Life cycle assessment of the functional nutrition in the context of the circular economy

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Abstract. In accordance with the principles of sustainable development, all production wastes should be considered as sources of raw materials for other production. Whey in Russia was previously discarded with wastewater, but after studying its properties, it turned out that it has great potential for the production of protein-enriched products. And in order to further reduce the environmental impact, a milk protein life cycle assessment has been carried out. The article presents the results of the study of this assessment. The analysis was carried out for such indicators of the category as global warming potential, total emissions of substances that contribute to ozone formation, total emissions of acidifying compounds, potential for eutrophication, consumption of abiotic resources, consumption of biotic resources, water consumption, air consumption. The categories of impacts that make the greatest contribution to environmental pollution and resource consumption are identified, namely, total emissions of substances that contribute to ozone formation by categories of output flows and water consumption by categories of input flows. Recommendations was given to reduce the impact.

1. Introduction
In the dairy industry, when cheese, cottage cheese or casein are produced, whey is produced, the yield of which is approximately 90% of all milk used for the production of these products. In the Russian Federation, only 30% of whey is processed industrially, versus 80% of whey obtained in Western Europe [1,2]. For a long time, the discharge of whey with industrial waters was considered one of the relatively safe options for its disposal and was widely used at dairy enterprises. But research has shown that this way of solving the problem has a negative impact on the environment. To reduce the environmental impact of dairy production, it is necessary to analyze the possibility of its processing and the demand for the obtained raw materials on the food market. This approach to the issue of waste disposal is within the framework of the circular economy approach [3].

The circular economy is a model of production and consumption products as long as possible. In this way, the life cycle of products is extended. Unlike the traditional linear economic model based on a «take-make-consume-throw away» pattern, a circular economy is based on the notion that all waste can be considered as valuable resources in an almost closed loop, where products and the materials they contain are highly valued [4]. In practice, it implies reducing waste to a minimum. The main objective of this study
is to analyze the reduction of the environmental impact of the dairy industry in order to use the by-product for the development of functional nutrition.

To achieve the goal of the study, the following tasks were set:
1. to analyze the specialized food market;
2. to investigate the functional and technological properties of raw materials - secondary milk processing products;
3. to conduct a life cycle environmental assessment of food [5,6].

2. Results and Discussion

It is known that the growing up of an organism is characterized by a gradual decrease in the intensity of metabolic processes that underlie the vital activity of the organism. Often, most diseases of the elderly are associated with protein-energy malnutrition. Nutrition is the main factor in maintaining normal physiological condition and performance. Whey contains a large amount of whey proteins. Their biological value exceeds the value of all food proteins known in nature. Thus, whey is an excellent base for creating functional food products [7].

Today, there are a number of brands that produce protein-fortified foods. These nutritional supplements are made from whey powder. Currently, proteins are supplied to the Russian market from Lithuania, Australia and New Zealand.

The transport of this ingredient makes a significant contribution to the environmental impact. But, if we speak about production products, based on circular economy principles, we need to make full analyze using life cycle assessment method.

The method for assessing the life cycle of a product or service is based on the collection of information, comparison and assessment of input and output flows, as well as possible impacts on the environment throughout the life cycle of a product system by determining and quantifying the amount of energy consumed, material resources and emissions into the environment; quantitative and qualitative assessment of the impact on the environment; identifying and assessing opportunities to improve the ecological state of the system [3]. Based on the main principle of LCA - "from the cradle to the grave", the entire production chain is subject to greening - from the production of products to their disposal.

The main categories of environmental impacts are resource use, human health and environmental impacts. The definition of the purpose, scope, as well as the implementation of the inventory analysis are carried out in accordance with the requirements of the international standard ISO 14041 (Fig. 1) [3].
Life cycle inventory analysis is the longest and most costly stage at which data is collected on the input and output material and energy flows involved in production. To account for them, the production system is subdivided into separate modules based on the stages of the product life cycle (extraction of raw materials, obtaining semi-finished products, manufacturing, sale, use, disposal of the product).

In relation to the object of study, the life cycle stages include the production of materials; product manufacturing; use of products, recycling or disposal of waste after the end of their life (if necessary) (Fig. 1). The stage of whey use should be considered in the composition of the product, for example bread.

The structure of unit production processes is shown in Fig. 2.

The method of analyzing resource efficiency, in contrast to LCA, is based on considering only the input material and energy flows of resources in the product creation chain. The determination of resource efficiency in the life cycle is carried out on the basis of the MIPS analysis methodology [4]. The indicator MIPS (from the English Material Input per Product or Service Unit) is the specific resource intensity, which characterizes the material input per unit of product or service. The definition of this indicator is based on the "viewing" of mass and energy flows in the product chain of a product or service [7].

Environmental impact categories for LCA and MIPS analysis of whey protein include the consumption of all types of MF material resources that cross the boundaries of the production system and global categories [5].

The MIPS calculation can be performed using pre-computed MIT ratios representing the average resource intensity of the material, avoiding complex and time-consuming primary resource production calculations. The most complete database of MIT coefficients for various materials is published and constantly updated by the Wuppertal Institute [6].

During the investigation for future results we defined a protein production system.
Figure 2. Protein production system.
Block diagram of the considered product system

3. Conclusion
The results of the study are shown in Figures 4 and 5 in the form of diagrams by categories of impact of input and output streams.
Figure 4. Input Impact Categories

Figure 5. Output Stream Impact Categories
The proposed methodology for the environmental assessment of protein production comprehensively covers all aspects of environmental impact, taking into account the product life cycle.

The largest contributor by the input impact category is water consumption at the production stage due to high electricity consumption.

The largest contribution in terms of output flow categories is made by the potential of photochemical ozone formation at the transportation stage due to high fuel consumption; accordingly, an important factor is to consider the possibility of import substitution.

The assessment of the life cycle as part of the creation of an environmental product declaration shows the need for the development of import substitution in this area and the development of technology for producing protein at domestic enterprises.

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