

BY-PRODUCTS, BIOPROTEINS AND ANIMAL FEED

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Abstract

By-products from food industry are very good sources of amino acids, peptides and proteins with high biological value. Transforming these by-products into nutritional supplements, in protein, peptide or amino acid sources would have beneficial effects both for the large quantities of whey from industry and for the food, feed and pharmaceutical industries. Such a protein-valuable by-product is the whey resulting from the cheese processing industry. Due to the high amount of whey this product it is considered "environmental pollutant", due to the high demand for oxygen for biodegradation (BOD – biochemical oxygen demand; COD – chemical oxygen demand). Thus, whey can be used directly in obtaining whey concentrates, protein isolates, whey powder; or indirectly in the production of feed, bioproteins, probiotics, lactose. Whey can be concentrated through several technological processes to produce products with different nutritional characteristics, being a good source of protein for the production of protein-supplemented feed or it can even be ingredient for the food industry. Bioproteins or cell biomass are unconventional sources of protein with much higher yields than the proteins produced by the bovine organism (which is considered a standard), but they are little used, especially in our country, and due to limitation of food and feed sources this has to be highlighted and took more in consideration.

Key words: by-products, whey, bioproteine, animal feed

INTRODUCTION

Last decades were very rich in finding animal feed resources due to increasing population in some countries which need food sources, and due to increasing the number of farm animals. In ancient, world population increased slowly, but in the last century the world population increased yearly a lot. Thereby, compared to 1980, the world's population increased with 19.5% in 1990, with 37.8% in 2000, with 56.0% in 2010, and with 71.2% in 2018 [20]. Thus, researchers studied different possibilities for produce new feed and food, more effective, more concentrated, cheaper, but the most important easy available. So, starting with

this idea researchers try to develop various resources of food and feed using as raw materials by-products from different technologies and industries.

Milk by-products resulting from milk process technology are liquid products resulting in high amounts from the manufacture of various dairy products like cheese, butter, ghee, cream, and others [9]. These milk by-products are rich in nutrients like vitamins (hydro-soluble vitamins), minerals, carbohydrates, and proteins. According to statistical data provided by United States Department of Agriculture (USDA) all over the world we have important quantities of by-products resulting from milk products industries (Table 1).

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Table 1 Dairy products reports of USDA – June 2018 Highlights [21]

Dairy product categories	Dairy by-products	Quantity [million Kg]
<i>Dry milk products</i>	Nonfat dry milk, human	67.0
	Skim milk powder	26.7
<i>Whey products</i>	Dry whey, total	39.6
	Lactose, human and animal	41.4
	Whey protein concentrate, total	18.1
<i>Frozen products</i>	Ice cream, regular (hard)	32.3
	Ice cream, low fat (total)	20.6
	Sherbet (Hard)	1.67
	Frozen yogurt (total)	2.46

Like it can be observed from table 1 there are high amounts of whey and other dairy by-products resulting from milk industry. The quantity of these products is very important because this is considerate „environmental pollutant” due to a high demand for oxygen needed for its biodegradation (BOD-biochemical oxygen demand; COD-chemical oxygen demand). Due to organic components presents in whey, to rapidly assimilation of carbohydrates and to slowly degradable proteins and lipids – the whey is a product with high biochemical and chemical oxygen demand (BOD and COD) varying between 0.1 and 100g/L. The biochemical oxygen demand in the fifth day of degradation (BOD₅) was considered to be an important indicator of the whey organic pollution, but new researches demonstrated that BOD₅ has to be correlated with the biochemical oxygen demand of the ultimate twentieth day (BOD_u), and also with BOD₅/COD ration [13]. In diary manufacturing processes are produced high heterogeneous products characterized by high quantities of water consumption and high „environmental pollutants” [10].

These facts have determined the dairy producers to find economically profitable solutions to transform the environmental pollutants in useful products. Whey is used to obtain concentrated whey, dry whey, whey protein, whey protein concentrate, whey protein isolate, lactose and other products which can be used as natural additives in

food and feed products (like breads, pastry, animal food).

WHEY AS A BY-PRODUCT

Whey, known also as lacticinia, is obtained mainly in cheese production and depending on the type of cheese we can have different types of whey. Thus, the most common is fluid acid whey, which is usually concentrated or dry (freeze dry, lyophilization) to be used then in feed and food production as ingredient or nutritional supplement. Whey is released liquid after milk has been curdled and then strained in the cheese production technology. There is more type of whey, depending on the products from where came the by-product: sweet whey – produced in hard cheese technology (such as Cheddar or Swiss), acid whey or sour whey – produced in acid dairy products (like cottage cheese or yogurt).

Even whey is a by-product in cheese technology, Codex Alimentarius introduced this product in a distinct category, while European Union classified whey cheese in products of animal origin (class 1.4) and not in the cheese class (class 1.3) – that gives trust to whey as a very good nutritive ingredient [16]. Whey is a raw material for concentrated whey protein, but to be concentrated the whey has to be low or free of lipids. For this the whey has to be skimmed (defatted) before the concentration process, especially when the method of concentration is reverse osmosis [1].

There are different methods to concentrate the whey or whey protein: reverse osmosis – used as concentration method, nanofiltration, evaporation, spray drying, freeze drying and others [2, 3, 7]. But reverse osmosis and nanofiltration are used successfully both in concentration of acid whey protein and sweet whey protein [7]. These methods are very safe because during the concentration of whey proteins a membrane filtration is used, and this gives to the final product microbiological safety.

In cheese production whey is considered a dairy by-product with high nutritional value due to the fact that about 50% of the total solid content is found in whey. The total solids from whey are mainly represented by lactose and lactalbumin.

WHEY NUTRIENTS

In whey the proteins are a mixture of high valuable proteins, easy digested, have low allergenic potential, and can be administrated to humans and animals (mammalian) to any age. Cow milk proteins are represented by 20% whey proteins and 80% casein, while human milk proteins contain 60% whey proteins and 40% casein [5, 6]. Whey proteins are represented by USDA, a department in USA which search and report data about the production of whey and about the nutritional composition of whey [21]. Thereby, in Table 2 we present the mainly nutritional components from whey [21].

Carbohydrates are the highest components from acid whey followed by protein and then lipids in very low quantities. Also, together with macronutrients, the whey contains important minerals and vitamins – which increase the beneficial properties of whey in human and animal consumption. Because the whey has very low lipids or is free of lipids, the whey does not contain any liposoluble vitamins. From whey components, the proteins and carbohydrates (represented only by lactose) are the components that presenting the most

importance because the concentrated whey can be a raw material for lactose and protein additives – with the possibility of using it in food, feed, or pharmaceutical technologies.

BIOPROTEIN FROM WHEY

Bioproteins, known also as cell biomass are considered unconventional sources of high biologic value proteins. These bioproteins have higher yields than proteins produced by bovine organism (considered as standard). Even so, these protein sources are used very little due to reduced promotion and limitation of food and feed additives and supplements technologies. Unconventional sources of protein are new research study aims, because it was proved that if the 500 kg bovine organism (weight of an adult bovine) – considered standard – produces an average of about 0.5kg of protein daily, over 500kg of bacterial mass synthesizes in a day 5 to 50 tons of protein.

Whey proteins are represented mainly by globular proteins represented by about 65% β -lacto-globulin, 25% α -lactalbumin, 8% bovine serum albumin and immunoglobulins [4].

Bioproteins are considered protein-rich products obtained in natural process of fermentation usually for animal feeding [18]. Milk and whey proteins are very important in nutrition due to its amino acids content – cysteine content, which is a substrate for glutathione synthesis, being a compound with very good antioxidant properties [11]. The amino acids from whey protein isolates are represented by histidine, isoleucine, leucine, lysine, methionine + cysteine, phenylalanine + tyrosine threonine, tryptophan, valine [18-21].

Bioproducts were developed for several years due to a progressive increase of whey production. Thus, the whey is transformed in value-added-products. Whey and whey permeate are transformed by fermentation in food-grade bioprotein or single cell protein [15].

Table 2 Acid whey nutrients composition [USDA, National Nutrient Database for Standard Reference Legacy Release]

Whey nutrients and energy		Acid whey, fluid [USDA code – 01112]	Acid whey, dried [USDA code – 01113]
<i>Proximates</i>	Water [%]	93.42	3.51
	Carbohydrates [%]	5.12	73.45
	Protein [%]	0.76	11.73
	Total lipids [%]	0.09	0.54
	Energy [kcal/100g]	24	339
<i>Minerals</i>	K [mg/100g]	143	2289
	Ca [mg/100g]	103	2054
	P [mg/100g]	78	1349
	Na [mg/100g]	48	968
	Mg [mg/100g]	10	199
	Zn [mg/100g]	0.43	6.31
	Fe [mg/100g]	0.08	1.24
<i>Vitamins</i>	Riboflavin [mg/100g]	0.140	2.060
	Ascorbic acid, total [mg/100g]	0.100	0.9
	Niacin [mg/100g]	0.079	1.160
	Thiamin [mg/100g]	0.042	0.622
	Vitamin B ₆ [mg/100g]	0.042	0.620
	Folate [μg/100g]	2	33
	Vitamin A [μg/100g]	2	17
	Vitamin B ₁₂ [μg/100g]	0.18	2.50
<i>Lipids</i>	Saturated Fatty acids, total [%]	0.057	0.342
	Monounsaturated Fatty acids, total [%]	0.025	0.149
	Polyunsaturated Fatty acids, total [%]	0.004	0.021
	Cholesterol [mg/100g]	1	3

WHEY COMPONENTS AS HEALTH PROMOTORS

Whey is used in human and animal nutrition due to its nutritional, medical and therapeutically properties. Whey proteins improve energy balance and also the metabolism, promotes weight loss, improves the diabetic control, liver function, and decreases adiposity [14].

Experimental researches demonstrated that administration of whey and whey casein improves activity and release of gut hormones, improves glucose metabolism and glycemic control, and also modify the taste preference in diet-induced obese rats [8, 12].

European Commission reported that a recent European research project studied the whey as a raw material in technology for obtaining a new biodegradable plastic. The study tested a possibility to use whey cheese

and other agricultural waste in laminated cardboard for food packaging industry [19].

CONCLUSIONS

Large quantities of by-products results from different industries results, these by-products being considered “environmental pollutants”.

Transformation of by-products in valuable ingredients for food and feed products depends on whey composition and the method of transformation. Most useful and safe concentration method for whey proteins and whey isolate protein are reverse osmosis and nanofiltration.

Whey can be used as a raw material for different products like whey concentrate or whey protein concentrate, lactose, whey protein isolates and others.

The products obtain from whey could be ingredients for food and feed products, could

be ingredients in food packing technology, could be pharmaceutical ingredient, or can be used in enhancement the immunity due to its high valuable proteins.

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