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Organoleptic Characteristics of Whey Treated by Cation Exchange Resin

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ABSTRACT

A single column cation exchanger resin was used to eliminate cations from renet cheese whey, with particular reference to the improvement of taste and flavor. Ten panelists were convened to assess the contribution of the mineral components to the salty taste of whey, judging on the basis of taste, flavor and color. The organoleptic characteristics of untreated whey were arbitrarily assigned a score of zero and the best treated whey in terms of quality, a score of 20. The use of a strong-acid cation exchange resin resulted in the removal of 28% of the calcium and 45% of the magnesium from treated whey with a concomitant increase in the concentration of sodium. The average score of treated whey increased from zero, for untreated whey, to 19.7 for the first element of whey passed through cation exchange resin.

Keyword: Whey, Cation exchange, Resin, Taste, Flavor**.**

INTRODUCTION

Whey is a serum or the watery part of milk that remains after separation of the curd resulting from the coagulation of milk by proteolytic enzymes. Whey, therefore, contains many of the nutrients present in milk that are useful for human consumption. However, the objectionable taste of whey has resulted in the disposal of this nutrient in the effluent from cheese-making factories.

The use of cheese whey in both a pilot project and on an industrial scale was reviewed under the following headings: whey disposal, animal feed, dried whey, fermented whey, deproteinized whey, whey permeate, hydrolysed whey and lactose and lactose derivatives [8]. In 1992, Jelen [4] investigated the manufacture, composition, nutritional value and utilization of cheese whey as a beverage.

Vasil'eva [14] and co-workers developed a cheese whey beverage by heating the whey, allowing it to stand, filtration, the addition of extract an of hawthorn or sweet briar in a proportion of 10-13% to the whey, mixing, pasteurization, cooling and decanting. The aforementioned extract was obtained by comminuting plant fruits to a particle size of 1.0 to 1.5mm before extraction, with clarified whey, in a ratio of 1:20-25. The extract was then mixed with 2-3% sugar [14]. In another study, three citric acid whey beverages were prepared using acid whey, deproteinated acid whey plus toned milk (in a ratio of 3:1) or acid whey plus toned milk (in a ratio of 3:1) [6].

In 1998, Barabas and Albrecht [1], also studied the production of three flavors of whey drink-orange, apple and lemon-with a 90% whey content in the final product.

In order to lower the level of protein sedimentation, the production technology was modified by placing homogenization after pasteurization. Furthermore, Reddy and co-workers [13] made a whey beverage from deproteinized whey by the addtion of (i) 6% lemon juice and 11 % sugar, (ii) 8% lemon juice and 14% sugar or (iii) 0.3% lemon flavor and 9% sugar as well as the addition of coloring, heat treatment to 80 ^{0}C for 15

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minutes, filtering, bottling and sterilizing at 120 ºC for 10 minutes. This was followed by cooling and refrigeration (4-6ºC) ors storages at room temperature, (18-25ºC), for up to 15 days. In another study, Michell [7] prepared two tomato beverages which were fortified with whey protein concentrates (WPC) that had been manufactured by ultrafiltration.

Patil *et al*. [12], in 1984 reviewed the manufacture of whey-soy beverages. In 1983, Nolan (9) prepared a chocolate-flavored shake-type beverage containing 84% whey and 8% groundnuts at the University of Arizona, Tucson. The whey was untreated prior to use but the whole groundnunts along with their skins were soaked in sodium bicarbonate overnight to decrease the groundnut flavor before being incorporated into a whey slurry. Other ingredients used were 7%, sugar 1% cocoa and 0.05% emulsifier.

The presence of lactose in whey provides the opportunity to develop fermented cheese whey. In one study, ginseng extract and sucrose were added to whey which had been fermented with lactic acid bacteria for four days and to a non-fermented (control) whey [11]. Sensory evaluation was carried out, and changes in composition were examined. The initial pH of the whey was 6.14, its acidity was 0.11%, the protein content 0.77 g%, Lactose 4.89g%, Lactic acid 8mg%, and ash 0.4 g%.

Hoppes and Higgins [3] proposed various different techniques of demineralization including: ion exchange, electrodialysis, reverse osmosis and counter diffusion. Ion exchange, in its traditional form, is a fixed-bed technique involving the use of resins that have a discrete capacity for the absorption of ions. When this capacity has been utilized, the absorbed minerals have to be removed from the resin by regeneration before it can be re-used.

The objective of this study was to assess the effectiveness of a cation exchange resin for eliminating cations from cheese whey using a single column cation exchanger, with particular importance placed on the improvement of flovor.

Experimental Materials

Cheese milk was cooled to 4ºC immediately after milking and held at this temperature prior to pasteurization. The milk was then pasteurized at 72ºC for 15 seconds and acidified using a culture of selected lactic acid-producing bacteria to achieve a uniform and predictable rate of acid production. Coagulation was achieved using bacterial renin. The curd was then cut for dehydration and the watery part remaining from the milk after separation of the curd was collected for further analyses.

The resin, a strong-acid cation exchanger, was produced by Zalion [Zalion Co., Tehran, Iran]. All chemicals used were reagent grade and purchased from Merck Co. [Merck Co., Germany].

Ion Exchange Treatment

For the regeneration of the cation exchanger, 1 M NaCI was used. A one-column treatment was carried out by passing whey through a 20×100 cm column. A uniform bed column of resin was prepared by packing a slurry of the cation exchanger in 1 M NaCI. The effluents of each run of ion-exchanged whey were collected for chemical analyses.

Sampling

The object of sampling was to obtain information about the organoleptic characteristics by inspection of a small portion of whey removed from the bulk sample. To achieve a good sampling technique, it was essential to draw the sample in such a way that it corresponded as closely as possible with the bulk. The procedure was repeated three times, until the mean value estimated approached more and more closely the true value of the sample.

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Every part of the sample had an equal chance of being represented, a technique known as random sampling.

Assessment of the Contribution of Mineral Components to the Salty Taste

In order to assess the improvement in taste, ten panelists were convened. In a series of 12 runs of cheese whey the panelists judged for taste, flavor and color. when assessing the organoleptic characteristics, cheese whey was used as reference.

Analyses

Moisture-Moisture was determined by drying 50 ml samples at 105°C for 24 hours to constant weight [2].

Ash-Ash was determined by incinerating the samples at 550 °C for 5.5 hours to constant weight. Ashes were cooled in desiccator and dissolved in distilled water. The sample volume was adjusted to 250 ml [2].

Flame photometry-A flame photometry method was applied to determine the sodium and potassium levels. The flame photometre was calibrated with a standard solution (1000 ppm). Calcium and magnesium levels were determined by the EDTA-calcein titration-method [10].

Flavor analysis-A panel of ten untrained members scored the aliquots of resin-treated wheys. The salty flavor, the color and taste of untreated whey were arbitrarily assigned a score of zero and the best treated whey in terms of quality a score of 20 (Table 1).

Statistical Analysis

All experiments were conducted in triplicate and standard deviations were calculated using Lotus software.

RESULTS AND DISCUSSION

The cationic composition of ionexchanged resin effluents is shown in Table 2. The composition of whey varies mainly owing to the number of times a run is passed through ion exchange.

Table 1. The arbitrary scores for taste, flavor and color of untreated and resin-treated wheys.

Taste [a]	Score	Flavor	Score	Color	Score
Whey	0 [b]	Whey	0	Whey	0
Sweet	20 [c]	Yoghurt serum	19	Fruit	20
Fruit	20	Mild whey	10	Milky	10
Sour	17	Milky	20	Grey	15
Sweet to sour	18	Yoghurt and water	18	Light- yellow	20
Milky-yoghurt	19				
Sour-sweet	15				
Mildly sour	18				

[a] A panel of 10 members scored the organoleptic characteristics including taste, flavor and color.
[b] A score of zero was considered as a reference for untreated whey.
[c] The most improved taste, flavor and color scored twenty.

The cations of whey often include calcium, magnesium, sodium and potassium. The results (Table 2) showed that the amount of calcium decreased from 350 mg/l in untreated whey to 250 mg/l after four runs of passing whey through an ion exchange column. The same trend was observed for magnesium. The results given in Table 2 also demonstrated that the concentration of sodium increased from 391 mg/l in untreated whey to its maximum 1246 mg/l after four runs and then stabilized throughout the twelve runs. The results given in Table 2 also showed that the amount of potassium decreased rapidly from 1102 mg/l in

Table 2: Cationic composition of different whey type (mg/ml)

Number of runs[a]	Ca	Mg	Na	K
Untreated [b]	350 ± 0.082 [c]	103 ± 0.025	391 ± 0.032	1102 ± 0.036
1	290 ± 0.045	72 ± 0.012	1000 ± 0.031	138 ± 0.011
2	270 ± 0.046	68 ± 0.016	1000 ± 0.061	240 ± 0.029
3	260 ± 0.071	60 ± 0.031	1100 ± 0.012	260 ± 0.032
4	250 ± 0.018	56 ± 0.072	1246 ± 0.054	256 ± 0.012
5	265 ± 0.011	60 ± 0.047	1050 ± 0.081	225 ± 0.022
6	266 ± 0.055	60 ± 0.011	1050 ± 0.021	235 ± 0.056
7	269 ± 0.085	72 ± 0.44	1048 ± 0.044	256 ± 0.075
8	273 ± 0.011	72 ± 0.072	1000 ± 0.041	300 ± 0.022
9	282 ± 0.019	72 ± 0.018	1005 ± 0.022	208 ± 0.041
10	285 ± 0.046	84 ± 0.015	1000 ± 0.042	325 ± 0.028
11	311 ± 0.019	85 ± 0.034	1000 ± 0.031	288 ± 0.021
12	359 ± 0.011	85 ± 0.081	1000 ± 0.044	310 ± 0.031

[a] The number of renet whey aliquots passed through the strong-acid cation exchanger.
[b] Untreated renet whey was considered as a reference.
[c] Standard deviation of n=3.

untreated whey to 138 mg/l at the first run of passing whey through resin, then gradually increased throughout the twelve runs. The results in Table 2 also demonstrated that 28% calcium and 45% magnesium were removed from treated whey with a concomitant increase in the concentration of sodium. Dabrowski [2] obtaind good results from desalting renet whey using an anion exchanger, resulting in the removal of 76% Cl, 73% SO_4, 25% inorganic P, 16% Ca, 16% Mg and a loss of 3.7% of the protein.

Ion exchange resin for the demineralization of whey was based on polymeric plastic materials for building the porous matrix structure. Common materials were polystyrene/divinly benzene and polyacrylate. The functional group was chemically bound to these matrices, typically of the following type-Sulphonic groups–$SO^-_3H^+$ (strong acid cation exchanger) [5].

As illustrated in Figure 1, the whey enters the strong cation exchanger loaded in H form. The resin contains ions of the same charge sign present in the whey solution being treated. The following reaction took place when a strong cation resin regenerated in its hydrogen form came into contact with a solution cantaining sodium ions:

$$2R\text{-}SO_3H + Ca^{++} \longleftrightarrow (R\text{-}SO_3)_2Ca + 2H^+$$
$$2R\text{-}SO_3Na + Ca^{++} \longleftrightarrow (R\text{-}SO_3)_2Ca + 2Na^+$$

Where R represents the insoluble resin exchange site. The equilibrium constant varies depending on the ion species, which determines the selectivity of the ion exchange processes. Generally, the following selectivity order exists: multivalent ions have higher selectivity than monovalent ones and ions of the same valence are selected according to ion size so that larger ions have a higher selectivity. For cations typically found in liquid dairy products, the selectivity decreases in the order of:

$Ca^{2+} > Mg^{2+} > K^+ > Na^+$

The mechanism of cation exchange chromatography is based on the formation and/dissolution of ion pair bonds between the resin in its stationary phase and the solutes. The samples are absorbed into the resin and then eluted by means of a gradient of salt concentration that progressively decreases the charge interaction.

Depending on the level of regeneration and the resin type, ten to fifteen bed volumes of sweet whey can normally be treated per regeneration (the volume of the cation exchanger is the basis for calculating the bed volume). Whey with a higher ion load, such as cheddar and casein whey, reduces the number of bed volumes of whey that can be treated per cycle. The following equation shows the regeneration:

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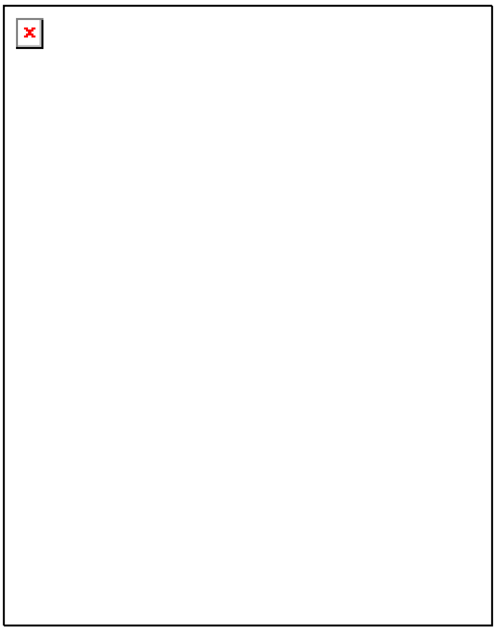

Figure 1. Diagram of the ion exchange column; (a) Watery part of milk remaining after renin coagulation; (b) Filtration made by Watman paper; (c) Resin, strong acid cation exchanger by Zalion; (d) The effluents of treated whey were collected for further analyses.

$$RCa + 2NaCl \longleftrightarrow RNa_2 + CaCl_2$$

Organoleptic Characteristics of Treated Whey

The results given in Table 3 for the taste, flavor and color of the untreated and treated whey indicated that a single run was sufficient to improve the quality of resin treated whey. Scores of zero, and twenty were assigned to the untreated and cation exchange resin-treated wheys, respectively, to establish an anchored hedonic scale. Using this scale, the average score of treated whey increased from zero, for untreated whey, to 19.7 for the first element of whey passed through cation exchange resin. The results (Table 3) demonstrated that the quality score stabilized to around 17 after five runs and then decreased steadily.

The results also showed that the unpleasant salty taste of cheese whey was mainly due to the presence of calcium ions. The same results were observed by Dabrowski [2], during modification the ionic characteristics of cheese whey.

Table 3. Organoleptic characteristics of untreated and treated whey using arbitrary scores from 0 to 20.

Number [a]	Taste [b]	Flavor	Color	Average
Untreated [c]	0	0	0	0
1	20	19	20	19.7
2	18	19	10	15.7
3	17	20	15	17.3
4	18	19	15	17.3
5	18	18	15	17.0
6	18	10	20	16.0
7	19	10	15	14.7
8	0	18	20	12.7
9	18	19	15	17.3
10	18	10	20	16.0
11	15	10	15	13.3
12	15	10	15	13.3

[a] The number of renet whey aliquots passed through the strong-acid cation exchanger.
[b] A panel of 10 members scored the organoleptic characteristics including taste, flavor and color.
[c] Untreated renet whey was considered as a reference.

CONCLUSION

Chosen from among different techniques of demineralizing cheese whey, a one column ion exchange was used to improve the salty taste of cheese whey. Ion exchange involved a fixed bed technique using resins which had a discrete capacity for the absorption of ions. When this capacity was utilized, the absorbed minerals had to be removed from the resin through regeneration before it could be re-used. The ion exchange resin consisted of a macromolecular porous plastic material formed into beads. Chemically, these act as insoluble acids which, when converted into salts, remain insoluble. The main characteristic of the ion exchange resin was its capacity to exchange the mobile ions.

Demineralization using ion exchange was already an established process for water treatment. However, in this study we used a

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strong-acid cation exchange resin for the demineralization of whey. We obtained good results in the desalting renet whey using a cation exchanger that resulted in the removal of 28% of Ca and 45% of Mg with a concomitant improvement in the organoleptic characteristics of the treated whey.

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بررسی تاثیر رزین تعویض یون کاتیونی روی ویژگیهای کیفی آب پنیر

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چکیده

یک ستون از رزین تعویض یونی کاتیونی به منظور خارج کردن کاتیونهای موجود در آب پنیر مورد

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استفاده قرار گرفت. کاتیونهایی مورد نظر بوده اند که نقش بیشتری در ایجاد طعم و مزه آب پنیر دارند. برای ارزیابی میزان مشارکت کاتیونها در طعم نمکی آب پنیر ده نفر جهت آزمایش ویژگیهای ظاهری نمونه ها انتخاب گردیدند. این افراد مزه، بو و رنگ نمونه های آب پنیر را مورد قضاوت قرار دادند. برای ارزیابی و مقایسه کیفیت نمونه ها از اعداد انتخابی صفر و بیست به ترتیب برای آب پنیر قبل از عبور از ستون و بهترین نمونه آب پنیر پس از عبور از ستون استفاده گردید. نتایج بدست آمده نشان داد که با استفاده از یک رزین تعویض یونی حاوی گروه فعال اسید قوی کاتیونی می توان تا ۲۸ درصد کلسیم و ۴۵ درصد منیزیم آب پنیر را خارج کرد. حذف این کاتیونها همراه با افزایش غلظت کاتیون یک ظرفیتی سدیم بوده است. نتایج ارزشیابی ویژگیهای کیفی آب پنیر نشان داد که خارج شدن یونهای دو ظرفیتی از آب پنیر تاثیر قابل توجهی در بهبود طعم و مزه آن دارد.