Physicochemical properties, microbial load and sensory attributes of sweet and sours whey of white cheese

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Abstract

The goal of this study was to examine the quality and safety of two types of Sudanese liquid bovine whey. Sweet and sour whey were employed for this study. Moisture content, fat content, ash content, crude protein, and lactose content for sweet and acid whey content were 93.48-39.1%, 0.13-0.15%, 0.15- 0.19 %, 3.26-3.13%, and 2.75-2.90%, respectively. The pH, density, total solids (TSS), and acidity of sweet and acid whey were measured to evaluate their physiochemical parameters and the results showed 4.40-4.15, 1.318-1.271(g/ml), 6.48-6.44%, and 0.17-0.28%, respectively, are the results. Sodium, potassium, and calcium content in sweet and sour bovine whey were determined and the stat showed 2.27-3.41, 10.65-10.21, and 24.33-23.42 (mg/100 ml), respectively. The bacterial load, yeast, mold, and coliform bacteria in sweet and sour bovine whey were counted to define the microbial profile. The results demonstrate that the bacterial loads for sweet and sour whey were 10^7 and 10^6 (CFU/ml), respectively, with no yeasts, molds, or coliform bacteria development. Sensory evaluation of whey flavor, color, odor, texture, and overall acceptability was performed, and the results suggest that there is no significant difference ($p < 0.05$) in sensory evolution except in taste, where sweet whey taste was significantly greater than sour whey taste.

Keywords: Physicochemical properties, microbial load, sweet whey, sour whey, sensory

1. Introduction

Mammals have adapted to consume all other foods. Milk provides nutrition in the form of energy from the carbohydrate present in the form of lactose, nitrogen from the protein content and a rich source of calcium to build bones, to name but a few. Milk also provides other important benefits, such as biological activities associated with certain components in milk. Almost without exception, these biologically active components are exclusively found in the whey or serum fraction of milk. Whey is the watery and thin liquid yellowish color, which is received during cheese making by coagulating and separating casein proteins from milk. In sweet whey, rennet type enzymes are used at a pH of 5.6 to induce coagulum, whereas in the case of acid whey coagulum is produced when milk is acidified by lactobacillus culture or mineral acid at a max pH of 5.1. Whey's composition and sensory characteristics vary depending on the type of whey (acid or sweet), source of the milk (cow, sheep, bovine milk etc.), the feed of the animal, the cheese processing method, time of the year and the stage of lactation (Tsakali*et al.,* 2010).

Whey is the by-product of cheese or casein production, and it is of relative importance in the dairy industry due to the large volumes produced and its nutritional composition. Worldwide, whey production is estimated at approximately 185×10^6 tons/year; of this amount, only 92.5 $\times10^6$tons/year is processed which accounts for 50% of the treated and transformed into various foods and feed products. An estimated 41 billion kilograms of whey was generated as a byproduct of cheese production in 2006 (Estrella *et al.,* 2014).Approximately half of this is used directly in its liquid form, 30% as powdered cheese whey, 15% as lactose and it's by products, and the remaining is used as cheese whey-protein concentrates (Spalatelu, 2012).Cheese whey is produced in huge amounts and is a significant environmental problem due to the high levels of organic matter content. Cheese whey represents a biochemical oxygen demand (BOD = 230mg/mL) and a chemical oxygen demand (COD = 70mg/mL). Lactose is largely responsible for the high BOD and COD, since protein recovery reduces only about 12% of the whey COD. On the other hand, whey retains much of the milk nutrients, including functional proteins and peptides, lipids, lactose, minerals, vitamins. Therefore it has a vast potential as a source of added value compounds, challenging the industry to face whey surplus as a resource (Ghanadzadeh*et al*., 2012).The type and composition of whey at dairy plants mainly depends upon the processing techniques used for casein removal from liquid milk. Furthermore, the dairy industry suffers a financial setback as a result of the exorbitant costs of whey treatment and disposal. Although several possibilities of cheese whey utilization have been explored, a major portion of the world cheese whey production is discarded as effluent. Its disposal as waste causes significant environmental risks to the environment. (Macwan*et al.,* 2016).

Dairy waste discharged by milk processing industry in Sudan under uncontrolled and unsuitable conditions is causing significant environmental problems. The importance of dairy wastewater treatment is undoubtedly a key factor to bring sustainable development and safe local environment. However, since these company discharges the waste whey into the environment without any treatment, it poses a serious threat on natural water streams the general public health and the soil become polluted. In addition, the communities around the factory consume the water, because dairy industry is usually located in cities. It reduces dissolved oxygen of water and soil and thereby, affects aquaticlife. The chesses industry in Sudan was largely found in rural areas (White Nile locality) and released whey to the environment without any treatment, which causes changes to the soil properties and fertility as well as the animal feeding from such grass grown in the surrounding areas. Generally, it has an effect on economic destruction and losses of soil fertility.

The goal of this research was to examine the physical, chemical, microbiological, and sensory properties of sour and sweet whey produced from white cheese processing. This work will pave the road for finding solutions to the massive problem that whey waste has created in the Sudan by the white-cheese industry. The data presented here will assist other researchers in beginning to consider strategies to make use of this waste now that its composition has been determined.

2. Materials and methods

2.1. Materials

The Sudanese whey was obtain from cheese (white cheese) manufacture, and was obtained from Fabi Factory, Khartoum North. The sweet whey was obtained from enzymatic curdling of milk by rennet enzyme during traditional cheese manufacture, sour whey was obtain from cheese manufacture by acidification of milk by addition of lactic acid, experiments were done in industrial research and consultancy center. All chemicals and reagents used were of analytical grade donated by the Food Research Centers store, Shambat and the Department of Food Science and Technology, Faculty of Agriculture, Omdurman Islamic University.

2.2. Cheese manufacture

Twenty liters of milk were heated to 65°C for 30 min, cooled to 35° C, and then salted, 2% (w/w) of sodium chloride were added to the whole milk. The milk was then divided into two batches of 10 Liter each. The first batch was curdling with Rennet tablet and the second batch curdling with acidity (lactic acid bacteria).The first batch rennet tablet was dissolved in 20-ml distilled water and the solution was hand stirred for five min using a spoon. The batch was then incubated at 40°C and left to develop a curd. After coagulation the curd was cut with an ordinary stainless

steel knife to allow for whey separation. The curd was poured into small wooden molds lined with cheesecloth, pressed and left over night. The second batch starter culture were dissolved in 100 ml of milk, incubated for 2 hours at 37 °C, then adding to the whole milk, the batch was then incubated at 37°C and left to develop a curd. After coagulation the curd was cut with an ordinary stainless steel knife to allow for whey separation. The curd was poured into small wooden molds lined with cheesecloth, pressed and left over night.

2.3. Analytical procedures

2.3.1. Chemical composition of raw sweet and sour whey

2.3.1.1. Moisture content determination

Moisture content of whey was determined by the method described by AOAC (2000) as follows:
Three grams of whey sample or 3 ml of milk were weighed into a clean dry aluminum dish of a known weight. The dish was uncovered, placed on a boiling water bath for half an hour, and then the dish was placed in a well ventilated oven at 100°C for 3 hr. The lid was placed and the dishes were transferred to a desiccator to cool for about half an hour and weighed the heating and weighing was repeated until a constant weight was obtained.
The moisture content was calculated as follows:

$$\text{Moisture } \% \ = \frac{W1 \ - W2}{W0} \times 100$$

Where:
W_0 = weight of sample before drying.
W_1 = weight of sample before drying.
W_2 = weight of sample before drying.

2.3.1.2. Fat content determination

The fat content was determined by the Gerber method (AOAC, 2000). A 10 ml sulfuric acid, were poured into clean dry Gerber tubes. About 3 grams of whey was weighed into a pre-weighed 50ml beaker, 3-4 ml of warm (50-55ºC) distilled water were added and mixed with the glass rod until a uniform slurry was formed. The slurry was transferred quantitatively to a Gerber tube, then 1 ml of amyl alcohol was added to the tube followed by addition of distilled water. The contents in the tube were thoroughly mixed till white particles were seen. The tubes were centrifuged at 1100 rpm for 5 minutes. The fat column separated was read and taken as percent fat in sample.

2.3.1.3. Ash content determination

The ash content of the whey samples was determined according to the AOAC (2000). Weight 3–5g well-mixed test portion were weighed into ashing dish that have been pre heated, cooled in desiccator, and weighed soon after reaching room temperature. Then heated in furnace at 550°C (dull red) until constant weight. Cooled in desiccator and weighed at room temperature.
Calculation:

$$\boldsymbol{Ash}(\%) = \frac{W_2 - W_1}{weight\ of\ sample} \times 100$$

Where:

W1 = Weight of empty crucible
W2 = weight of the crucible plus sample after ignition.

2.3.1.4. Total protein determination

The method recommended by the AOAC Analytical Methods (2003) for the determination of total nitrogen in whey using Kjeldahl. Whey sample (2 g) was placed in Kjeldahl flask, 25 ml of concentrated sulfuric acid was added, heated for digestion for 3 hours till a clear solution was obtained, cooled and transferred to the distillation apparatus

with 10 ml of NaOH solution (40%). The distillate was received in 10 ml of boric acid (2%) with added indicator (methyl red and bromocresol green) and then titrated against 0.02 N HCl where the total nitrogen was calculated according to the equation:

$$Nitrogen\ \% = \frac{T \times 0.1 \times 0.014 \times 20}{\text{weight of sample}} \times 100$$

Where:
T = volume of titration
0.1 = HCl normality
0.014 – nitrogen atomic weight
20 = dilution factor
% total protein = total nitrogen × 6.38.

2.3.1.5. Lactose determination

Lactose was determined by Lane and Eynon method according to AOAC (2003). 25 ml from liquid whey were suspended in distilled water, clarified by lead acetate (2 ml), and potassium oxalate (3 ml), then filtrated and made up to 250 ml with distilled water. Felling solution (25 ml) was prepared in 300 ml conical flask, 15 ml of sugar solution was added and boiled, 3.5 drops of methylene blue indicator and 1.0 ml of sugar solution was added every 10–15 sec until the blue color disappeared. The volume of sugar solution required to reach the end point was recorded. The lactose content was calculated from the standard curve.

2.4. Physiochemical properties

2.4.1. Acidity determination as citric acid (mg NaOH/g)

The acidity of cheese was determined according to the AOAC method (2000). Whey sample (10 ml) and 95 ml of distilled water at 40 °C was added. The sample was then vigorously agitated and filtered and 25 ml of the filtrate were pipette into a porcelain dish and 5 drops of phenolphthalein indicator were added. The sample was titrated against 0.1N NaOH till a faint pink color was obtained. The acidity was calculated from the following equation:

$$Acidity = \frac{T \times 4}{W}$$

Where:
T = ml titre
W = weight of sample.

2.4.2. Total soluble solids determination

The total solids were determined according to AOAC (2003), where 5 g of milk were placed into a clean aluminum dish. The dishes were heated in a water bath for 10–15 min and transferred to an air oven for 12 hours at 75 °C and at room temperature. Heating, cooling and weighting were repeated several times until difference between two successive weightings was less than 0.5 mg.
The total solid content was calculated as follows

$$\text{Total solids}\ \% = \frac{W1}{W0} \times 100$$

Where:
W_1 = weight of sample before drying.
W_0 = weight of sample after drying.

2.4.3. pH determination

The pH was determined as described by AOAC (2000). Whey solution sample was tested using a glass electrode pH meter (KARL KOIB, D-6072 Dreieich) at room temperature (25 ºC).

2.4.4. Density (Specific gravity) Determination

The specific gravity of milk was determined as described by Pearson (1976). Milk (300 ml) was poured into a measuring cylinder, milk temperature was recorded, the lactometer was then immersed in the cylinder and the reading was taken. The specific gravity of milk was then computed from the following equation:

$$\textbf{specific gravity} = \frac{\boldsymbol{correct\ lactometer\ reading.}}{\mathbf{1000}}$$

2.4.5. Determination of minerals content

Minerals of whey samples were extracted according to Pearson (1976) method. Each sample was ashed in a muffle furnace at 550°C and let stand for 0-15 min and 5 ml of 5 N HCl was added. Then the solution was carefully filtered in a 100 ml volumetric flask and finally distilled water was added to make up to the mark. The extracts were stored in bottles for further the determination of sodium, calcium and Potassium using Perkin-Elmer 2380 atomic absorption spectrophotometer.

2.5. Microbial load determination

2.5.1 Total viable count

Total viable count was carried out using the pour plate count method described by Harrigan (1998). Aliquots (1 ml) from dilution was transferred aseptically into sterile Petri dishes to each dilution 10-15 ml where melt and cool at 42 °C plate count agar was added. The inoculums were mixed with media and allow solidifying and the plate was then incubated at 37 °C for 48 hours. A colony counter was used (Quebec colony counter) for viable bacteria.

2.5.2. Yeast and mold enumeration

From suitable dilution of sample, 0.1 gm cholramphenicol per one liter of medium (potato dextrose agar) to inhabit bacteria growth sample was spread all over the plate using sterile bent glass rod. Plates were then incubated at 25-28 °C for 48 hours as described by Harrigan (1998). Colony results were presented as cfu/g.

2.5.3. Total coliform bacteria

One ml from the first three dilutions was inoculated in tubes, (MacConkey broth). The tubes were incubated at 37 °C for 48 hours. The most probable number was then recorded according to Harrigan (1998).

2.6. Sensory evaluation

In food acceptance test, it is typical for respondents to rate a product on over all acceptability and on a series of product attributes. In this study the sensory attributes of color, odor, teste, texture and overall acceptance was done by assigning a liking score on a 7- point hedonic scale , were 1=strongly disliked ,2= moderately disliked,3=slightly disliked, 4=indifferent,5=slightly liked, 6= moderately liked and 7= strongly liked (Lawless, Heymann,1999). A panel of 44 evaluators were sought by putting up notices for volunteers made up of male (19) and female (25) untrained panelists. The panelist's age between 18-55 years were trained and 23 of them were found capable of telling the relatively small difference between sweet and sourer taste.

2.7. Statistical analyses

Replicate of each sample was analyzed using SAS statistical software and the analysis of variance (ANOVA) was performed to examine the significant difference between parameters and the Least Significant Difference test (LSD test) was used to separate the means (Peterson, 1985).

3. Results and discussion

3.1. Chemical composition of raw sweet and sour bovine whey

The chemical composition of sweet and sour whey used in this study is shown in Table 1. There was no significant different (P≥ 0.05) between the chemical composition of sweet and sour whey except in ash content where sour whey (0.19%) significantly (P≥ 0.05) higher than sweet whey (0.18%), respectively. Higher or lower chemical composition values for different kinds of sweet whey were reported by Macwan et al., (2016) to be as; moisture content ranged from 93.65–93.13%, fat content 0.60–0.34 %, protein content 0.90–0.98%, ash content 0.59–0.54% and lactose content 5.00–5.01%. These findings were comparable to results of Mustafa (2006) who reported 90–85%, 0.3–0.5%, 0.7–0.2%, 7.1–5.2% for sweet whey of moisture content, fat content, ash content and crude protein, respectively. Macwan et al., (2016) reported the chemical composition data for acidic whey as; moisture content (94.05–93.04%), fat content (0–0.43%), ash content (0.72%), crude protein (0.70 – 0.38%) and lactose content (4.30%). The higher ash content of sour whey compared to sweet was reported by Mollea et al., (2013) indicating that the main differences between the sweet and acidic whey types were in the mineral content, acidity and composition of the whey protein fraction. The acid protein coagulation approach results in substantially increased acidity (final pH approximately 4.5) which is necessary for casein precipitation agreeing with Mollea et al., (2013) who indicated that the colloidal calcium contained in the casein micelles in normal milk is solubilized at low pH and passed into the whey, whereas rennet clotting produces a fragment k-casein molecule, termed as glycomacropeptide (GMP). Miller et al., (2000) observed that the wide ranges in the nutrient content (protein, fat, lactose and minerals) of whey are recognized because of specific manufacturing processes presently used for cheese from which sweet and acid whey products are obtained. Whey maintain high biological value compared to most other protein because it has high content of sulfur containing amino acid important for the biosynthesis of glutathione, a tripeptide with antioxidant, anti-carcinogenic, and immune stimulating properties, in addition, it is the highest natural source of branched chain amino acid capable of stimulate muscle protein synthesis (MeBean 2003)

Table (1). Chemical composition of sweet and sour whey

Item	**sweet**	**sour**
Moisture	93.48^{a}±0.938	93.10^{a}±0.375
Protein	3.26^{a}±0.150	3.13^{a}±0.206
Fat	0.13^{a}±0.0152	0.15^{a}±0.0360
Ash	0.15^{b}±0.0360	0.19^{a}±0.01
Lactose	2.75^{a}±0.588	2.9^{a}±0.692

*Mean ± SD values across row bearing different superscripts are significantly different (P0≥05).

3.2. Physiochemical prosperities of raw sweet and sour bovine whey

The physiochemical prosperities of sweet and sour whey used in this study is presented in Table 2. There were no significant different (P≥ 0.05) in the physiochemical prosperities of sweet and sour whey except the pH value where the sweet whey had a higher value (4.40) compared to sour whey (4.15). The average pH, density, total solids (TS) and acidity of sweet whey content were 4.40, 1.318 g/ml, 6.48 % and 0.17 %, respectively. Bylund (2015) that the whey prepared by isoelectric precipitation (acidification) or rennet coagulation are called acid whey and sweet (rennet) whey, respectively. They differ in composition from each other and from milk serum because of the

changes that occur during their preparation. Higher and lower values for physiochemical prosperities of different types of sweet whey were reported as; density 1.025 g/cm (at 20 °C), pH in the range of 6.10-6.40, 7% TSS and acidity in the range of 0.13-0.14 % (Macwan et al., 2016). These findings were lower than those obtained by Mustafa (2006). Higher and lower values for physiochemical prosperities of different types of sour whey were reported by Macwan et al., (2016) as; 1.0248 g/cm density, pH in the range of 4.60-4.00, TSS as 7% and acidity in the range of 0.25-0.24% as lactic acid. There are significant differences (P≥ 0.05) in pH value, where the pH of sour whey was significantly lower than pH of sweet whey, 4.15 and 4.40, respectively, which could be due to the conversion of substantial portion of lactose into lactic acid, during the formation the acidic chesses, which transform the casein from a suspended state (colloid) to a precipitated curdle. These findings are in agreement with Alsaed et al., (2016) who indicated that whey is classified to two types, sweet whey with a pH of about 6.02 to 6.58 and acid whey with a pH of 3.57 to 4.34 which is in line with Tratnik, (2003) who reported that sour whey had lower pH than sweet whey due to higher amount of lactic acid whereas the content of minerals (mostly Ca-phosphates and Ca-lactates) is also higher due to increased calcium solubility. That causes abundant acidity and appearance of clots in the final product and also formation of higher amounts of sediment during whey heat treatments. Patrick et al., (2000) noted that sweet whey is a byproduct of the manufacture of rennet-coagulated cheese or rennet casein and its composition varies depending on its source (e.g., pH 6.2-6.6), depending on the extent of acidification that had occurred prior to whey separation (hence the concentration of some salts varies somewhat).

Table (2). Physiochemical properties of raw sweet and sour whey

Item	sweet	sour
pH	4.40^{a}±0.100	4.15^{b}±0.060
Density	1.318^{a}±0.045	1.271^{a}±0.050
Total Solids	6.48^{a}±0.336	6.44^{a}±0.249
Acidity	0.17^{a}±0.056	0.28^{a}±0.071

*Mean ± SD values across row bearing different superscripts are significantly different (P0≥05).

3.3. Mineral content of raw sweet and sour bovine whey

The mineral content of sweet and sour whey used in this study is shown in Table 3. There is no significant different (P≥ 0.05) mineral content of sweet and sour whey except in sodium content were raw sour whey significantly (P≥ 0.05) higher than raw sweet whey 2.27–3.41 (mg/100 ml) respectively. The average value of whey mineral (sodium, potassium and calcium), of raw sweet whey content were 2.27, 10.65 and 24.33 (mg/100 ml) respectively. Higher and lower values for mineral content of different varieties of sweet whey were reported by Bylund (2015) reported that the mineral composition of sodium content of sweet whey were 45.0, potassium content 140 calcium content 350 ppm. The average value of whey mineral (sodium, potassium and calcium), of raw sour whey content were 3.41, 10.21 and 23.42 (mg/100 ml) respectively. Higher and lower values for mineral content of different varieties of sweet whey were reported by Bylund (2015) reported that the mineral composition of sodium content of sour whey were 50, potassium content 160 calcium content 120 ppm. These results were comparable with Bylund (2015) who stated that the chemical composition of whey varies mostly in relation to method used for its production (sour whey or sweet whey). The main differences are in the calcium, phosphate, lactic acid, and lactate contents, which are higher in acid whey These results were in disagreement in some point with Patrick et al., (2000) who reported that acid whey contains a much higher concentration of calcium, magnesium, phosphate, and citrate than sweet whey or milk serum owing to the solution of the colloidal milk salts upon acidification.

Table (3): Mineral content (mg/100 ml) of raw sweet and sour whey

item	**sweet**	**sour**
Sodium	2.27^{b}±0.115	3.41^{a}±0.173
Potassium	10.65^{a}±0.582	10.21^{a}±0.100
Calcium	24.33^{a}±0.980	23.42^{a}±.2.515

*Mean ± SD values across row bearing different superscripts are significantly different (P0≥05).

3.4. Microbial profile of raw sweet and sour bovine whey

The microbial loads of sweet and sour whey used in this study were shown in table 4. There is no growth of yeast, molds and coliform bacteria in sweet and sour whey, while both sample had some microorganisms which were seen throw the total bacterial count, the sweet whey had higher bacterial cells (10^7 CFU/ml) than that of sour whey333 (10^6CFU/ml), these results indicate that milk prepared for cheese making subjected to heat treatment reduces microbial load. These result in agreement with Da Silva Duarte et al., (2020) reported that total mesophilic bacteria in raw whey from different companies were highly heterogeneous, ranging from 8.3×10^4 to 2.5×10^8 cfu/mL This results in the same line with (Tarrah et al., 2018) who reported that the most of the cheeses manufactured in the dairy plants involved in the study are produced from heat-treated milk, and all the products were obtained by the addition of commercial or natural bacterial starter cultures, whose presence is reasonably included in the mesophilic count results, although many technological species are thermophilic and probably not able to develop well at the mesophilic conditions of the analysis. Bacterial presence in whey is abundant, normally higher than that of milk, since cheese-making procedures favor bacteria growth, even in the case of the use of pasteurized milk, due to the addition of bacterial starter cultures, therefore the microbiological scenario should be carefully evaluated from both a quantitative and qualitative point of view, to make proper use of this material (De Arauz et al., 2009)

Table (4). Microbial profile (CFU/ml) of raw sweet and sour whey

	sweet	**sour**
Total bacterial count	10^7	10^6
Total yeast and molds	**Nil**	**Nil**
Coliform bacteria	**Nil**	**Nil**

*Mean ± SD values bearing different superscripts are significantly different (P0≥05).

3.5. Sensory evaluation of raw sweet and sour bovine whey

The sensory evaluation of sweet and sour whey used in this study was shown in Table 5. They were used in an increasingly wide array of ingredient applications for functionality, but with the current consumer focus on health and nutrition, these ingredients are also used widely to enhance nutrition. As with all foods, organoleptic prosperities play a large role in acceptance and product success. There is no significant different (P≥ 0.05) in sensory evolution of sweet and sour whey except in taste, taste of raw sweet whey was significantly (P≥ 0.05) higher than raw sour sweet whey 3.67–3.0 respectively. Sweet whey were non significantly (P≥ 0.05) higher than sour whey in Color, odor, texture and overall acceptances 3.67-2.67, 2.67-2.67, 3.33-2.00 and 2.67-2.33 respectively. It clear that panelist preferred sweet whey that may be due to the sugary taste. Popović-Vranješ and Vujičić (1997) mention that the whey's composition and sensory characteristics vary depending on the kind of the whey (acid or sweet), the source of the milk (cow, sheep, bovine milk, etc.) and the feed of the animal which produced the milk, the cheese processing used, the time of the year, and the stage of lactation.

Table (5). Sensory evaluation of raw sweet and sour whey

Sensory attribute	sweet	sour
Taste	3.67^{a}±1.53	3.00^{b}±1.00
Color	3.67^{a}±2.309	2.67^{a}±0.578
Odor	2.67^{a}±1.527	2.67^{a}±.0.577
Texture	3.33^{a}±2.081	2.00^{a}±1.001
Overall acceptability	2.67^{a}±0.577	2.33^{a}±1.154

*Mean ± SD values bearing different superscripts are significantly different (P0≥05).

4. Conclusion

The majority of the cheese whey content is lactose and the remains in cheese whey constituting the 90% fraction of the organic load. Lactose is largely responsible of organic contamination that causes environmental pollutions. Therefore, it is important to manage dairy cheese whey rather than discharging it to the environment, also because it has high nutritional values.

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