Systematization and ranking of linguistic terminology of secondary dairy raw materials in its rational use

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Abstract. Any spontaneous or directed and controlled bioenergy effect on milk as a heterogeneous biotechnological system leads to the inevitable emergence of a fundamentally new type of dairy raw material. When producing products depending on the processing methods used: traditional, based on biotechnology (starters, enzymes) and the use of chemical reagents (acid, alkali, salt) and innovative separation methods (membrane, etc.), two large classes of lactose-containing raw materials are formed: traditional and innovative. For a number of years, this raw material has been generically called by various terms. It is known that the terminology distorting the essence of the subject often leads to negative consequences. Therefore, the name of the raw material should reflect not only the essence, but also focus on the content of valuable components that need to be used for food or feed purposes. Based on the analysis of modern terminology, the classification of dairy products proposed by academician N.N. Lipatov and Professor Z.M. Tskitishvili was chosen as the basic one. When compiling this classification, experience was used to create a classification of technological liquids as ultrafiltration objects, which reflected milk whey. It is based on the detailing of milk-protein lactose-containing raw materials, namely, one of its classes which are lactose-containing raw materials. The following is the systematization and ranking of linguistic terminology of secondary dairy raw materials in the aspect of its rational use.

1. Introduction

At dairy enterprises all milk raw materials under processing undergo various treatments in order to obtain the required products [1]. In this case, the so-called by-product milk raw materials such as skimmed milk, buttermilk and milk whey are formed [2].

In accordance with the provision of modern monitoring, as a tracking system for an object, it is necessary to present milk from the perspective of the biotechnological system (BTS), while recognizing the legality of the biotechnological system of milk (BTS M) term [3].

Any spontaneous or directed and controlled bioenergy effect on milk as a heterogeneous biotechnological system (BTS M) [4] leads to the inevitable appearance of a fundamentally new type of milk raw material: whey of milk - milk whey or dairy whey (briefly - whey) [5]. In total, according to approximate calculations (based on the assortment of cheeses, cottage cheese and caseins), there are more than 15,000 types of whey in the world [4, 6].
In our country we can name about thousands of species [7]. In practice, they usually deal with two categories of milk whey - sweet and acidic. They are by-products of cheese making (sweet whey) or from the production of cottage cheese and casein (acidic whey).

The name of the raw material should reflect not only the essence, but also focus on the content of valuable components that should be used for food or feed purposes. Currently, in relation to whey, we can talk about the legislative framework of the federal level - Federal Law No. 88 TR, which clearly classifies it as secondary raw materials of the dairy industry (i.e. dairy raw materials), with all the consequences arising from this provision. For a number of years, the raw material for the production of milk sugar was terminologically called by various terms [7, 8]. The following is the systematization and ranking of linguistic terminology of secondary dairy raw materials in the aspect of its rational use.

2. Materials and methods

All dairy raw materials were selected as the source material hierarchy for linguistic analysis. The table 1 shows the composition of the main components of the ranked milk raw materials.

Table 1. Main components in whole milk, skimmed milk, buttermilk and whey, %.

| Components          | Whole milk | Secondary dairy raw materials |
|---------------------|------------|--------------------------------|
|                     |            | Milk whey | Skimmed milk | Buttermilk |
| Solids, %           |            | 12.5      | 6.3          | 8.8        | 9.2        |
| Including:          |            |           |              |            |            |
| Fat                 | 3.6        | 0.2       | 0.05         | 0.5        |
| Proteins (nitrogenous substances) | 3.2 | 0.8 | 3.2 | 3.2 |
| Lactose             | 4.7        | 4.7       | 4.7          | 4.7        |
| Minerals            | 0.7        | 0.6       | 0.7          | 0.7        |

Considering the main components of the above dairy raw materials, it should be noted that half of milk solids pass into whey. Taking into account this postulate, milk whey was selected for systematization and ranking of linguistic terminology of secondary milk raw materials. The content of identified (sample) compounds in whey is the average data compared to milk and they are shown in table 2.

Table 2. Whey Composition vs. Whole Milk.

| Components                  | Content in 100 g | Degree of transition, % |
|-----------------------------|------------------|-------------------------|
| Solids, g                   | Whey: 6.3        | Milk: 12.7              | 52.83        |
| Proteins, g                 | 0.89             | 3.2                     | 27.81        |
| Fat, g                      | 0.36             | 3.6                     | 60.00        |
| Carbs, g                    | 4.55             | 4.8                     | 94.80        |
| Organic acid, g             | 0.016            | 0.16                    | 10.00        |
| Minerals (ash), g           | 0.7              | 0.7                     | 100          |
| Amino acids, mg             | 873              | 3144                    | 27.77        |
| Macroelements, mg           | 283              | 559                     | 70.00        |
| Micronutrients, mg          | 501.15           | 716.7                   | 70.00        |
| Vitamins, mg                | 1.728            | 2.36                    | 73.22        |
| Vitamin-like substance, mg  | 54               | 53.6                    | 101.70       |
| Water, g                    | 93.66            | 87.3                    | 107.28       |

More than 2000 compounds [8] are identified in milk whey and contain about 100,000 molecular structures [9], which are in dissolved (nanolevel) and colloidal-dispersed (clusters) states, as well as in the form of suspension (casein dust) and emulsion (milk fat) [1, 8]. Physical and chemical analysis of dairy raw materials was carried out in accordance with the classical developments [Teppel] and the.
requirements adopted in the dairy industry for all standardization levels [PG, HR FMS, Gorlov Lactul]. The article uses tested (published) data from reliable sources [2, Gorlov Lactul]. Benign (purity) was calculated as the percentage ratio of lactose to dry matter.

3. Results and discussion

It seems necessary and relevant to systematize and rank the linguistic terminology of secondary dairy raw materials. This work was carried out by conducting a comparative analysis of the validity and legality of the terminology of raw materials resulting from various methods of processing milk raw materials (separation, heating, coagulation, precipitation, microfiltration, etc.).

The ranking of components of milk raw materials depending on the classification type, with emphasis on the selected milk whey, is graphically presented in figure 1 [6].

\[ \text{Figure 1. Ranking of main whey components versus whole milk, defatted milk and buttermilk.} \]

The fact that in general the traditional milk whey contains half of the milk solids and up to 70% lactose makes it possible to consider it a carbohydrate raw material. The conversion of the main components of the raw material milk to milk whey depends on the method of its production and is shown in table 3.

Table 3. Transition of main milk components to milk whey.

| Milk component | Degree of conversion of components to milk whey, % |
|----------------|-----------------------------------------------|
|                | Traditional | Innovative methods |
| Milk fat       | 7.7         | 0.0               |
| Proteins:      | 22.5        | 0.0               |
| Casein         | 95.0        | 98.0              |
| Serum          |             |                   |
| Lactose        | 96.2        | 96.5              |
| Mineral salts  | 81.1        | 60.6              |
| Solids         | 49.9        | 45.1              |
The use of innovative methods such as membrane filtration, thermodynamic separation by biopolymers allows to extract milk fat and casein complexes completely. At the same time, the degree of conversion of the components of the initial milk raw material into milk whey, with traditional methods for producing protein-fat products - PFP (coagulation and syneresis), can be presented in the form of a diagram (figure 2).

![Figure 2. Conversion of milk raw material components to whey.](image)

It follows from the diagram that about half of the dry matters of the raw milk are converted to milk whey. Thus, this is a sufficient basis for the term "half-milk". The patterns of the conversion of milk components have not yet been established, but the relationship

The information data file above allows for a brief discussion of the termological definitions associated with the industrial processing of milk. The term "production waste" was not only deeply flawed but also harmful. Waste is what is to be disposed of. It is obvious that this was one of the main reasons for the neglect of the processing of skimmed milk, buttermilk and whey, which in its turn led to the low efficiency of the manufacture of products from such raw materials.

Raw materials used again are called secondary. Skimmed milk, buttermilk and milk whey cannot be classified as secondary raw materials because they are whole milk products and are not used for a second time. The authors believe that this term requires additional explanation i.e. secondary (milk-protein) raw materials. In accordance with GOST R 513-917-2002 "Dairy and milk-containing products. The terms and definitions"these objects have a conditional generalizing term which is secondary dairy raw materials and of advisory nature. By analogy with secondary raw materials, the term "secondary material resources," in relation to milk raw materials, is not entirely legitimate. According to this terminology, skimmed milk, buttermilk and milk whey are referred to as secondary raw materials, which can be combined by the generalizing term low-fat dairy raw materials.

The term low-fat dairy raw material only indicates the absence of fat in the dairy raw material: skimmed milk, buttermilk and whey formed in the production of butter, natural cheeses, cottage cheese and milk protein according to traditional technology, so this term cannot be considered exhaustive either. In some publications it is found that low-fat dairy raw materials are normal by-products.

The use of the term "by-product" or "secondary dairy" according to some authors is synonymous with the term "normal by-products." These terms are scientifically unsubstantiated. There is a natural underestimation of this raw material, which significantly affects the processing of skimmed milk, buttermilk and whey. The term “intermediate raw materials (by-products)” used does not disclose the essence of these raw materials, does not show its true significance, therefore it also cannot be considered exhaustive. In this regard, it was proposed to call these types of raw materials by the term “milk-protein raw materials". A number of authors consider intermediate (associated) products such as albuminous milk (protein mass) and milk sugar molasses an additional source of raw materials in the dairy industry.
Based on modern views on the construction of terminology, which was given great attention by academician N.N. Lipatov, it was proposed to introduce the term “milk-protein lactose-containing raw materials” for the general characteristic of skimmed milk, buttermilk and whey. The introduction of this term, according to the authors, will increase the responsibility for the use of this raw material at all levels of production, planning and control bodies. Recognizing the validity of such a definition V.A. Pavlov believes that it is complicated. In this regard, he suggests to call skimmed milk, buttermilk and milk whey as “milk protein-carbohydrate raw materials”. Both terms define the essence of the feedstock. The name of the raw material should reflect the essence and focus on the content of valuable components.

Distorting the essence of the subject terminology can lead to negative consequences. Based on the analysis of modern terminology, the classification of dairy products proposed by academician N.N. Lipatov and Professor Z.M. Tsikitishvili was chosen as the basic one. When compiling this classification, experience was used to create a classification of technological liquids as ultrafiltration objects, which reflected milk whey. It is based on the detail of milk-protein lactose-containing raw materials, namely, one of its classes - lactose-containing raw materials. The absence of the term “milk-protein” is explained by two reasons. Firstly, lactose is a unique species of carbohydrate of animal origin - carbohydrate of milk, which is practically not found in nature. Secondly, protein substances are present in residual amounts in classified raw materials. Such a name as “lactose-containing raw materials” defines its main component and emphasizes the importance of the raw materials as a source for the production of lactose and its derivatives.

Traditional methods of processing milk, based on biotechnology (starters, enzymes) and the use of chemical reagents (acids, alkalis, salts), lead to the formation of syrup, cottage and casein whey. In the technology for the production of milk sugar in the form of crystalline α-lactose monohydrate, an molasses intercrystal liquid is formed. The listed objects belong to traditional lactose-containing raw materials.

In the manufacture of products with the use of innovative methods of separating milk, buttermilk and whey, for example, membrane methods, leads to the formation of filtrates (permeates). Due to the fact that the compositions of filtrates differ depending on the separation process micro- and ultrafiltrates are closer compared to nanofiltrates. It is necessary to isolate several objects in the group.

The use of electrophysical effect and thermodynamic incompatibility of casein fractions of milk proteins with some polysaccharides and biopolymers (sodium carboxymethyl cellulose, pectin, etc.) leads to the production of the non-casein phase. Production of lactose-free milk from dry skimmed milk by extracting lactose and mineral salts with an aqueous-alcoholic or aqueous solution with a certain pH leads to formation of extracts. All of these resulting separation products should be referred to as unconventional lactose-containing raw materials using unconventional treatment methods.

Based on the analysis of modern terminology of secondary dairy raw materials, the term lactose-containing raw materials is adopted as the basic term that most accurately reflects the essence. Depending on the methods used to process milk raw materials i.e. traditional, based on biotechnology (starters, enzymes) and the use of chemical reagents (acid, alkali, salt) and innovative separation methods (membrane, etc.) two large classes of lactose-containing raw materials traditional and innovative are formed in the production of dairy products. Actual content of components and integrity of traditional and non-traditional raw materials are given in Table 4.

Table 4. Composition and qualities of traditional lactose containing raw materials (averaged data).

| #  | Indicators                     | Mass fraction, % | Integrity, % |
|----|-------------------------------|------------------|--------------|
|    |                               | Solids | Lactose | Ash | Protein |              |
| 1  | Unsalted raw whey             | 6.2    | 4.87    | 0.54 | 0.78    | 78.5         |
| 2  | Salted raw whey               | 9.2    | 4.10    | 2.14 | 3.11    | 44.6         |
| 3  | Cottage whey                  | 6.3    | 4.39    | 0.71 | 0.84    | 69.7         |
| 4  | Casein whey (lactic acid)     | 6.6    | 4.25    | 0.72 | 1.10    | 64.4         |
| 5  | Casein whey (salt- acid)      | 5.7    | 4.10    | 0.75 | 0.80    | 70.2         |
| 6  | Thermochlor-calcium deposition whey | 5.7 | 4.55 | 0.57 | 0.32 | 79.8 |
Analyzing the given data of table 4 it should be noted that raw whey integrity level has obvious advantage among lactose containing raw materials. Comparative analysis of innovative raw materials on an example of its ultrafiltrates compared to raw whey is given in table 5.

Table 5. Comparative analysis of raw whey composition and its ultrafiltrates.

| Indicators                          | Raw whey | Acid purified | Acid-alkaline purified | Industrial | Laboratory |
|------------------------------------|----------|---------------|------------------------|------------|------------|
| Mass fraction, %: solids           | 6.22     | 5.76          | 5.74                   | 5.45       | 5.43       |
| Lactose                            | 4.52     | 4.53          | 4.55                   | 4.61       | 4.63       |
| Total protein                      | 0.78     | 0.42          | 0.36                   | 0.24       | 0.21       |
| Non-protein nitrogenous substances | 0.19     | 0.21          | 0.23                   | 0.18       | 0.17       |
| Ash                                | 0.62     | 0.61          | 0.67                   | 0.48       | 0.47       |
| Integrity, %                       | 72.7     | 78.6          | 79.3                   | 84.6       | 85.3       |

The level of lactose containing raw materials integrity is noticeably increased under the membrane processing according to table 5. It should be noted that in the adopted in GOST R 51917-2002 "Dairy and milk-containing products. The terms and definitions "conditional generalizing term “secondary dairy raw materials” are advisory in nature and do not conflict with the term proposed by us i.e. lactose-containing raw materials related exclusively to the production of dairy sugar.

4. Conclusion
The suggested classification determines the prospects for the use of lactose-containing raw materials, which are focused on the production of lactose (crystalline milk sugar in a – form and amorphous in b – form), its derivatives (glucose – galactose syrups; lactulose; lactitol) and other products (beverages; fodder, etc.). Of particular importance is prebiotic No. 1 in the world of lactulose as a fundamental information.

References
[1] Gorlov I F 2018 Innovative agricultural and food technologies as the basis for the development of the agro-industrial complex of Russia Agricultural and food innovations 1(1) 7-12
[2] Khramtsov AG 2011The phenomenon of whey (Profession) 804
[3] Tepel A 2012 Chemistry and the physics of milk (Profession) 832
[4] Sama AAl-Mutwalli, Mehmet Dilaver and Derya Y Koseoglu-Imer 2020 Performance Evaluation of Ceramic Membrane on Ultrafiltration and Diafiltration Modes for Efficient Recovery of Whey Protein Journal of Membrane Science and Research 6138-46
[5] Khramtsov A G and Sergeev V N 2018 Technological breakthrough of agricultural and food innovations of dairy business on the example of universal agricultural raw materials Agricultural and food innovations 2(2) 15-20
[6] Talebi S, Suarez F, Chen G Q, Chen X, Bathurst K and Kentish SE 2020 A pilot study on the removal of lactic acid and minerals from acid whey using membrane technology ACS Sustainable Chemistry & Engineering doi:10.1021/acssuschemeng.9b06561
[7] Sinelnikov B M, Khramtsov A G, Evdokimov I A, Ryabtseva S A and Serov A V 2017 Lactose and its derivatives (Profession) 770
[8] Gorlov I F and Slozhenkina M I 2020 The use of lactulose-containing drugs in animal husbandry and in the processing of livestock products (SPHERE) 152