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Research Article

Methodology for the Use and Valorization of Whey

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Abstract: Industry of cheese in Mexico is very important for its volume of production; during the cheese making is obtained the whey as byproduct; it contains proteins, sugars and minerals, important compounds for the human diet. However, such compounds give a high Biological Oxygen Demand value to the cheese factory effluents. Although its nutritional composition this byproduct is not used, and sometimes is discharged to the environment generating contamination problems. In other countries, whey is dehydrated and commercialized to make food and pharmaceutical products. In this research whey was concentrated and dehydrated and used to make Oaxaca type cheese. We found that it could be used less than 10 % of concentrated whey mixed with milk to make Oaxaca type cheese, with a similar yield than using 100 % milk. In other hand 1 % of dehydrated whey was used as substitute of powder milk yielding the same cheese production. We demonstrate that concentrated or dehydrated whey could be used in the cheese plants to make more cheese, avoiding discharging it and contaminating the environment.

Keywords: Whey, Oaxaca type cheese, ultrafiltration, dehydration.

INTRODUCTION

The cheese is obtained by coagulation of milk by the action of rennet or other coagulating as enzymes¹. The amount of residual whey is 5 to 10 times greater in volume than the cheese produced. This is rich in proteins by this reason is valuable for the food and pharmaceutical industry². In developed countries, whey is commercialized as powder or concentrate as protein isolates³. Besides its nutritional contribution whey helps creaminess, texture, water holding capacity, opacity and adhesion to various food products^{3, 4}.

However whey is one of the most severe contaminants, its Biological Oxygen Demand⁵ is 40,000 to 60,000 mg/L. When a compound with a high Biological Oxygen Demand, such as whey, is discharged into water bodies, microorganisms to degrade it need a large amount of dissolved oxygen in the water, and if the amount drops significantly, are produced fetid odors and death by asphyxiation of the fauna of the ecosystems⁶. There are several applications for whey in order to minimize the costs of treatment and increase the economic benefits. However, the use of whey components requires a complex technology and therefore greater investment to obtain derivatives with high benefit⁷.

The aim of this study was to demonstrate that the concentrated or dried whey may be used for make Oaxaca type cheese, as an alternative to using water treatment systems for dairy effluents, avoiding the costs of installation, operation and maintenance of a treatment plant and minimizing the pollution caused by discharging this byproduct to water bodies.

METHODOLOGY

Physicochemical characterization of whey: The Company Lactoproducts, located in the state of Tlaxcala, Mexico provided whey. The whey was taken directly from the tub Oaxaca type cheese production. To the samples were determined: pH with a potentiometer ORION model 410A; fat, protein, lactose, not-fat and total solids with a dairy analyzer MilkoScan (S-54B, Foss Electric A / S, Hillerod)

Ultrafiltration of whey: Whey was ultra-filtered to concentrate it⁸, with a Multistage NIRO (RO, R model, brand GEA). Ultrafiltration process was done under the following operating conditions: inlet pressure to the membrane 5.5 kg cm⁻², concentrate flow 9.3 L s⁻¹, pressure 3.7 kg cm⁻², temperature 25 - 45 °C, and cut size of 10 KDa membrane. The filtrated and retentate were analyzed with the Milkoscan.

Dry of concentrate whey: The dried of whey was performed in a dryer type spray dryer Brand Galaxi (Model 2520). The operating conditions were inlet air temperature 200 °C and outlet 80 °C; evaporation rate of 250 L h⁻¹. Dehydrated whey obtained had a moisture content of about 3%.

Cheese production with concentrated whey: Oaxaca type cheese was prepared following the typical process for this type of cheese, with the variant that it was used different amounts of concentrate whey: 0, 5, 7, 10, 12, 15 and 19% mixed with fresh milk until 4 L. To the mixture of milk and whey was added rennet, the mixture was maintained at 35 °C for 2 hours until phase separation and formation of curd. The curd was separated from the whey by manually pressing, and passed by hot water at 80 °C for 2 minutes and finally it was spin.

Cheese production with dry whey: Oaxaca type cheese was prepared following the typical process for this kind of cheese, with the variant that was adding 0 and 1% of dried whey. The same procedure was followed to prepare the cheese as described above.

RESULTS

Physicochemical characterization of whey: Table 1 shows the average composition of: a) the milk used for experimentation, b) whey obtained after Oaxaca cheese formulation in Lactoproducts, c) whey concentrated by ultrafiltration and d) dehydrated whey.

Table 1: Physical and chemical assay to milk, whey, concentrated whey and powder whey

	Milk	Whey raw	Concentrated whey	Dried whey
pH	6.42	6.30 \pm 0.124	5.77 \pm 0.52	7.97
% fat	3.25	0.29 \pm 0.062	1.08 \pm 0.13	2.82
% protein	3.12	1.25 \pm 0.029	2.66 \pm 0.26	47.32
% lactose	4.46	4.48 \pm 0.047	4.67 \pm 0.27	14.9
% minerals	0.88	0.75 \pm 0.004	0.82 \pm 0.01	9.1
% total solids	11.51	6.76 \pm 0.049	9.23 \pm 0.59	94.86
% humidity	88.49	93.24 \pm 0.04	90.77 \pm 0.59	5.14

Fat and some of the proteins were coagulated to form cheese; the rest was removed in the whey, so it contains about 50% of the original milk proteins, and all of the lactose.

After concentration of the whey by ultrafiltration, the content of fat and protein increased, in the case of fat in 3.7 times and in the case of protein, content was doubled, reaching values close to the nutritional content of the milk. While protein from the dehydrated whey increased 17 times, and fat increased by 2.6 times compared with the concentrated whey.

Oaxaca type cheese production with concentrate whey: After verifying the composition and characteristics of whey proceeded to make Oaxaca type cheese by adding different amounts of concentrate whey. Table 2 shows yields of Oaxaca type cheese with the addition of various percentages of concentrate whey and control without adding it (using 100% milk).

In all cases the yield of cheese with the addition of concentrated whey was similar to the control using 100% milk, it was about 110 g cheese/L. This yield coincides with that reported by SAGARPA⁹, who pointed out that making cheese yield is 9-11 kg cheese/100 L milk. The addition of 5, 7 and 10% concentrate whey is recommended to make cheese, higher quantities difficult to spinning and getting the rubbery appearance. This could be explained because the addition of higher amounts of concentrate whey diminishes the total amount of protein and fat in the milk-whey mixture. It is known that proteins are responsible for the spatial alignment of the strands of the cheese; if the amount of protein in the milk-whey mixture is low, cheese making becomes difficult. Furthermore, it is important the butterfat content, since in the kneaded dough and spun fat is distributed in rows along the direction of the arrangement of the protein fibers¹⁰; with higher content of concentrate whey up 10% spinning was poor and was obtained a chewy dough consistency.

The suggested amounts of concentrate whey to be added to milk, for production of Oaxaca type cheese is less than 10%. Formulations of cheese obtained with addition of less than 10% concentrate whey had the following advantages over other formulations studied: a) good incorporation of whey constituents (mostly fat and protein), b) behavior in the process of manufacture was acceptable, c) the same yield was obtained but

using smaller amount of milk, which results in a cost savings for milk output. On the other hand, there are reports that the use of fermented whey can reduce the time of acidification of milk, which is the longest stage in the development of Oaxaca type cheese¹¹.

Table 2: Yield of Oaxaca type cheese with milk and different quantities of concentrated whey

% Concentrated whey	Oaxaca type cheese yield (g cheese/L)
0 %	112.7 \pm 0.41
5%	113.5 \pm 0.08
7%	113.6 \pm 0.57
10%	113.8 \pm 0.68
12%	113.2 \pm 0.06
15%	110.7 \pm 0.61
19%	107.6 \pm 0.72

Physicochemical analysis of whey resulting from each of the experimental samples was similar to the sample made with 100% milk; this indicates that the whey can be further concentrated and applied to the development of more Oaxaca type cheese.

Use of dried whey for making Oaxaca type cheese: The dried whey was used for making Oaxaca type cheese; this was tested in order to evaluate the use of dried whey instead of powder milk. When the demand for cheese is higher or when milk supply is lower, cheese factories use powder milk. Table 3 shows the yields obtained in formulating Oaxaca type cheese with the addition of 1% dried whey and with 1% milk powder (which is the amount usually added by dairies industry). The yield using dried whey was the same as using powdered milk, so dehydrated whey can be used to replace powdered milk. Furthermore, the use of dehydrated whey powder instead of milk, did not affect the process to get Oaxaca type cheese; the product was obtained with the characteristics of this cheese features, was easy to spin and consistency was acceptable. When analyzing the whey obtained in this series of experiments, it was found that is similar to those obtained for a typical formulation of Oaxaca type cheese.

On the other hand, it is known that there are significant price fluctuations, supply and demand for milk, which affects producers, such as the winter period, where the cost of maintaining cows rises because there is an increase in fodder and sometimes make it unaffordable cheese making. The results of this paper open up an alternative for cheese producers, to use a byproduct to diminish manufacturing cost and avoid to discharge it diminishing environmental problems.

Table 3: Yield of Oaxaca type cheese using dried whey and powder milk

	<i>Yield of cheese</i> (g/L)
1 % Dried whey	125.0 \pm 0.51
1 % Powder milk	117.5 \pm 0.55

CONCLUSIONS

Whey is an abundant byproduct of cheese making, by ultrafiltration and drying it is possible to concentrate its protein and fat content, making it suitable to be exploited in the manufacture of cheese. The use of whey in the same company brings several benefits: diminish milk consumption by using until 10% concentrated whey or 1% powder whey, manufacturing cost are lower and avoid the use of a waste water treatment plant.

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