

UTILIZATION OF WHEY IN DAIRY AND FOOD INDUSTRY PRODUCTION PROFITABILITY

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Abstract

Considering the fact that milk is one of the strategic products for the economy of each country, there is a tendency to provide the population with sufficient quantities through the development of primary milk production. According to the conducted analysis, out of 1.5 billion liters of milk per year, approximately half, about 50%, is purchased by the dairy processing industry. Milk production and processing in Serbia is mainly focused on products that do not require a lot of time nor complex or lengthy technological processes of production. Such products have a short shelf life, but are most often consumed on the market. Fermented dairy products are the most important group of products in the market structure of domestic supply and demand. These products are the most popular commercial industrial products because they contain probiotic microorganisms that have a beneficial effect on the human digestive system. Since whey is a by-product of cheese and casein production, it is one of the underutilized by-products of the dairy industry in Serbia. Therefore, the first part of this paper analyses the production of cow's milk and dairy products intended for the market in the period 2013-2015 with special emphasis on fermented milk products. The second part focuses on the utilization of whey, as one of the more effective solutions in the production of functional fermented whey-based beverages in the food industry, which mainly uses whey concentrate or whey powder.

Key words: milk products, whey, cost-effective production

INTRODUCTION

According to the Ministry of Agriculture, milk processing takes place in about 200 dairy plants in Serbia. Milk is directly submitted to the dairies by milk producers through their raw material network or is purchased from raw material companies that have their own collection facilities. Average capacity utilization of registered dairy plants is at the level of about 60%. There are 25 industrial facilities in Serbia with over 10 tons of daily milk purchase, accounting for 85% of purchased milk. Then, there are 175 small milk facilities, with daily purchase of 3-10 tones, accounting for 15-20% of purchased milk. There are numerous mini-dairies that purchase less than 5 tons per day [5]. From the standpoint of the range of finished products according to the installed capacities, there are several different kinds of basic facilities for raw milk processing. There are capacities:

-For the production of pasteurized and

sterilized milk (i.e. drinking milk)

-For the production of fermented products (yogurt, sour cream, sour milk, etc.) and

-For the production of solid dairy products (cheese, butter and milk powder).

Production capacities of the majority of dairy plants are predominantly oriented toward the production of fermented milk products and the production of solid milk products; whereas the production of liquid milk products (drinking milk) is significantly lower [11]. Milk producers are the largest producers of whey, which is formed during the production processes in an amount that is approximately equal to the amount of processed milk. Whey processing would lead to an increase in its price and would solve the problem of its utilization which would consequently have a direct economic benefit for the producers.

Whey contains high amount of lactose, proteins of highest biological value, essential minerals and immunoactive substances as well as the B-group vitamins. Such

composition makes it convenient for the preparation of fermented and probiotic beverages where within a single process all the potential of whey as a raw material is exploited. Thus, material which is a hazardous biological pollutant is removed from the environment, and on the other hand an inexpensive, completely healthy and natural product is obtained [13].

Production of fermented whey beverage makes whey become a healthy and tasty product with extended shelf life, which, according to numerous studies, has a positive effect on a number of different functions in the human body. On the other hand, the loss due to underutilization of whey is transformed into a 100% gain. Expanding range of fermented milk and whey products in competitive conditions in the market has a strong commercial character and brings higher profits to processors [8].

MATERIALS AND METHODS

The first part of the paper presents the state and the tendency of movement of total cow milk production in Serbia from 2010-2015. By calculating the base index, where 2010 represent the basic year, according to which statistical data processing leads to results that indicate a decline in the total production of cow's milk compared to the basic year until the 2013, but in 2014 and 2015 there is a slight increase. In the second part of the paper work statistical data obtained from the Statistical Office of the Republic of Serbia (SORS - SZS) for 2015, which are related to milk products from cow's milk obtained in dairies and intended for the market in the period from 2013 to 2015 with special emphasis on fermented dairy products. Also, the production of cheese in which process comes to the production of large quantities of whey, which represents one of the underused auxiliary products of the dairy industry in the Republic of Serbia. Therefore, the paper presents the possibility of full utilization and use of whey in the production of fermented functional drinks, whose production is economically justified for the dairy industry.

RESULTS AND DISCUSSIONS

Production of milk and dairy products

From the nutritional point of view it can be concluded that milk is the most complete and most balanced foodstuff. In Serbia, the most common is cow's milk and is mainly used in the production of dairy products, while sheep's and goat's milk are produced in smaller quantities and they together account for only about 2% of total production. In recent years there has been an increasing emphasis on their advantages, which has resulted in larger production of sheep's and goat's milk both at home and abroad.

Total milk production in Serbia amounts to over 1.5 million tonnes, but in the period 2010 - 2015 a decrease in total milk production was observed, comparing 2010 as the base year to 2014 when there was a slight increase of 1.98%. In 2015 there was an increase in production of up to 2.7%, as can be seen in Table 1, which is very little compared to the previous year. With regard to the displayed total milk production index, milk yield per cow has a reverse trend. There was an increase beginning with 2010 (reaching its highest level in 2015 with 3,477 litres), which makes an average of 3.1 thousand litres per cow in the observed period (Table 1.) (Statistical Yearbook of the Republic of Serbia 2013-2016) [15].

Table 1. The amount of produced cow's milk in Serbia in the period 2011-2015 and base

Year	Total cow's milk production in ml	Index – total production 2010=100	Liters of milk per cow
2010	1462	100	2.795
2011	1434	98,08	2.865
2012	1442	98,63	2.920
2013	1451	99,25	3.246
2014	1491	101,98	3.269
2015	1501	102.67	3.477
Average	1.464	600.61	3,1

Source: Author's calculations based on the data provided by Statistical Yearbook of the Republic of Serbia 2013-2016 (without data for Kosovo and Metohija) [15].

If we look at different regions throughout Serbia there are differences in terms of milk yield per cow. Thus, Vojvodina has much

higher milk yield of 3,890 litres per cow, since great breeders of dairy cows are situated there, compared to central Serbia where milk yield is 2,730 litres per cow. One important reason for these differences in milk yield is the breed composition, because Friesian-Holstein breed prevails in Vojvodina with 52%, while Simmental cattle and cattle of Simmental type are dominant in central Serbia. Another important factor, in addition to breed difference, is the quality of animal feed, especially in mountainous regions (central Serbia), which do not meet the needs of dairy cattle, thus resulting in lower production than in lowland areas such as Vojvodina [16].

Cow's milk and milk products are of excellent nutritional value, water and dry matter are the basic components of milk. Water is a dominant component in milk and ranges from 80 to 90%, 87.3% on average. Dry matter in milk contains proteins, fat, lactose and minerals. Its composition is not constant, but varies depending on the species, breed, lactation period, diet and other factors [19].

Besides being a foodstuff milk is also a raw material with great potential as it is a basis for a large number of products such as sour milk, yogurt, a variety of cheeses, sour cream, butter, fermented milk products and other products that are obtained from milk [10]. Lately, new, enriched dairy products could be found on the market, by which dairy manufactured products, well known from ancient times, have been developing into a new generation of dairy products with different characteristics and better nutritional and health values [1].

Some milk products can be prepared under very simple technical conditions, whereas many other products require appropriate technical equipment, usually of high capacity, which only industrial dairies own. In order to be sold to the final consumers, it is necessary that milk be prepared following specific procedures of control, processing and packaging [20].

In Serbia, dairy industry is highly developed and there is a large number of dairies. However, their big problem is a small amount of milk on the market, seasonal variations in

milk production and the existing milk quality. With regard to milk quality, the existing regulations are complied with the EU regulations, but they are still not sufficiently implemented in practice. Milk quality directly affects the structure of dairy production as well as the product quality and shelf life, but also the production efficiency [1, 2].

The paper work presents results According to the Report of SORS - SZS Belgrade for 2015 and data processing for dairy products from cow milk (1,000 t) obtained in dairies for market realization in the period from 2013 to 2015, where one can notice the movement of certain products on the annual production level [7].

Given that there are a number of dairy products, this paper will take into account only those market products that are relevant to the subject of this paper, such as drinking milk, fermented products and cheese production.

Table 2. Total produced amount of drinking milk (1,000 t) for placement on the market in the period 2013-2015.

Year	Drinking milk	% in total production over 3 years
2013	251.04	34.53
2014	237.27	32.64
2015	238.73	32.83
Total	726.97	100 %

Source: Author's calculation according to the data of the Statistical Office of the Republic of Serbia, Belgrade [7].

Taking in account total volume of production of drinking milk intended for the market, for the observed years it amounts to 726.97 thousand tons. Observed by years, the largest production is in 2013, which in the total production for the three years (2013-2015) is 34.53%. The next two years there is recording a slight decline in the production of drinking milk marketed for the market, as can be seen from Table 2.

According to the data of the Statistical Office for the given period (2013-2015), as in the above table, there was a slight decrease in the production of fermented milk products intended for the market as of 2013 as shown in Table 4, but with a slight increase in 2015

compared to the previous year.

According to the data of the Statistical Office for the given period (2013-2015), as in the above table, there was a slight decrease in the production of fermented milk products intended for the market as of 2013 as shown in Table 3, but with a slight increase in 2015 compared to the previous year.

Table 3. Total produced amount of fermented milk products (1000 t) for placement on the market in the period 2013-2015.

Year	Fermented milk products	% in total production over 3 years
2013	214.22	34.24
2014	200.73	32.1
2015	210.59	33.66
Total	625.54	100 %

Source: Author's calculation according to the data of the Statistical Office of the Republic of Serbia, Belgrade [15].

Table 4, shows that production of cheese intended for the market increased from 2013 to 2015, which means that during cheese production the amount of whey as a by-product, that could be used in the production of various fermented and other products, increased too.

Table 4. Total production of cheese from cow's milk for placement on the market in the period 2013-2015.

Year	Total production of cheese	% in total production over 3 years
2013	28.22	27.54
2014	33.71	32.89
2015	40.55	39.57
Total	102.48	100%

Source: Author's calculation according to the data of the Statistical Office of the Republic of Serbia, Belgrade [15].

The biggest problem of the dairy industry is that only 10-20% of milk is used for the preparation of a product, while whey comprises 80-90% of milk entering the process [13].

The amount of whey obtained during the process of cheese making is nearly equal to the amount of milk required for its production. That means that during the production of 1 kg of cheese an average of 9 kg or 8-12 l of whey is obtained, depending on the variety of cheese produced [14].

Scientists believe, on the basis of data on cheese production projected by 2019, that the world whey production will record a permanent annual growth of about 2% by the end of 2019 [9, 12].

Therefore, the dairy industry is increasingly developing new, fortified milk products which have proved very successful, with different characteristics and better nutritional and health properties. Whey-based beverages certainly belong to this group of new products, although whey as a by-product has long been disposed of as waste or used as animal feed.

The possibility of full utilization and use of whey

Due to the rapid population growth and insufficient food production, and despite increased production, the issue of rational utilization of food, which has already been produced for human consumption (ex. cheese), is raised. With regard to the production and processing of milk, whey is certainly one of the most common by-products, which retains the largest quantity of milk nutrients. Whey contains 93% water on average, and over 50% dry matter of milk, depending on the basic composition of milk and the technological processes of cheese or casein manufacture. The dry matter of whey is composed essentially of lactose (about 70%), which is a very important energy source, whey proteins make up approximately 1% and water-soluble minerals and vitamins are present in smaller quantities.

In our country and the world, dairy industry treated whey as a waste product obtained during the cheese making process up until a few years ago. Today, however, bearing in mind that whey is rich in lactose, proteins, (especially lactalbumin and globulin), minerals and vitamins; there is a tendency to use this product in as cost-effective way as possible, either completely or as individual whey components. Today, the best-known whey preparations are acid and sweet whey powder, condensed whey, and modified whey powder [19]. One of the most economical and efficient procedures in improving the structure and viscosity of many life groceries is the use of whey preparations.

Whey preparations are widely used as additives in the food industry, where they contribute to valuable food products characterized by improved organoleptic properties, increased shelf life and higher levels of nutrients. Baking industry is the largest consumer of dry whey for human consumption. Considering the fact that the vast quantity of skimmed milk powder is used in baking and dairy industry, it can be substituted with dry whey. Whey has similar properties as milk powder, which is preferred for use in the baking industry, and there are also strong economic reasons to replace the more expensive skim milk by cheaper whey, either by whey powder or condensed whey [18].

Whey is also widely used in the dairy industry, especially in the production of ice cream and similar frozen dairy products. It is used in the production of processed cheese as well, and whey is especially desirable ingredient in the production of soft and spreadable processed cheese and similar products.

It is also suitable for producing various toppings, gives good texture and enhances the taste of cheese. Whey is also used in other food products in smaller quantities, such as mixtures for cakes, sauces, spices and the like. The use of whey is constantly increasing in the confectionery industry and it has also been applied in the meat industry.

Due to the high amount of lactose and biologically valuable proteins wide ranges of baby food as well as various types of dietary supplements are made on the basis of whey. Whey is very important for the pharmaceutical industry as well, due to lactose which is used in the manufacture of tablets and pills, most often as an inert carrier for the drug substance.

Among numerous possibilities of whey processing, a very important role belongs to alcoholic and non-alcoholic beverages. The use of whey in beverage production began back in the 1970s, and a large group of whey beverages has developed so far.

Analysis of production of non-alcoholic whey beverages, compared to alcoholic beverages, has so far given many favorable results

throughout the world.

Baković, D. and Tratnik, Lj. (1979, 1980) provide numerous possibilities of using whey and its products in many branches of the food industry, by means of pasteurization, thickening and fermentation. Today, the food industry in particular shows the tendency towards the production of lactic acid fermented products such as soft drinks based on fruit and vegetables, milk and whey-based beverages, which represent a very healthy, so-called "functional food products" [3, 4].

Fermented whey-based beverages proved to be the best option in preparation of products with favorable sensory characteristics. Fermented whey-based beverages hold a special place among whey beverages, and can be divided into two groups: functional and probiotic. Both groups have beneficial effects on the host organism but in two different ways [6].

Probiotic drinks are characterized by direct effects of live microorganisms (probiotics), while functional drinks are characterized by indirect effects through metabolites synthesized during fermentation, which are also called biogenic.

During the fermentation of whey its components are broken down into various functional substances, such as lactic acid, butyric acid, bioactive peptides, β -galactosidase and exopolysaccharides which show a significant effect on the human organism [17].

Therefore, nowadays, the issue of whey mostly amounts to finding the types and forms of whey products that will be as useful and affordable as possible. Further research in this field and close cooperation with the dairy industry would offer the possibility of greater utilization of whey through products that would be of interest from the standpoint both of nutrition and placement.

In most industrialized countries in Europe and the United States whey has already found an important place in the food industry.

There is a wide range of whey products on the markets of these countries.

Efforts have been made in our country as well, to utilize this important by-product of dairy industry as much as possible in order to

reduce the loss of whey nutrients.

CONCLUSIONS

The importance of the dairy sector in Serbia is reflected in the fact that milk production: among the all agricultural sectors with the highest value of primary production of over 500 million Euros a year, which additionally increases in processing, the sector that covers over 280 thousand producers and significantly contributes to the rural development of Serbia, the sector which, due to the quantity and nutritionally significant consumption, is important for the food safety of the country, the sector that is most demanding by the standards that need to be met when joining the EU, and the sector in which Serbia has significant potential only for further development.

Structure of milk production in Serbia is such that fermented products and liquid milk account for almost 90% of products manufactured each year.

With regard to fermented products, the amount of fermented whey products is minor, which leads to the conclusion that by whey fermentation we could obtain products with significant place among the range of dairy products intended for mass consumption. Regarding the current lack of facilities for whey processing, a huge amount of money would be saved if whey processing was stimulated in Serbia instead of being imported. In terms of prospects of utilization of whey as a raw material and in accordance with the existing equipment situation in Serbia, the main goal should be incentives for utilization of whey in the food industry.

One of the ways to include whey in daily diet, i.e. to activate its regular processing in the food industry, is to produce functional fermented whey-based beverages.

This is another effort to preserve as much of the whey for human consumption, by creating products using simple and economically viable technology for our industry.

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REFERENCES

- [1]Arsić, S., Kljajić, N., Vuković, P., 2010, Analyses of the current situation in cattle production in Serbia (With Special Review of Milk and Meat Production (Edita II). *Competitivitatea economiei agroalimentare si rurale in conditiile crizei mondiale II.* (340-347), Bucharest, Academia de Studii Economice.
- [2]Arsić, S., Vuković, P., Kljajić, N., 2011, Stanje i perspektive proizvodnje mleka u Srbiji. XXV Conference of agronomists, veterinarians and Technology engineering, Institute PKB ćAgroekonomik, Belgrade, Vol.17 (3-4), 57-69.
- [3]Baković, D., Tratnik, L.J., 1979, Mogućnost korištenja sirutke u prehrani, *Mljekarstvo*, 29 (2), 36-40.
- [4]Baković, D., Tratnik, L.J., 1980, Mogućnost korištenja sirutke u ishrani, *Hrana i ishrana*, 21 (9-12), 271-273.
- [5]Bošković, T., 2014, Tržište mleka i mlečnih proizvoda, *Privredni pregled*, 29-30 september 2014.
- [6]Bulatović, M., Rakin, M., Mojović, Lj., Nikolić, S., Vukašinović Sekulić, M., Đukić Vuković, A., 2012, Surutka kao sirovina za proizvodnju funkcionalnih napitaka, *Hemijska industrija*, 66(4), 567-579. 2012. Web. Link: http://www.fao.org/fileadmin/user_upload/newsroom/docs/ENGLISH_outlook.pdf (Retrieved on April, 21th, 2017).
- [7]Mlečni proizvodi od kravljeg mleka (1000 t) dobijeni u mlekarama za realizaciju na tržištu po mesecima u periodu 2013 – 2015, *Izveštaj*, Republički Zavod za Statistiku, Beograd 2015.
- [8]Jelen, P., 2003, Whey Processing, in: H. Rginski, J. F. Fuquau, P. F. Fox (Eds.), *Encyclopedia of Dairy Sciences*, London, Academic Press – An Imprint of Elsevier, Boston, London, 2740, Vol. 4, 369-370.
- [9]Jelinić, J., Đurović, S., 2009, Poljoprivredna politika - sektor mlekarske proizvodnje, *Fond za otvoreno društvo, centar za primenjene evropske studije*, Beograd, 54–56.
- [10]Kljajić, N., Savić, M., Arsić, S., 2009, Proizvodnja mleka i mlečnih proizvoda u Republici Srbiji, *Ekonomika*, Vol. 55 (6), 166-177.
- [11]Komisija za zaštitu konkurencije, 2012, *Sektorska analiza tržišta otkupa sirovog mleka, proizvodnje i prerade mleka i mlečnih proizvoda*, Beograd, Srbia, Avgust 2012.
- [12]OECD - FAO, 2010, *Agricultural outlook 2010 – 2019, highlights*, pp. 83.
- [13]Popović Vranješ, A., I., Vujičić, I., 1997, *Tehnologija surutke*, Poljoprivredni fakultet Novi Sad.
- [14]Savant, V. D., Torres, J. A., 2000, *Chitosan-based*

coagulating agents for treatment of cheddar cheese whey, *Biotechnology Progress*, Vol. 16 (6), 1091–1097.

[15] *Statistical Yearbook of the Republic of Serbia 2013 – 2016*, Belgrade.

[16] *Strategy for Agriculture and Rural Development of the Republic of Slovenia for the period 2014-2024*, Belgrade, Official Gazette No. 85/14.

[17] Tamime, A. Y., Božanić, R., Rogelj, I., 2003, Probiotički fermentirani mliječni proizvodi, *Mljekarstvo* 53 (2), 111-134.

[18] Tratnik, Lj., 2003, Uloga surutke u proizvodnji funkcionalne mliječne hrane, *Mljekarstvo* 53(4), 325 - 352.

[19] Tratnik, Lj., 1998, *Mlijeko-tehnologija, biokemija i mikrobiologija*, Hrvatska mljekarska udruga, Zagreb, Hrvatska.

[20] *Pravilnik o kvalitetu i drugim zahtevima za mleko, mlečne proizvode, kompozitne mlečne proizvode i starter kulture*, Tehnologija Hrane, <http://www.tehnologijahrane.com/pravilnik/o-kvalitetu-i-drugim-zahtevima-za-mleko-i>, Retrieved on April 30, 2017.