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Full Length Research Paper

Utilization of milk permeate in the manufacture of sports drinks

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The purpose of this study was to milk permeate in the manufacture of sports drinks. The milk permeate contained 6.1% total solids, 4.2% lactose and 0.54% ash. The permeate was treated through several processes, heat fermentation and clarification. Strawberry and mango homogenates were prepared and stored at -20°C until use. Fruit beverages were prepared using the pretreated permeate and fruit homogenates at ratio of 3:1 (v/w). Sports drinks were chemically analyzed and organoleptically evaluated fresh and every 5 days until 15 days of storage in refrigerator. The results revealed that milk permeate was a good source the essential electrolytes such as calcium, potassium, sodium, magnesium and phosphorus which may be taken as sports drinks after normal or vigorous exercise to replace these ions. Using strawberry or mango greatly increased calcium, potassium, sodium, magnesium and phosphorus content in the prepared drink. Mango was a better source for potassium and magnesium compared to strawberry, whereas strawberry was a better source with respect to calcium and phosphorus. Sensory evaluation indicated that the two sports drinks with fruits were more acceptable than the plain control.

Key words: Milk permeate, mango, strawberry, sports drinks.

INTRODUCTION

Ultrafiltration of milk produces a large quantity of permeate as by-product. It contains Lactose as the major constituent in addition to water soluble vitamins and the salts of milk. Therefore, permeate can be considered as a solution of nutritious significance. In this respect, Renner and Abd El-Salam (1991) reported that permeate appears as a crystal clear, greenish fluid. Besides lactose, minerals and vitamins are fractioned between the retentate and the permeate. The permeate will contain about 80% of the original lactose, whilst the other components will pass into the permeate in various proportions.

With regards to the use of permeate in food industry, several procedures may be applied to obtain products of modified properties which upgrade their use. This is quite important since permeate itself is of limited use, primarily because lactose has low sweetness, low solubility and is poorly digested by lactose-intolerant people. Geilman et al. (1992) and Beucler et al. (2005) reported that using lactose enzyme to hydrolysis of lactose because the lactose was reduced problems for consumer if unhydrolyzed to increase sweetness. On the other hand Abd El-Salam et al. (1991) and Abd El-Khair (2009) using yogurt culture or LAB containing *Lactobacillus helveticus, LH 100* to produce fruit beverages and sports drink. Konopoka (2001) found that the average electrolyte compositions of milk permeate resemble of human sweat. Whereas, Williams (2001) industry sports drinks, such as Gatorade are formulated to supply appropriate amounts of carbohydrates and electrolytes needed to maintain the optimal performance.

Some research was carried out in this respect by Geilman et al. (1990, 1992) and by Abd El-Khair (2009) and also why permeate was used for the products by Girsh (1999), Djuric et al. (2004) and Beucler et al. (2005).

The present study was therefore conducted to use milk permeate after fermentation, to make sports drinks (SD) including local fruits like strawberry and mango, different from plain or fruit SD.

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MATERIALS AND METHODS

Milk permeate

Milk permeate was obtained from Sorad-Garbyia Industrial region, Egypt. It was a by-product from the UF cow's skim milk. It was prepared at 50°C using spiral-wound module membrane supplied by APV pasilac, Denmark. The permeate contained 6.1% total solids, 4.2% lactose, 0.24% protein (Nitrogenous compounds) and 0.54% ash and had the pH of 6.46. The permeate was immediately heated in a water bath at 80°C for 10 min and cooled to 4°C, and kept frozen at -20°C until use.

Fruits

Strawberry and mango were collected from the local market in Kafr El-Sheikh -Egypt.

Additional ingredients

Commercially available sucrose and sodium benzoate were also collected from the local market in Kafr El-Sheikh -Egypt.

Milk permeate pretreatment

The frozen permeate was thawed at 4°C and heated in a water bath at 42°C for 24 h. *L. helveticas LH100* (Chr. Hansen's Lab, Copenhagen, Denmark) was added at the rate of 0.5 g/100 mL. This process aimed reducing lactose content in the permeate to avoid problems related to lactose absorption that could have resulted if unhydrolyzed lactose was consumed and to increase sweetness (Geilman et al., 1992). High performance liquid chromatography (HPLC) analyses of treated milk permeate indicated absence most of lactose and presence of small amounts of glucose and galactose. The pH of milk permeate was adjusted to 6.0 using ammonium hydroxide.

Preparation of fruit homogenate

The outer rind and seed were removed from mango whereas strawberry was well cleaned up after removing the green parts. The whole fruits were homogenized in a blender without any additives. The final homogenate was kept at 4 ± 1°C to be used directly in manufacturing the final product or kept at -20°C for storage.

Preparation of sports drinks

It was prepared by mixing the pretreated permeate with the prepared concentrated fruit homogenate at the rate of 3:1 (v/w) while 2% sucrose was also added.

The final mixture was filled into the well clean glass bottles and treated at 80°C for 10 min in a water bath and then cooled to room temperature, while sodium benzoate was added at the rate of 0.05%. The product was stored in a refrigerator at 4 ± 1°C. The treated drink without added fruit served as a control.

Chemical analysis

pH of the permeate was measured using a pH-meter. (HANNA, HI8519pH-METER). Total solids were determined using drying oven according to B.S.I. (1952). Ash content was determined as reported in AOAC (2007). The Gerber's method was followed for fat determination as described by B.S.I. (1955). Phosphorus content was determined as molybdenum blue by the colorimetric method of Allen (1940). Minerals contents were determined using an atomic absorption spectrometer (Hitachi instruments Engineering Co., 882 1chige kotsuta shi, ibaraki-ken, 312 Japan). Lactose, galactose and glucose were determined in milk permeate by high perphormance liquid chromatography (HPLC) Hewlett Packard 1040A HPLC detection system as given by (Jeon et al., 1984).

Sensory evaluation

Sensory evaluation of the prepared sports drinks (SD) was carried out when fresh and during storage of 15 days by panel tests of 8 to 10 judges. The maximum attainable scoring points were 50, 25 and 25 points for flavour, appearance and colour respectively.

Statistical analysis

Analysis of variance and Duncan's test were carried out using SPSS computer program (SPSS, 1999).

RESULTS AND DISCUSSION

The lactose in the permeate should logically be hydrolyzed into glucose and galactose before some of the glucose gets fermented into Lactic acid. However, this is quite important and saves people with lactose intolerance, whereas absence of casein in UF permeate also gives an advantage for such liquid to be used in making sports beverages, since avoiding milk proteins allergy should also be taken into consideration. In this respect, Geilman et al. (1992) demonstrated that the main sweeting agents used in commercial sports drinks are sucrose, dextrose and fructose. The same authors used 0.06% neutral lactase enzyme at 43.3°C for hydrolysis of 80% of lactose, whereas the addition of 1% sucrose and 0.35% (w/w) citric acid to hydrolyze permeate resulted in desirable sweetness and tartness as determined by judges. To produce the shelf-stable permeate beverage for consumer testing, hydrolyzed, sweetened, acidified and flavored permeate was processed using UHT procedures.

More recently, Abd El-Khair (2009) carried the fermentation process of the permeate using thermophilic lactic acid culture (*L. helveticus, LH100*) at 42°C for 24 h. This was followed by heating at 80°C for 5 min, adding activated charcoal for clarification and centrifugation for 30 min at 3000 rpm.

Table 1 reveals pH and composition of the different prepared fresh sports drinks (SD). The pH of the plain SD (control) was 6.31. This was mainly due to the fact that the pH of permeate was adjusted after the fermentation process using a food - grade ammonium hydroxide. However, the pH values of fruit SD (5.90 and 5.95 for strawberry and mango respectively) were significantly lower than that of the control (6.31). This may be due to

Table 1. Composition and pH values of the plain (control) and fruit fresh sports drinks (SD)*.

Property	Plain SD	Strawberry SD	Mango SD
pH	6.31^{a}	5.90^{b}	5.95^{b}
TS (%)	6.09^{c}	6.41^{b}	6.56^{a}
Fat (%)	0.22^{b}	0.25^{a}	0.26^{a}
Ash (%)	0.52^{b}	0.62^{a}	0.63^{a}

Averages of three replicates, values (a, b ……etc.) within the same row with different superscripts differed significantly (P<0.05).

Table 2. The changes in pH during storage of sports drinks (SD)*.

Storage period (days)	Plain SD	Strawberry SD	Mango SD
Zero	6.31^{a}	5.90^{a}	5.95^{a}
5	6.01^{b}	5.80^{b}	5.90^{a}
10	5.87^{b}	5.65^{c}	5.70^{b}
15	5.52^{c}	5.55^{c}	5.68^{b}

Averages of three replicates, values (a, b ……etc.) within the same column with different superscripts differed significantly (P<0.05).

Table 3. Minerals content (mg/100g) in fresh sports drinks (SD)*.

SD	Na	K	Ca	P	Mg
Plain	50^{c}	150^{c}	40^{c}	40^{c}	6^{c}
Strawberry	56^{b}	344^{b}	65^{a}	87^{a}	22^{b}
Mango	68^{a}	374^{a}	60^{b}	62^{b}	28^{a}

Averages of three replicates, values (a, b ……etc.) within the same column with different superscripts differed significantly (P<0.05).

the natural acidity of the used fruits.

TS content of the plain SD (Table 1) was 6.09% whereas those of strawberry and mango SD were 6.41 and 6.56% respectively. These higher values for TS content in strawberry and mango SD could be explained by the addition of sugar and the natural sugars present in the fruit homogenates.

The prepared SD was nearly fat-free. The traces given in Table 1 are mainly due to the incomplete separation of fat during skimming and UF processes.

Ash content in the plain SD was significantly less than the values recorded for strawberry and mango SD (Table 1). This is mainly due to richness of the used fruits in minerals.

The composition of SD is due to the corresponding composition of the permeate used which in general agrees with the figures given in the literature for 5 permeate composition. Renner and Abd El-Salam (1991) reported the values of 5.8, 4.9, 0.45 and 0.25% for total solids; lactose, ash and crude protein of permeate originating from milk respectively. The corresponding figures reported by Abd El-Khair (2009) were 6.1, 5.3, 0.54 and 0.26% respectively. However, Abd El-Salam et al. (1991) reported the values of 0.09, 6.64, 5.87, 0.037 and 6.51% for acidity, total solids, lactose, total nitrogen and pH respectively of permeate prepared from reconstituted skim milk. The values 0.29, 6.55, 5.47, 0.048 and 4.81% when the permeate was fermented at 42°C for 24 h using yoghurt starter.

Quality stability during storage of the prepared SD was followed by measuring the pH for a period of 15 days in the refrigerator (Table 2). The pH gradually decreased in all drinks, the most important decrease observed being that of the plain drink which showed significant differences in this respect. The pH changes in strawberry and mango SD were insignificant in 10 and 15 days old drinks. Such results are in agreement with those given by Hegazi et al. (2009) who used milk permeate in making fruit beverages and stored the products for 30 days. More strict processing and filling conditions are usually followed on industrial scale to prolong the shelf-life of such products.

Table 3 reveals minerals content in SD expressed as mg/100 g. The recorded values for Na, K, Ca, P and Mg

Table 4. Organoleptic scoring of different sports drinks (SD) when fresh and during storage period*.

SD	Flavour (50 points)				Appearance (25 points)				Colour (25 points)			
	Zero	5	10	15	Zero	5	10	15	Zero	5	10	15
Plain	44[b]	42[b]	41[b]	40[b]	22[b]	21[b]	20[b]	20[b]	20[b]	20[b]	18[b]	16[c]
Strawberry	49[a]	47[a]	46[a]	43[a]	25[a]	24[a]	23[a]	22[a]	24[a]	23[a]	22[a]	20[b]
Mango	48[a]	47[a]	45[a]	42[a]	25[a]	25[a]	23[a]	22[a]	25[a]	23[a]	22[a]	22[a]

Averages of three replicates, values (a, b ……etc.) within the same column with different superscripts differed significantly (P<0.05).

were 50, 150, 40, 40 and 6 mg/100 g respectively in the plain drink (control). Abd El-Khair (2009) and Konopka (2001) reported that the values were 45, 145, 35.7, 34.6 and 7.8 mg/100 mL in order for milk permeate. Geilman et al. (1992), produced an electrolyte beverage from milk permeate and compared of two commercial samples of electrolyte beverage. Their data showed that their preparation contained much higher K (~ 118 mg/100 mL) than the commercial samples, whereas Na content was (~25 mg/100 mL) in electrolyte beverage and commercial samples. Mg content was nearly the same (~8 mg/100 mL).

The same comparison was recorded by Abd El-Khair (2009) who diluted the milk permeate with double deionized water (1:10 ratio) until the level of potassium 125 mg / L in Gatorade. This dilution greatly decreased sodium content, so the author added sodium chloride (0.5 g / L) and sodium citrate (1 g / L) to increase sodium content to be 47.3 mg/100 mL. However, from the gravically given results, it may be concluded that the product contained about 48, 12, 4, 6, and 3 mg/100 mL beverage for Na, K, Ca, P and Mg respectively who were quite lesser than the results given in Table 3 and were also different from the values given by Konopka (2001) for human sweat.

Adding strawberry homogenate significantly increased the minerals content in the prepared SD. Table 3 shows that the recorded values for Na, K, Ca, P and Mg were 56, 344, 65, 87 and 22 mg/100 g respectively. Significant increases in figures were observed when mango homogenate was used in this respect. The recorded values were 68, 374, 60, 62 and 28 mg/100 g in order. Such impact of using fruits could be attributed to richness of the prementioned fruits with most of the given minerals. The values given in the literature (Chen, 1992; Konja and Lovric, 1993) were 1, 189, 15, 29 and 13 mg/100 g of strawberry and 3, 214, 10, 10 and 18 mg/100 g of mango with respect to Na, K, Ca, P and Mg contents respectively.

The organoleptic scores of the different formulations of sports drinks (SD) are given in Table 4. In fresh drinks the plain drink ranked the lowest in points scored for flavour, appearance and colour when compared with those given for strawberry and mango drinks. The differences in flavour scores were significant, whilst those due to type of fruits were insignificant. This also was recorded for the colour. The given scores for appearance due to type of fruits were insignificant.

All the given organoleptic scores gradually decreased during storage, reaching the lowest values at the end of storage period.

From the foregoing results it can conclude that milk permeate can be successfully used in the preparation of sports drinks that can be used for the replacement of minerals particularly those lost in sweat. Addition of strawberry or mango produced more acceptable drinks.

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