To the issue of using secondary dairy raw materials

O N Pastukh and E V Zhukova

Moscow Agricultural Academy named after K.A. Timiryazev, 48, Timiryazevskaya str., Moscow, 127434, Russia

E-mail: pastukh.on@rgau-msha.ru

Abstract. One of the main tasks that the dairy industry is currently facing is to expand the outgoing product range, increase the production volume of the enterprise and improve the quality of its products in the conditions of a distinctive market economy. The current high level of development in the food and processing industries requires an entirely new approach to the use of raw materials. The economic essence of this approach is to create activities and implement resource-saving technologies that allow maximizing and comprehensively extract all the most valuable components from raw materials, processing them into useful products. It allows reducing or eliminating the damage that is caused to the environment only as a result of emissions from production waste. The milk processing to whole-milk products is accompanied by obtaining skimmed milk, buttermilk and whey. These main products are also secondary raw materials and resources with a generic name "secondary dairy raw materials" (SDRM). As the retail output of dairy products is increasing the question of increasing the efficiency of their production arises. First of all, it is significant for resource-saving as raw material cost reaches 80% of the cost of dairy products. The development and implementation of technological separation processes for skimmed milk, buttermilk, and whey processing are the first major tasks in the modernization of the dairy industry of Russia. Involving cycle industries allows optimizing the commercial use of raw milk, as it expands the range of functional products produced from secondary dairy raw materials.

1. Introduction
The problem of full and rational milk processing exists in all countries with developed dairy farming. The current level of development of the food and processing industry and the state of the raw material base requires a fundamentally new approach to the problem of using dairy resources. It is the creation and implementation of waste-free technologies allowing the maximum and complex extraction of all valuable components of raw materials and turning them into useful products. These technologies allow excluding or reducing the damage caused to the environment as a result of waste emissions [1-4].

Industrial traditional milk processing to whole-milk products, butter, cheese is inevitably connected to the skimmed milk, buttermilk and whey productions called «secondary dairy raw materials» (SDRM) or protein-carbohydrate dairy raw materials.

2. The purpose of the research
Processing of secondary dairy raw materials.

3. The object of the research
The object of the research was skimmed milk, buttermilk, and whey.
4. Materials and methods
The research was conducted at the Department of technology for the storage and processing of animal origin products of the Russian State Agrarian University - MTAA.

5. Discussion of the results
The composition of skimmed milk, whey, and buttermilk indicates that these are full-fledged raw materials and their biological value is almost equal to the value of whole milk. However, the skimmed milk and buttermilk energy value are almost 2 times, and it is almost 3.5 times less than whole milk. It makes it advisable to use IUD technology in dietary food products manufacturing. As the retail output of dairy products is increasing the question of increasing the efficiency of their production arises. First of all, it is significant for resource-saving as raw material cost reaches 80% of the cost of dairy products. So the production of 1 ton of butter gives 20 tons of skimmed milk and 1.5 tons of buttermilk. 1 ton of cheese and cottage cheese productions give about 9 tons of whey. Skimmed milk is also obtained when whole milk is normalized by fat. The total volume of secondary milk raw materials is about 70% of the volume of processed milk, and it reaches 15-20 million tons annually in Russia. Thus it requires a particular approach to the industrial processing organization of SDRM [3, 4].

From 50% to 75% of milk solids transit to skimmed milk, buttermilk and whey passes from 50 to 75% of milk solids (Table 1).

| Milk components (100%) | Degree of transition, % |
|------------------------|-------------------------|
|                        | in skim milk | in buttermilk | in whey |
| Dry matter             | 70,4         | 72,8          | 52,0    |
| Milk fat               | 1,4          | 14,0          | 5,5     |
| Protein                | 99,6         | 99,4          | 24,3    |
| including:            |             |               |         |
| - casein               | 99,5         | 99,5          | 22,5    |
| - whey protein         | 99,8         | 99,6          | 95,0    |
| Lactose                | 99,5         | 99,4          | 99,5    |
| Mineral salt           | 99,8         | 99,6          | 98,0    |

The mass fraction of the main components of skimmed milk, buttermilk and whey in comparison with the whole milk (in%) is shown in table 2.

| Indicator             | Whole milk | Secondary dairy raw materials (SDRM) |
|-----------------------|------------|--------------------------------------|
|                       |            | skim milk | buttermilk | whey |
| Mass fraction, %:     |            |           |            |      |
| - dry matter          | 12,5       | 8,8       | 9,1        | 6,5  |
| - fat                 | 3,7        | 0,05      | 0,5        | 0,2  |
| - protein             | 3,3        | 3,3       | 3,3        | 0,9  |
| - lactose             | 4,8        | 4,8       | 4,7        | 4,8  |
| - mineral substance   | 0,7        | 0,7       | 0,7        | 0,6  |

The primary and most valuable components of secondary milk raw materials are proteins, milk fat, and lactose. In addition to the main components, skimmed milk, buttermilk, and whey contain mineral salts, non-protein nitrogenous compounds, vitamins, enzymes, hormones, immune bodies, organic acids, i.e., almost all the components of the milk and water solids. Water is the dispersion phase of milk protein-carbohydrate raw materials, but it differs in the forms of connection with the dry substance (the dispersed phase) from whole milk. First of all, the quantity of water in this type of raw
milk is slightly higher than in whole milk. Besides, it is associated with dry matter more energy-intensive, which affects the efficiency of moisture removal processes (evaporation, drying) [3,4].

The SDRM lipid complex is represented mainly by milk fat as well as in the milk. The higher degree of fat ball dispersion in this raw material is considered specific in comparison with whole milk. The size of fat globules in the SDRM is 0.5-1.0 microns, which contributes to easier fat absorption and accelerates its lipolysis, especially in buttermilk and whey. In addition to milk fat, all other fractions of milk lipids, including phosphatides (lecithin, kefalin, sphingomyelin) and sterols (cholesterol and ergosterol) are contained in skimmed milk, whey and especially buttermilk.

All casein and whey protein fractions represent protein nitrogenous compounds of skim milk and buttermilk, and they are almost identical to whole milk. Whey contains some casein fractions that cannot be converted by enzymes and acids, and all fractions of soluble whey proteins-lactalbumin, lactoglobulin, euglobulin, and pseudo-globulin. The amino acid set of SDRM proteins includes all essential amino acids [5, 6].

SDRM non-protein nitrogenous compounds are represented by free amino acids, urea, uric and hippuric acids, creatine and purine bases, which are products of the nucleic acid breakdown. In whey, the spectrum of non-protein nitrogenous compounds is more expressed than in skim milk and buttermilk, which is the result of protein hydrolysis during the production of cheese and cottage cheese [3, 4].

Carbohydrates of milk protein-carbohydrate raw materials are mainly represented by lactose and its hydrolysis products - glucose, galactose. There is also evidence of the pentose and lactulose presence in SDRM [7].

Organic and inorganic compounds represent minerals of secondary dairy raw materials in the form of salts in a free and bound state as well as in whole milk. Macronutrients of mineral substances are represented by cations of potassium, sodium, calcium, magnesium, and anions of citric, phosphoric, lactic, hydrochloric, sulfuric and carbonic acids. Dairy raw materials also contain all the milk microelements: iron, copper, manganese, cobalt, iodine, silicon, germanium. There are fewer mineral salts in whey compared with skimmed milk and buttermilk since some of the salts transit to the main product (cheese, cottage cheese). At the same time, it is necessary to take into account the introduction of certain salts in the SDRM during milk processing (calcium chloride) [3, 4].

It should be noted the significant decrease of the fat-soluble vitamin content in the SDRM in comparison with whole milk (table. 3). This fact should be taken into account when products from skimmed milk, buttermilk, and whey have to be enriched with vitamins A, D, and E. At the same time the content of pyridoxine (B6), choline and riboflavin (B2) in whey exceeds the indicators in milk. Those components are due to the vital activity of lactic acid bacteria [8,9].

| Indicator       | Whole milk | Secondary dairy raw materials (SDRM) | Skim milk | Buttermilk | Whey |
|-----------------|------------|--------------------------------------|-----------|------------|------|
| Thiamine (B1), mg / kg | 0,45       | 0,35                                 | 0,36      | 0,37       |
| Riboflavin (B2), mg / kg | 1,5        | 1,8                                  | 2,0       | 2,0        |
| Pyridoxine (B6), mg / kg | 0,33       | 1,5                                  | 1,6       | 1,3        |
| Cobalamin (B12), mcg / kg | 4,0        | 4,0                                  | 4,2       | 2,6        |
| Ascorbic acid (C), mg / kg | 1,5        | 2,3                                  | 2,7       | 4,7        |
| Retinol (A), mg / kg | 0,25       | 0,03                                 | 0,08      | 0,04       |
| Tocopherol (E), mg / kg | 0,85       | 0,5                                  | 0,55      | 0,29       |
| Biotin (N), mcg / kg | 56,0       | 0,01                                 | 0,01      | 0,01       |
| Choline, mg / kg | 313,0      | 328,0                                | 466,0     | 662,0      |

Table 3. Vitamin content in SDRM
SDRM enzymes belong to the groups of hydrolases, oxidoreductases, transferases, lyases, isomerases, and ligases. Moreover, the enzyme systems are more expressed in whey and buttermilk obtained from sour butter. It must be taken into account in their storing and processing. Heat treatment of skimmed milk, buttermilk and whey allow inactivating enzymes according to the accepted pasteurization regimes [10].

The nutritional value of secondary dairy raw materials is characterized by high quality and harmlessness, good caloric content and digestibility, the optimal ratio of nutrients, biological and physiological usefulness. The energy value of skimmed milk and buttermilk is 58%, and whey is 36% of whole milk, which should be taken into account in organizing industrial processing and determining the cost. The digestibility of the SDRM main components corresponds to whole milk; it exceeds the index of 98% due to lactose and whey proteins. According to the organoleptic properties, skimmed milk and cheese whey can be classified as satisfactory raw materials, buttermilk and curd whey- optimal ones [11].

Skimmed milk is a source of high-value protein that should be attributed to the best types of animal protein. Proteins of skimmed milk are absorbed directly into the blood during splitting. Skimmed milk contains more choline which is a lipotropic anti-atherosclerotic substance. Whole milk powder contains 81 mg% choline; skimmed milk powder contains 110 mg%. Skimmed milk and its products are also rich in amino acids. For instance, the amount of essential amino acids in skimmed milk powder is 1.46 times greater than in whole milk powder [7, 11].

Beverages, especially fermented milk with fillers with full use of skimmed milk solids, represent the most significant interest in terms of nutritional value. The technology of such products is almost identical to one of the whole milk products. Significant importance is the milk-protein concentrate production from skimmed milk. A separate group of products from skimmed milk is feed products and substitutes for whole milk in liquid, condensed and dry form for young farm animals [12].

Buttermilk is a by-product in butter production. It has unique properties that make it classified as dietary products and products made from buttermilk – as medicinal. Buttermilk is a product of high biological value which is due to the presence of a phospholipids complex considered as lipotropic substances. Up to 75% of phospholipids pass into buttermilk during the butter production. Phospholipids possess biological properties: they are part of tissues, blood and cell membrane systems, they participate in the normalization of fat and cholesterol metabolism and activate the work of enzymes. The particular value of buttermilk is due to the most active form of lecithin as it is connected with protein. Its consumption is almost unlimited for all age groups of people. Buttermilk contains a minimum amount of cholesterol (30 mg per 100 g). Therefore it does not have atherogenic properties [10, 11]. Buttermilk milk fat is also represented by high-value fatty acids: linoleic, linolenic and arachidonic. Buttermilk lactose normalizes fermentation processes by preventing the development of putrefactive processes and autointoxication. This SDRM is recommended for comprehensive implementation in the nutrition for all age groups [10].

The composition and properties of buttermilk depend on the butter production method. So there are the following types of buttermilk: buttermilk obtained in the production of butter by churning cream on butter producers of periodic and continuous action; buttermilk obtained in the production of butter by converting high-fat cream. Besides, there is a distinction between buttermilk obtained in the production of sweet butter (acidity 16-21°T) and buttermilk obtained in the production of sour butter (acidity 50-70°T). These fundamental differences must be taken into account in organizing industrial processing and using buttermilk. Buttermilk from sweet butter (sweet) with the currently dominated production is close to natural and skimmed milk in acidity and can withstand the heat treatment. Buttermilk obtained from sour-butter does not withstand heat treatment which complicates its use for food purposes. According to the small volumes of such buttermilk, its processing and use in the food industry are not specific and considered rarely [10].

Buttermilk is an essential source of high – grade protein, and it consists of 8.5-9% of dry substances and 3.2-3.5% of proteins (Table 4). In 100 kcal buttermilk contains the same amount of protein as sturgeon and chicken meat. Its proteins are among high value, including an optimally
balanced amount of vital amino acids. Lysine, methionine, and cystine contained in buttermilk are unique lipotropic properties. Useful properties of buttermilk proteins are particularly effective with the complex of vitamins present in it: thiamine, riboflavin, cobalamin, biotin and ascorbic acid. At the same time, the caloric content of 100 g of buttermilk is 33-36 kcal, which is 2 times lower compared to milk and fermented dairy drinks [7, 10].

Table 4. Composition and properties of buttermilk

| Indicator                        | Method of buttermilk production |
|----------------------------------|---------------------------------|
|                                  | the method of churning         |
|                                  | periodical                     |
|                                  | continuous                     |
|                                  | the method of converting high-fat cream |
| Mass fraction, %:                |                                 |
| - dry matter                     | 9,1                             |
| - dry skim milk residue          | 8,9                             |
| - fat                            | 0,5                             |
| - squirel                        | 3,2                             |
| - lactoses                       | 4,7                             |
| - mineral salt                   | 0,7                             |
| Density, kg / m³                 | 1032                            |
| Acidity, T                       | 20-50                           |
|                                  | 1030-2                          |
|                                  | 1031                            |

In comparison with skimmed milk, the specific feature of buttermilk is a higher content of milk fat and increased biological value, which is associated with the qualitative characteristics of the lipid complex. The buttermilk fat peculiarity is its high degree of dispersion which increases the digestibility of buttermilk to 94-96 %. Thus despite the low-fat content, it has high biological activity in buttermilk and has a positive effect on a human body [10].

Almost all milk proteins transit to buttermilk and their positive effect is enhanced by technological processing: separation, pasteurization, and mechanical action during oil formation. Protein micelles are dispersed, facilitating their assimilation. Buttermilk proteins consist of 18 amino acids, including lysine, methionine, cystine, which have anti-sclerotic properties. The beneficial properties of buttermilk proteins are naturally enhanced by a complex of vitamins, especially group B, including choline and pantothenic acid [10].

The mineral complex of buttermilk performs a variety of functions in the body: building the supporting tissues of the skeleton (Ca, Mg), maintaining the necessary osmotic pressure in cells and blood, ensuring metabolic processes (Na, K), oxygen transfer (Cu, Fe), synthesis of vitamins and enzymes. Thus buttermilk is quite a complete food product due to its mineral composition. [7,10].

The therapeutic effect of buttermilk is due to its multiple properties. As whole buttermilk does not contain any substances affected the metabolism, growth and general condition of the body badly. The medicinal properties of sour buttermilk have been practically used in the treatment of dyspepsia and other children's diseases, as well as in diseases of the liver, kidneys, and gastrointestinal tract since ancient times. In recent decades, the therapeutic use of buttermilk, including sweet one, has expanded significantly, especially for the prevention of atherosclerosis, hypertension, cardiovascular abnormalities, colitis, flatulence, and other intestinal diseases. Thus, buttermilk is a biologically complete product which has both medicinal and dietary properties and is widely used in nutrition.

In the dairy industry buttermilk is used for the production of medicinal products to reduce the energy value of dairy natural and fermented drinks especially with fillers, condensed and dry concentrates, baby food products, high-protein products, as an additive in food products primarily dairy [7,10].

For considering the composition and value of buttermilk the main directions of processing can be recommended.
Buttermilk obtained from the sweet butter production might be used for normalization of raw materials in the production of all types of dairy products, production of natural and fermented milk drinks, with fillers and without fillers, production of protein products (cottage cheese and cheese), production of canned milk (condensed and dry buttermilk); separation of buttermilk components by ultrafiltration; use of buttermilk and products derived from it in the production of food products (baking, confectionery industry); use in the production of whole milk substitute.

Buttermilk from the production of sour-butter obtained by churning cream might be used in the production of beverages in natural form or with fillers; production of fermented milk drinks; production of protein products; production of ice cream; use in the production of food products; use in the production of fermented whole milk substitute.

Whey is a by-product left in the production of traditional protein and fat products like cheese, cottage cheese, and casein. The theoretical volume of the obtained serum (yield) is approximately 90% of the processed raw materials. In practice, the output is from 65 to 80% taking into real account losses. Therefore 1t of milk processing for protein and fat products gives 800 litres of whey. In the world, up to 100 million tons of whey is obtained annually from the production of cheese, cottage cheese, and casein.

Depending on the type of main product obtained by traditional technology, whey is designated as podsyrnaya, cottage cheese, and casein whey. Non-traditional methods of milk processing lead to the formation of whey-filtrate analogues (membrane separation of milk) and the with-no-casein phase (separation of milk by biopolymers) [3-6].

Milk whey is a biologically valuable food product due to the significant content of lactose (Table 5). In comparison with other carbohydrates, the slow hydrolysis of lactose limits the fermentation processes normalizes the vital activity of the useful microflora and prevents autointoxication. Whey proteins, which are an essential component of whey, are optimally balanced by the amino acid set, especially the sulfur-containing amino acids-cystine, methionine. The last ones create excellent opportunities for the regeneration of liver proteins, haemoglobin and blood plasma proteins. The exceptional value of milk fat should be emphasized as it is more dispersed than in whole milk with its small content in whey. Serum mineral salts are almost identical to whole milk salts and contain "protective" complexes with anti-sclerotic action [13].

| Table 5. Composition and properties of whey |
|---------------------------------------------|
| Indicator                  | cheese | curd    | casein   |
| Dry matter, %:             |        |         |          |
| - fat                      | 0,05-0,5| 0,05-0,4| 0,02-0,1 |
| - protein                  | 0,5-1,1 | 0,5-1,4 | 0,5-1    |
| - lactoses                 | 3,9-4,9 | 3,2-5,1 | 3,5-5,2  |
| - mineral salt             | 0,3-0,8 | 0,5-0,8 | 0,3-0,9  |
| Acidity, T                 | 12-25  | 50-85   | 50-120   |
| Density, kg/m³             | 1018-1027 | 1019-1026 | 1020-1025 |

The main component of whey is lactose, which is 70-75% in dry matter. This amount of lactose is slightly less in curd whey due to fermentation into lactic acid, which affects the whey acidity. The degree of individual milk component transition to whey is associated with the processes of gelation and syneresis.

Up to 12.4% of fat is converted to whey, but its full content varies widely depending on the fat content of the raw material and the technology, and it can account from 0.05 to 0.5%. Milk fat in whey is dispersed more than in whole milk. For example, the number of fat globules less than 2 microns in whey is 72.6%, and in milk 51.9%. The composition of the carbohydrate complex of whey includes monosaccharides, oligosaccharides, and aminosaccharides. Curd whey contains 0.7-1.6% glucose,
which is due to the hydrolysis of lactose in the production of cottage cheese. Neuroaminic acid, sialic acid, and ketopentose were found in the whey. Oligosaccharides are represented by lactose, lactulose, and serologically active sugars which are similar to the blood composition.

A fundamentally new methodological approach to the assessment of raw materials in the dairy industry has allowed solving the scientific problem of developing a new generation of technologies for whey products, some of which are still not used, which causes not only economic but also environmental damage. Full use of the entire milk residue of whey is associated with the production of beverages, condensed and dry products. In a market economy, the industry is particularly interested in obtaining low-alcohol beverages; condensed concentrates with sucrose and glucose-galactose syrups; dry dairy products based on whey. In terms of food products for direct consumption, it is advisable to implement numerous recipes for drinks based on whey such as kvass, koumiss, with fillers and flavourings. Thickening and drying make it possible to smooth the seasonality of production of dairy raw materials [12].

Obtaining individual components from whey is connected to the extraction of milk fat (cream), whey proteins, and lactose. Protein products from whey in native or denatured forms have not yet found mass use for food purposes although they deserve it. The processes of obtaining albumin (cottage cheese "Nadugi") and protein masses such as "rikota" as well as the technology of cheese mass "Kavkaz" are most developed. The technology for obtaining and using the mineral complex of whey has not been completely developed so far. The vitamin complex, free amino acids, including taurine and lactoferrin of whey, are of the most interest. Isolation of those amino acids has been already tested abroad [12].

Whey drying is always less effective in comparison with whole and skimmed milk. Besides, it is complicated by free lactic acid, especially in curd and casein whey. Such fillers as skimmed milk, flour, soy must be added to the whey before drying to eliminate these issues. Practical interest is in obtaining products from whey with average humidity in granules and briquettes.

In recent years special interest has been worldwide shown to membrane methods of processing whey (membrane technology): gel-filtration, hyperfiltration (micro-, ultra-, reverse osmosis), electrodialysis, ion exchange, flotation, sorption-desorption. These methods are based on the selective principle of molecular sieve filtration, so they consume a small number of energy resources and preserve the fundamental properties of whey components. They are also considered environmentally friendly. Ultrafiltration and electrodialysis have been found practical implementation [3-6, 12].

A special place in the industrial whey processing is occupied by biological methods (biotechnology): microbial synthesis and enzymatic catalysis. Cheese whey is good for the biological conversion of lactose, whey hydrolysates, and biologically active substances (BAS) extraction. It keeps a significant part of the protease enzyme and accumulates a powerful potential of pure cultures of lactic acid bacteria. As a result of biotechnological processing, Curd whey is enriched with BAS, pure cultures of lactic acid bacteria in the results of biotechnological processing. In fact, it can be ready for its use in the natural form as a fermented dairy drink.

The issue of whey processing is directly related to the rational, cost-effective use of the products obtained from it. Direct consumption products made from all types of whey can be: liquid drinks, condensed (syrups) and dry; cheeses of the Norwegian type; hydrolysates of whey proteins; lactose hydrolysates; butter from cheese cream; protein products (albumin milk and protein mass, albumin cottage cheese).

Whey and all its obtained products are widely used in the baking and the confectionery industries, the production of ice cream, desserts, honey substitutes, eggs, baby food, food vinegar, and lactic acid. Domestic and foreign experience shows that there is a possibility of replacing flour, enriching bread and eliminating potato disease by adding whey in natural, condensed and dry forms. Indirect methods of nutritional whey use are using it for feed purposes directly in the form of components, enriched products, silage and whole milk substitute. Thus, the industry has a large number of proven technologies for food products made from whey [4].
Significant volumes of secondary dairy raw materials and their sufficiently high nutritional value make it necessary to collect and use them rationally fully. Domestic and foreign experience shows that the solution to this problem is only on thy organization of industrial processing of this type of dairy raw materials into food products, feed semi-finished products, technical and medical preparations. Recycling production lines have begun to appear in specialized dairy enterprises since the 60s of the XX century. Where all secondary resources and waste from the dairy business were processed into dry concentrates, in small enterprises and farms, dairy protein and carbohydrate raw materials must also be thoroughly and efficiently to produce dairy products and not only to feed animals [3, 4].

Generally, secondary dairy products can be characterized by the phrase "minimum calories with maximum biological value". This process allows considering skimmed milk, buttermilk, whey and products made from them as biologically complete products with dietary and even medicinal properties protecting the internal environment of the body. All of the above makes the functional dairy drink production from secondary dairy raw materials very relevant.

There are two main directions of industrial processing of skimmed milk, buttermilk, and whey:
- full use of all raw materials components (beverages, condensed and dry products, whole milk substitutes);
- separate use of raw materials components (extraction of milk fat, proteins, lactose).

In recent years, a new, third direction has been formulated and scientifically developed. It is the production of derivative components of dairy raw materials (hydrolysates of casein and whey proteins, glucose-galactose syrups, ethyl alcohol, lactulose, lactitol). It should be noted that lactose derivatives called galactooligosaccharides and lactulose are excellent components for functional food products which are considered as healthy food products.

The main directions of processing skimmed milk, buttermilk, and whey depending on the final product are presented in the form of a diagram (Figure 1).

**Figure 1.** Main directions of SDRM processing

Milk drinks from secondary milk raw materials are produced in fresh or fermented form. Fresh drinks made from natural raw materials are available with or without fillers. It involves skimmed pasteurized or sterilized milk; pasteurized buttermilk; pasteurized whey. Flavouring additives, vegetable and fruit juices, concentrates of wild plants are used as fillers. The most familiar fermented dairy drinks are buttermilk diet; fermented buttermilk; low-fat yoghurt; low-fat yoghurt; a drink from the clarified whey; cocktails.

Protein dairy products represent a large group in terms of assortment and volume of production. They include low-fat cheeses; cottage cheese and low-fat cottage cheese products; milk-protein concentrates (Caseins and Caseinates); products and semi-finished products from whey proteins. Protein-carbohydrate products combine condensed foods with sugar and without sugar; whey with sugar and without sugar; dry products (skimmed milk powder, whey powder, dry buttermilk). Lactose-
based products include milk sugar, which is produced in the form of semi-finished products (raw sugar) and refined products. Lactose-based food products are produced for the baking and confectionery industry [3, 4].

Great importance for the development of the Russian agro-industrial complex is the production of feed products and, in particular, for the drinking of young animals – whole milk and skimmed milk substitutes. At the end of the last century, domestic and foreign scientists developed and introduced technologies and recipes for whole milk substitutes for various animals.

6. Conclusions
The development and implementation of technological processes for processing secondary raw materials are one of the essential tasks for modernizing the Russian dairy industry. The processing of skim milk, buttermilk, milk whey allows optimizing the use of raw milk, to expand the assortment of dairy products, including functional dairy products.

Skimmed milk, buttermilk, and whey which are secondary resources of the dairy subcomplex of the agro-industrial complex should be used thoroughly and efficiently. Secondary raw materials with whole milk and cream form a complex that can be called the term "dairy raw materials". This result is of particular importance in a market economy for implementing the principles of waste-free production of dairy products.

The use of new physical, chemical, and biological methods of molecular sieve filtration and cryotechnology allows the milk separation or concentration of milk components being targeted and avoid obtaining by-products.

Industrial processing of skimmed milk, buttermilk and whey make it possible to implement the principles of waste-free technology, increase the resources of full-fledged food products, increase the economic efficiency of production and eliminate environmental pollution. Marketing of finished products allows getting a significant economic benefit which is approximately equal to half the cost of raw materials.

References
[1] Poymanov V V, Grishanova D S and Antipov S T 2018 Research on the processes of freezing and vacuum freeze-drying of bacterial concentrates for the dairy industry Bulletin of VGUIT 80 (4) 19-24
[2] Ivkova I A, Scriabin O V, Ryabkova D S, Diner Yu A and Petrova E I 2018 Development of technology and research on the quality of canned milk for regions with limited resources of natural dairy raw materials Bulletin of VGUIT 80 (3) 254-258
[3] Khramtsov A G and Nesterenko P G 1989 Waste-Free technology in the dairy industry (Moscow: Agropromizdat)
[4] Khramtsov A G and Vasilisin S V 2003 Industrial processing of secondary dairy raw materials (Moscow: Delhi print)
[5] Sinelnikov B M, Khramtsov A G, Evdokimov I A, Ryabtsev S A and Serov A V 2007 Lactose and its derivatives (SPb.: Profession)
[6] Pastukh O N 2019 Milk drinks based on whey Proceedings of the International scientific and practical conference: Innovative processes in food technologies: science and practice pp 291-295
[7] Semenikhina V F and Rozhnova I V 2002 New achievements in the technology of fermented milk products Dairy industry 9 41-42
[8] Sokolova Z S, Lakomova L I and Tintyakov V G 1992 Technology of cheese and whey processing products (Moscow: Agropromizdat)
[9] Krasulya N S and Silin V I 1996 Drinks from buttermilk Dairy industry 4 72
[10] Matviyevsky V Yu 2010 Industrial processing of buttermilk Milk river 6 23-24.
[11] Tikhomirova N A 2001 Technology of therapeutic and preventive nutrition products (Moscow MGUPB)
[12] Khramtsov A G 2011 *The phenomenon of whey* (SPb.: Profession)

[13] Pastukh O N 2017 Import Substitution in cheese-making *Perspectives of new generation food production* Materials of the all-Russian scientific and practical conference with international participation dedicated to the memory of Professor George Saprygin pp 409-410