrates and fat component, the content of vitamins and trace elements. The choice of formula should be based on the conclusion of ESPGHAN (European Society of Pediatric Gastroenterology, Hepatology and Nutrition), which states that the most optimal mixture that should be used for breastfeeding is that "provides children with the same indicators of development, immune reactions and metabolic profile, as in children on natural feeding" [6].

The main raw material from which infant formula is made is cow's milk.

In order to find such a product that will have advantages in chemical composition over cow's milk and as close as possible to the composition of human milk, it is proposed to use mare's and sheep's milk.

Development of new and improvement of existing technologies of children's dairy products, in particular, functional purposes with the use of mare's and sheep's milk today is an urgent task for scientists.

Analysis of recent research and publications

In order to adapt dry milk formulas, milk undergoes a number of transformations. Analysis of dry milk formulas from leading European manufacturers (Nan1, Nutrilon1, Humana1) showed that such formulas contain demineralized whey, skim milk, vegetable fats, which make up 100% of all fat in the product. This means that the natural composition of milk in such products has changed. Based on this, it is clear that animal fats in the mixtures are absent, and therefore no fat-soluble vitamins in milk, the natural mineral composition of milk is disrupted due to demineralization, during a number of technological operations for milk processing water-soluble vitamins are lost.

One of the most common allergens encountered by young children is cow's milk protein. It is estimated that 6–8% of children under the age of 3 have food allergies and up to 4.9% have allergies to cow's milk protein. [7]

Cow's milk allergy is now one of the most common childhood food allergies, and studies show that 2 to 5% of infants in different countries with cow's milk protein allergy have been confirmed [8-11]. The main protein allergens of milk are casein and β-lactalbumin [12-15].

Australian scientists have reported that allergies to cow's milk proteins occur in 2% of young children. In Denmark, children in the first year of life – 2.2%, in Finland infants under 15 months – 1.9%, in Norway in newborns under 6 months – 4.9%, in the UK in infants – 2.5%, in the Netherlands in infants – 2.3 %, in Sweden – 1.9%, in the USA – 5.2%, in Canada – 7.5% [16-18].

The authors [19] studied in vitro and in vivo allergenicity of mare's milk in a population of selected children with allergies to cow's milk. The results of this study indicate that mare's milk is tolerated by 96% of children.

Scientists [20] conducted a study to assess the microbiological quality of commercially available infant formula from a health perspective. A total of fifty infant formulas and formulas (bottled or dry) from five different international companies were analysed. It was found that 2% of the samples were found to be inconsistent with the total number of aerobic mesophilic organisms, 22% for the number of coliform bacteria, 16% for the total amount of yeast and mold and 10% for the amount of B. cereus. In addition, L. monocytogenes was identified in 6% of samples, Salmonella spp in 4%, B. cereus in 10% and E. coli in 14%. Only 26% of the samples analyzed in the study did not meet the standards, and it was found that they contain pathogens that can cause serious health problems in infants.

However, other studies [21] indicate that pathogenic bacteria such as Escherichia coli, Listeria monocytogenes and Salmonella spp. were not detected in dry milk formulas. The authors found only the presence of opportunistic pathogen Cedecea lapagei.

The authors [22] studied goat's milk powder for 180 days at different storage temperatures. The authors report the presence of Escherichia coli and Salmonella in milk, but claim that if powdered milk is stored at 4°C, an increase in the number of microorganisms is observed. And when storing milk powder at a temperature of 22°C, the number of microorganisms decreases for 4 months.

Contradictory results on the stability of vitamin D in milk during processing and storage have been reported in the literature [23]. Natural vitamin D, present in milk, has been reported to be unstable during pasteurization and sterilization [24]. Conversely, free vitamin D added directly to milk before spray drying at 149°C and fluidized bed finishing at 107°C was completely reduced in milk powder [25]. In another study, the percentage recovery of free vitamin D in milk after pasteurization at 63°C for 30 min and sterilization at 121°C for 15 min was 90 and 67%, respectively [26]. Pasteurization at 73°C for 15 s, homogenization at 13.8/3.4 MPa and storage in opaque plastic containers at 4°C for 21 days did not affect the content of vitamin D added to milk. [27]. It was found that vitamin D is stable in milk when pasteurized at 63°C for 30 minutes and stored at 4°C for 7 days in glass bottles in the dark or for 32 hours in light, while the stability of vitamin D was ~ 90% when using polyethylene packages as packaging material, regardless of light exposure during storage. This phenomenon is associated with the absorption of vitamin D by the polymer. Sterilization at 121°C for 15 min also led to complete recovery of vitamin D, while stability during storage of sterilized milk has not been studied [28].

In [29], the authors report that vitamin A added externally was more stable than vitamin A present in milk. Vitamin A was photosensitive and its degradation increased significantly by 34.82-92.53% with increasing radiation intensity.

The authors [30] studied the stability of lyophilized foods for long-term storage with a moisture content of less than 2%. Stability was highest for vitamins B_1 and B_2 with average storage rates ranging from 93% to 97% for all storage temperatures. The lowest conservation rates were for vitamin E at 75%, 77% and 79% and vitamin B_6 at 85%, 86% and 88% after storage at 1°C, 30°C and 40°C, respectively.

The analysis of publications showed the absence of similar studies of both mare's and sheep's milk powder and dry milk products based on them.

The **purpose** of this work is to establish the possibility and feasibility of using mare's and sheep's milk in the technology of dry milk formula for baby food. The following **tasks** were set for this:

1. To develop recipes for dry milk formulas based on mare's and sheep's milk for feeding children from birth to 6 months;

2. Investigate changes in microbiological parameters of dry milk formulas based on mare's and sheep's milk during storage;

3. Investigate the stability of the vitamin composition of dry milk formulas based on mare's and sheep's milk during storage;

4. To establish the effectiveness of the use of dry milk formulas based on mare's and sheep's milk for feeding children with allergies to cow's milk proteins;

5. To establish the effectiveness of the use of dry milk formulas based on mare's and sheep's milk for children's nutrition to increase the body's resistance.

Research materials and methods

Milk collected from farms in Eastern, Western and Central Ukraine was used for the study. Quality indicators and chemical composition of native milk are presented in table.1.

Table 1 – Quality indicators and chemical composition of native milk

Indicator	Mare's milk	Sheep's milk
Mass fraction of protein, %	1,52	4,8
Mass fraction of fat, %	1,2	6,1
Mass fraction of carbohydrates, %	6,2	4,1
Mass fraction of moisture, %	9,2	18,4

Dry milk mixes were made on a semi-industrial spray dryer «Niro-Atomizer» with a chamber volume of 0.9 m^3 and a capacity of evaporated moisture up to 5.0 kg/h. Drying was performed at a temperature of 140-150°C for a mixture based on mare's milk and 180–190°C for a mixture based on sheep's milk. Drying took place according to the following parameters: the speed of the drying agent – 0.5 m/s, the relative humidity of the drying agent – 25%, the droplet size of the sprayed product – 40–50 μm, the mass fraction of dry matter in the product 40–43%.

The calculation of formulations was performed by optimizing the chemical composition using the standard Simplex program.

Taking into account the results of our own research and in accordance with the requirements for baby food, dry baby "initial" mixtures have been developed for children from birth to 6 months:

– Ligans mixture based on mare's milk

– Agnus mixture based on sheep's milk.

Formulations of dry milk formulas (Table 2) were developed in accordance with the requirements of the mandatory composition provided for in CODEX STAN 72-1981 (amendments: 1983, 1985, 1987, 2011, 2015, 2016), European Union Directive, 2016 (USA), Order "On approval of hygienic requirements for baby food, safety parameters and certain indicators of their quality" of August 6, 2013 № 696 [31].

Packaged products were stored for a year in cardboard packs with an inner package of combined polymer material. The air was removed from the package and replaced with nitrogen, the package was sealed by soldering the upper valve. Packs of mixtures were stored under the same conditions recommended by the manufacturers of infant formula at a temperature not exceeding 25°C. Mass fraction of moisture does not exceed 4%.

Table 2 – Recipes for dry milk mixtures "initial"

Name of raw materials	The amount of raw materials, %	
	Mixture Ligans	Mixture Agnus
Sheep's milk powder, %	–	56.00
Dry mare's milk, %	84.65	–
Soybean oil, %	–	4.00
Sunflower oil, %	7.00	2.00
Olive oil, %	8.00	–
Lactose, %	–	36.30
Lactulose, %	–	1.00
Fat-soluble vitamins, mg/100 g	0.03	0.03
Water-soluble vitamins, mg/100 g	0.23	0.31
Minerals, mg/100 g	0.21	0.56
Incl.		
sodium citrate, mg/100 g	–	4.63
potassium citrate, mg/100 g	–	13.88
Taurine, mg/100 g	0.03	0.03
Inositol, mg/100 g	0.11	0.11
Total:	100.00	100.00

Vitamins B_2 and B_6 were determined using ion-pair reversed phase high performance liquid chromatography with fluorescence detection, vitamin B_1 by fluorescence detection by reversed-phase liquid chromatography, vitamins A and E by the ultra-high performance liquid chromatography method with ultraviolet and fluorescence detection. [32]

The content of vitamins B_1, B_3, B_9, B_{12}, A, E in the mixtures was performed according to the methods [33-34], the content of vitamin D according to [35], vitamin C [36].

Microbiological parameters were determined according to the methods described [37-39].

Clinical and laboratory studies to study the effectiveness of milk formulas «primary» Ligans and Agnus in children's nutrition were conducted at the Children's Clinical Hospital № 8 Shevchenkivskyi district of Kyiv for 60 days.

All patients undergoing scientific research have given their written voluntary consent.

For the study of mixtures for hypoallergenic properties under supervision were 47 children, including 8 children who were breastfed and 39 children with allergies to cow's milk proteins, who were on artificial feeding with milk hypoallergenic mixtures of Ukrainian or foreign production, aged 1 to 7 months.

Group I includes breastfed children (n = 8), group II – children who are breastfed with hypoallergenic milk formulas of Ukrainian or foreign production (n = 17), group III – children who are breastfed mixtures of Ligans or Agnus (n = 22).

The level of total IgE was detected using a set of reagents for indirect enzyme-linked immunosorbent assay to quantify the desired parameter in the serum produced by LLC «CCFF» (Russia). Serum levels of IgE antibodies were determined using an automatic analyzer IMMUNOCAP 100 (Sweden).

To study the effectiveness of mixtures to increase the body's resistance under supervision were 26 ... 28 children (group I) aged 2 to 6 weeks who were on artificial feeding.

The comparison group (group II) consisted of 12 healthy children aged 2 to 8 weeks, who are on artificial feeding with initial mixtures of different manufacturers that do not contain nucleotides. The third group consisted of 15 healthy children aged 2 to 6 weeks, who are on artificial feeding with mixtures of the original, enriched nucleotides. Another comparison group (group IV) consisted of 17 healthy infants aged 1 to 6 weeks who were breastfeeding.

The study lasted 30 days and included 4 visits to the doctor. The first (V_1) – before the start of the study, the other three (V_2, V_3, V_4) – every 10 days from the start of the study.

Determination of the level of secretory Ig A (sIg A) in coprofiltrates was performed using solid-phase enzyme-linked immunosorbent assay using a set of reagents (REF K275 and REF K 276 «HEMA»).

Results of the research and their discussion

In the developed mixes whole milk is used, which was subjected only to the processing provided by the traditional technology of dry milk base. [40] Some fats in mixtures are represented by milk fat, the rest by vegetable oils. The chemical composition of mare's milk completely provides the Ligans mixture with lactose. Sodium and potassium citrate salts are included in the Agnus mixture to adapt the protein component of sheep's milk. It is this prescription composition provides the requirements for the mandatory composition of infant formula.

According to the recommendations of leading manufacturers, mixtures for children from birth to 6 months are reconstituted with water in a ratio of 1:6-7. This ratio is due to the fact that the reconstituted product has the necessary energy value and good rheological properties, similar to human milk.

The chemical composition of the developed mixtures and the requirements of regulatory documents for the composition of these products are presented in table 3. Data are presented per 100 kcal of reconstituted mixture according to the requirements of [41] and 100 g of dry product. This presentation of data (per 100 kcal of the reconstituted mixture) is due to the fact that the same composition of the dry product will give different values of the chemical composition of the reconstituted mixture with different amounts of reducing agent.

Table 3 – Composition and requirements for the composition of milk mixtures (n=2, p≤0,95)

Indexes	**The amount of substances per 100 kcal of the reconstituted mixture in accordance with the hygienic requirements for baby food.**	**Mixture Ligans**		**Mixture Agnus**	
		Per 100 g of dry product, %	**Per 100 kcal of reconstituted product, g**	**Per 100 g of dry product, %**	**Per 100 kcal of reconstituted product, g**
Mass fraction of protein, %	1.8–3.0	13.7	2.7	14.0	3.0
Mass fraction of fat, %	4.4–6.0	25.2	5.0	23.8	5.2
Mass fraction of carbohydrates, %	9.0–14.0	56.1	11.1	47.7	10.3
Energy value, kcal	60–70	506.0	63.2	461.0	63.8
Fatty acids	The amount of substances per 100 kcal of the reconstituted mixture in accordance with the hygienic requirements for baby food	Per 100 kcal of reconstituted product, g		Per 100 kcal of reconstituted product, g	
Linoleic acid, mg	300–1200	1164		743	
α-linolenic acid, mg	not less than 50	192		113	
The ratio of linoleic acid/α-linolenic acid	not less than 5 and not more than 15	6.06		6.6	
The content of lauric and myristic acids alone or in total,%	should not exceed 20% of the total fat content	12.7		15.1	
Amino acids					
Lysine	113	180		235	
Histidine	40	60		64	

Continuation of the table 3

Threonine	77	105	124
Threonine	38	45	38
Valine	88	124	145
Methionine	23	83	85
Isoleucine	90	102	109
Leucine	166	387	275
Tyrosine	76	101	135
Phenylalanine	83	108	146
The ratio of methionine and cystine	not more than 1:2	1:0,5	1:0.5
The ratio of phenylalanine and tyrosine	not more than 1:2	1:1	1:1.1
Vitamins			
Vitamin A, mcg	60–180	86	87
Vitamin D, mcg	1–2.5	1.73	1.7
Thiamine, mcg	60–300	122	138
Riboflavin, mcg	80–400	108	102
Niacin, mcg	300–1500	920	385
Pantothenic acid, mcg	400–2000	600	693
Vitamin B_6, mcg	35–175	78	52.1
Biotin, mcg	1.5–7.5	3.23	3.8
Folic acid, mcg	10–50	16.5	23.5
Vitamin B_{12}, mcg	0.1–0.5	0.2	0.32
Vitamin C, mg	10–30	25.6	20.85
Vitamin K, mcg	4–25	10.65	17.5
Choline, mg	7–50	22	23
Vitamin E, mg	0.4–5.0	1.85	1.5
Minerals			
Sodium, mg	20–60	28.4	31.0
Potassium, mg	60–160	88.0	67.4
Chlorine, mg	50–160	67.0	61.9
Calcium, mg	50–140	92.0	101.0
Phosphorus, mg	25–90	63.0	55.0
The ratio of Ca/P	not less than 1 and not more than 2	1.6	1.98
Magnesium, mg	5–15	7,0	8.8
Iron, mg	0.3–1.3	1.07	1.11
Zinc, mg	0.5–1.5	0.54	0.64
Copper, mcg	35–100	53.0	53.3
Iodine, mcg	10–50	18.3	11.3
Selenium, mcg	1–9	1.5	7.4
Manganese, mcg	1–100	22.0	26.0
Fluoride compounds, mcg	max.100	83	81

The table shows that the composition of the developed mixtures fully satisfies the requirements for the content of basic components (proteins, fats, carbohydrates), as well as the content of fatty acids, amino acids, vitamins and minerals and their ratio in baby food. The mass fraction of protein in the Ligans mixture is 10% lower than in the Agnus mixture. The protein content in the Agnus mixture corresponds to the upper limit of the permissible norm. The mass fraction of fat in the Agnus mixture is 4% higher than in the Ligans mixture. This is due to the significant predominance of protein and fat in sheep's milk.

The mass fraction of carbohydrates in the Ligans mixture is 7.2% higher than in the Agnus mixture. As for the content of polyunsaturated fatty acids in the mixtures, in the Ligans mixture they are 37% more. But the ratio of linoleic and α-linolenic acid, as well as their number, are within normal limits in both mixtures.

The amount of essential amino acids in the mixtures must not be less than specified in the requirements. It is established that the mixtures meet the requirements and contain similar values of the content of most amino acids. Only in a mixture of

Agnus lysine, tyrosine, threonine and phenylalanine 1.2–1.4 times more than in a mixture of Ligans

The amount of vitamins in the mixtures is in the middle of the allowable range. 2.4 times more niacin is observed in the Ligans mixture, compared with the Agnus mixture.

In the Ligans mixture, the amount of selenium and zinc is within normal limits, but close to the lower limit of the permissible range. The same is observed for the iodine content in the Agnus mixture.

When storing products in airtight packaging, the development of unwanted or even harmful microflora is possible. When the values of microbiological indicators exceeding the permissible level are reached, the product becomes unfit for consumption. Therefore, to determine the shelf life of the product it is necessary to study changes in microbiological parameters in dry milk formulas.

Changes in microbiological parameters were studied during storage of mixtures. Table 4 presents the changes in the microbiological parameters of the Ligans mixture during storage. There is a gradual growth of microorganisms throughout the storage period of the mixture. After one year of Ligans storage, the amount of B.Cereu and mesophilic aerobic and facultative anaerobic microorganisms (MAFAM) increased 2.5–3 times, and the number of microscopic fungi increased more than 4 times.

During the year of storage of Agnus, the number of microscopic fungi increased 5.5 times, MAFAM – 1.7 times, and the number of B.Cereu increased 2.5 times.

It should also be noted that during the year of storage the content of MAFAM, microscopic fungi and B.Cereu in Agnus mixture is 1.2–1.3 times higher than in Ligans mixture. The explanation for this is that the Agnus mixture contained more of these microorganisms at the beginning of the study than the Ligans mixture.

A study of the microbiological parameters of infant dry milk products showed that E. coli bacteria, E. coli, pathogens and staphylococci were not detected in any of the products. The obtained data correlate with the studies of the authors [21], who also report the absence of these microorganisms in milk formulas. However, other authors [20] indicate the presence of 26% of commercially available mixtures of pathogenic microorganisms.

The content of MAFAM, microscopic fungi and B.Cereu in mixtures of Ligans and Agnus is within acceptable limits. Thus, the results obtained indicate the microbiological safety and suitability of these products for breastfeeding during the specified storage time.

During long-term storage of food, a characteristic feature of vitamins is their destruction. Because dry baby foods have a long shelf life, storing vitamins throughout the storage period is a very important issue. Studies to determine the mass fraction of vitamins in dry mixes were conducted after 6 and 12 months of storage. The results are shown in table 5.

The results indicate that vitamins such as nicotinic acid, pantothenic acid and choline are fully preserved in both mixtures after 12 months of storage. Vitamins A, B_6 and B_{12} suffer the largest losses (9.0–12.0%) in Ligans and Agnus mixtures. Some vitamins (A, E, B_1, C) are gradually destroyed during storage. However, other vitamins (B_2, B_{12}) are stable during the first six months of storage. Thus, cyanocobalamin, whose losses after 12 months of storage are large, is almost not destroyed in the first six months. The dynamics of vitamin loss during storage is similar for both mixtures of Ligans and Agnus. But it should be noted that the loss of thiamine in Agnus is 2.3 times greater, and vitamin C is 2 times greater than in Ligans.

Table 4 – Changes in microbiological parameters of baby food products during storage (n=2, p≤0,95)

Indicator	**Expiration date**					**Norm**
	1 day	**1 month**	**3 months**	**6 months**	**12 months**	
Mixture Ligans						
Mesophilic aerobic and facultative-anaerobic microorganisms CFU in 1 g of dry product, not more	300	320	400	500	800	2000
B.cereus CFU in 1 g, not more	12	14	21	28	36	100
Microscopic CFU fungi in 1 g, no more	7	10	17	22	29	50
Mixture Agnus						
Mesophilic aerobic and facultative-anaerobic microorganisms CFU in 1 g of dry product, not more	400	460	500	570	680	2000
B.cereus CFU in 1 g, not more	8	9	16	21	27	100
Microscopic CFU fungi in 1 g, no more	4	7	12	16	22	50

Table 5 – Losses of vitamins in infant formula during storage (n=2, p≤0,95)

Vitamins	Mixture Ligans				Mixture Agnus			
	Per 100 g of dry product			Total losses,%	Per 100 g of dry product			Total losses, %
	initial	in 6 months	in 12 months		initial	in 6 months	in 12 months	
A, mcg	440.0	410.0	396.0	**10.0**	403.4	391.0	365.0	**9.5**
D, mcg	8.65	8.62	8.5	**1.8**	7.79	7.7	7.6	**2.2**
E, mg	9.4	9.3	9.2	**2.0**	6.92	6.88	6.8	**2.2**
B_1, mcg	612.6	611.0	610.8	**0.3**	642.2	638.5	637.7	**0.7**
B_2, mcg	549.3	543.0	516.0	**6.0**	471.75	470.5	440.6	**6.6**
B_3, mcg	4664.4	4664.4	4664.4	-	1776.0	1776.0	1776.0	-
B_5, mcg	3043.0	3043.0	3043.0	-	3213.5	3213.5	3213.5	-
B_6, mcg	390.8	374.0	356.0	**9.0**	237.0	226.0	220.0	**7.2**
B_7, mcg	15.4	15.0	14.8	**4.0**	17.65	17.61	16.8	**5.0**
B_9, mcg	83.65	80.8	79.5	**5.0**	110.87	107.5	105.0	**5.0**
B_{12}, mcg	1.0	1.0	0.89	**11.0**	1.5	1.45	1.33	**11.5**
C, mg	129.5	128.9	128.2	**1.0**	96.5	95.2	94.6	**2.0**
Choline, mg	112.4	112.4	112.4	-	107.12	107.12	107.12	-

The authors [30] also report loss of vitamins in foods during storage, in particular in pasteurized, sterilized and lyophilized foods. Losses of vitamin D in pasteurized and sterilized milk for 21 days were 10–37%, and vitamin A – 34.82–92.53%.

In lyophilized foods, the loss of vitamins B_1 and B_2 was 3–7%, vitamin E 23%, vitamin B_6 – 14% at a storage temperature of 30^0C.

Ligans and Agnus have significantly lower vitamin losses. Thus, the loss of vitamin B_1 in mixtures of Ligans and Agnus is 4-23 times lower than the results of studies by the authors [30]. There are also 11 times less loss of vitamin E and 1.6–1.9 times less loss of vitamin B_6 in mixtures of Ligans and Agnus, compared with lyophilized foods.

In general, the data obtained show that dry mixtures of Ligans and Agnus retain good vitamin composition and will meet the body's need for vitamins until the end of shelf life.

Because mare's milk, on the basis of which the Ligans mixture was developed, belongs to the albumin type, the fractional composition of proteins is dominated by whey proteins, this mixture can be recommended for children suffering from food allergies to cow's milk proteins.

Allergies may be related to milk lactose intolerance. In such cases, develop functional mixtures of low-lactose or lactose-free [41].

Sheep's milk, on the basis of which the Agnus mixture was developed, belongs to the casein group. However, it is dominated by β-casein, as in human milk, rather than α-casein (the main allergen of cow's milk).

Based on the definition, functional baby food - baby food that is offered to prevent or mitigate the disease of a child with special dietary needs, including in the case of congenital or acquired disorders of absorption of certain nutrients, their intolerance and / or certain diseases [40], the resulting mixtures are recommended as a functional baby food for children suffering from food allergies to cow's milk protein.

The presence of an allergic reaction in the body indicates the level of total IgE in the blood. The results of the research are presented in table 6 and table 7.

Assessing the tolerability of Ligans and Agnus mixtures, it was noted that children were less likely to suffer from colitis and flatulence than children from the comparison group. Before the study, 72–91% of children were bothered by colitis and flatulence. With the reception of mixtures, the incidence of colitis and flatulence began to decline rapidly.

When taking a mixture of Ligans, the incidence of colitis decreased by 94%, and flatulence – by 95%. Signs of atopic dermatitis disappeared.

Colitis, flatulence and atopic dermatitis in children completely disappeared when consuming Agnus mixture. The explanation for the fact that 4.5% of children did not disappear symptoms of colitis and flatulence when consuming a mixture of Ligans may be that this mixture does not contain sodium or potassium citrate salts that can degrade milk proteins, while these salts are present in the recipe Agnus.

A decrease in the total level of IgE by 88–90% in the blood of children indicates the hypoallergenic properties of mixtures of Ligans and Agnus.

Nucleotide-enriched mixtures that increase the body's resistance have been identified in the baby food market. However, it was found that the main protective factors in the child's body are immunoglobulin A and lactoferrin [2]. And nucleotides in breast milk in the first months of lactation are found in small quantities, so they can not be fully responsible for the formation of the immune response.

Despite the high content of mare's and sheep's immunoglobulin A and lactoferrin in milk, the effectiveness of using Ligans and Agnus mixtures to increase the child's body resistance was studied.

The level of secretory immunoglobulin A in coprofiltrates testifies to the effectiveness of the use of mixtures. The research results are presented in table 8.

Table 6 – Data on the tolerance of the tested mixture Ligans (n=2, p≤0,95)

Indexes	Group I				Group II				Group III			
	V_1	V_2	V_3	V_4	V_1	V_2	V_3	V_4	V_1	V_2	V_3	V_4
Colitis (frequency of manifestation),%	25.0	25.0	12.5	0	82.0	35.0	35.0	29.0	72.0	23.0	4.5	4.5
Flatulence (frequency),%	12.5	12.5	0	0	88.0	76.0	59.9	59.0	91.0	18.0	18.0	4.5
Frequency of atopic dermatitis	0	0	0	0	100	82.0	82.0	71.0	100	0	0	0
The level of total IgE, ml	3,8 ±0.8	–	–	3.2 ±0.6	34.8 ±4.2	–	–	14.8 ±4.2	32.7 ±3.5	–	–	3.4 ±0.3

Table 7 – Data on the tolerance of the tested mixture Agnus and the dynamics of the main indicators (n=2, p≤0,95)

Indexes	Group I				Group II				Group III			
	V_1	V_2	V_3	V_4	V_1	V_2	V_3	V_4	V_1	V_2	V_3	V_4
Colitis (frequency of manifestation),%	25.0	25.0	12.5	0	82.0	35.0	35.0	29.0	88.0	27.0	14.0	0
Flatulence (frequency),%	12.5	12.5	0	0	88.0	76.0	59.9	59.0	72.0	27.0	23.0	0
Frequency of atopic dermatitis	0	0	0	0	100	82.0	82.0	71.0	100	0	0	0
The level of total IgE, ml	3.8 ±0.8	–	–	3.2 ±0.6	34.8 ±4.2	–	–	14.8 ±4.2	34.3 ±3.2	–	–	4.1 ±0.4

Table 8 – The level of sIgA in coprofiltrates of children while taking formula (n=2, p≤0,95)

Indicator	Group I		Group II (mixtures that do not contain nucleotides)	Group III (mixtures enriched in nucleotides)	Group IV (breastfeeding)
	Ligans	Agnus			
sIgA, mg/ml	0.071±0.005	0.070±0.005	0.006±0.001	0.032±0.004	0.074±0.005

Analysis of sIgA content in coprofiltrates of children showed that the initial content of sIgA in coprofiltrates of breastfed children is almost no different from that of children who consumed Ligans and Agnus. At the same time, the level of sIgA in coprofiltrates of formula-fed infants with nucleotide-free "initial" mixtures and nucleotide-enriched "initial" mixtures is significantly lower than in breastfed infants. This is explained by the low level of immunoglobulins in these mixtures and in the milk from which they are made.

The ability to increase the level of secretory immunoglobulin A gives grounds to recommend mixtures of Ligans and Agnus for breastfeeding infants with reduced immunity to increase the body's resistance.

Conclusion

The possibility and expediency of using mare's and sheep's milk in the technology of dry milk formulas for baby food have been studied. Formulations of dry milk formulas based on mare's milk Ligans and sheep's milk Agnus for feeding children from birth to 6 months have been developed. Developed products meet the requirements for mandatory composition for this category of children's products. Changes in microbiological parameters of dry milk formulas during their storage have been studied. It was found that during the year of storage of Ligans mixtures, the number of B.Cereu and mesophilic aerobic and facultative anaerobic microorganisms (MAFAM) increased 2.5–3 times, and the number of microscopic fungi increased more than 4 times. No pathogenic microorganisms were detected in the mixtures. It was found that the microbiological parameters of Ligans and Agnus mixtures after a year of storage are normal.

The loss of vitamins in Ligans and Agnus mixtures during their storage was studied. Vitamins A, B_6 and B_{12} suffer the largest losses (9.0–12.0%). Some vitamins (A, E, B_1, C) are gradually destroyed during storage. Vitamins B_2 and B12 are characterized by stability during six months of storage. Taking into account the losses during the year of storage, the content of vitamins in the mixtures of Ligans and Agnus meets the requirements.

When taking a mixture of Ligans, the incidence of colitis decreased by 94%, and flatulence – by 95%. Signs of atopic dermatitis disappeared. Colitis, flatulence and atopic dermatitis in children completely disappeared when consuming Agnus mixture. A decrease in the total level of IgE by 88–90% in the blood of children indicates the hypoallergenic properties of mixtures of Ligans and Agnus.

The content of sIgA in the co-filtrates of breastfed infants and those consuming Ligans and Agnus was found to be almost the same. This confirms the effectiveness of using these products to increase the body's resistance.

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ДОСЛІДЖЕННЯ ЕФЕКТИВНОСТІ ТА ЯКОСТІ СУХИХ МОЛОЧНИХ СУМІШЕЙ ДЛЯ ДИТЯЧОГО ХАРЧУВАННЯ В ПРОЦЕСІ ЗБЕРІГАННЯ

К.О. Белінська[1], кандидат технічних наук, *E-mail*: kristina 0612@ukr.net
Н.О. Фалендиш[2], кандидат технічних наук, доцент, *E-mail*: falendysh96@gmail.com
Т.В. Марусей[1], кандидат економічних наук, доцент, *E-mail*: nikmar76@gmail.com
[1]Кафедра туризму та готельно-ресторанної справи
[1]Кам'янець-Подільський національний університет імені Івана Огієнка
вул. Суворова, 52, м. Кам'янець-Подільський, Україна, 32300
[2]Кафедра технології хлібопекарських і кондитерських виробів
[2]Національний університет харчових технологій, вул. Володимирська, 68, м. Київ, Україна, 01601

Анотація. Велика кількість дітей із різних причин не може отримувати природне харчування. У такому випадку дітей переводять на штучне вигодовування. Штучне вигодовування забезпечується за рахунок сухих молочних сумішей. Здебільшого сухі молочні суміші, представлені на ринку, виготовляються з коров'ячого молока. Але хімічний склад коров'ячого молока за багатьма показниками не відповідає жіночому молоку. Для розробки сумішей для дитячого харчування запропоновано використовувати молоко кобиляче та овече. Використовувалось молоко, зібране у фермерських господарствах Східної, Західної та Центральної України. Сухе молоко отримували розпилювальним сушінням. Розрахунок рецептур проводили шляхом оптимізації хімічного складу за допомогою стандартної програми Simplex. Розроблено сухі молочні суміші на основі кобилячого молока Ligans та овечого молока Agnus, призначені для харчування дітей від народження до 6 місяців. Проведені дослідження мікробіологічних показників сумішей показали, що протягом 12 місяців зберігання в кортонних пачках з внутрішнім пакетом з комбінованого полімерного матеріалу отримані продукти зберігають якість. За вказаний термін вміст вітамінів, які здатні до розпаду при зберіганні, також відповідає нормі. Оцінюючи переносимості сумішей Ligans і Agnus встановлено, що з прийомом сумішей частота виникнення коліту та метеоризму інтенсивно почала знижуватися. Зниження загального рівня IgE на 8890% у крові дітей свідчить про гіпоалергенні властивості сумішей Ligans та Agnus. Доведено, що вихідний вміст sIgA у копрофільтратах дітей, які перебувають на грудному вигодовуванні, майже не відрізняється від такого у дітей, які споживали суміші Ligans та Agnus. Розроблені суміші рекомендуються для підвищення резистентності організму. Ефективність сумішей підтверджено медико-біологічними дослідженнями.

Ключові слова: дитяче харчування, сухі суміші, овече молоко, кобиляче молоко.