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Utilization of milk permeate in the manufacture of sport drink

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The purpose of this study was utilized of 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 by going through several processes, which included heat treatment, fermentation and clarification. Strawberry and mango homogenates were prepared and stored at -20^{o}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 when fresh and every 5 days until 15 days of storage in refrigerator. The results revealed that milk permeate was a good source for 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 sweat lost. Using strawberry or mango greatly increased calcium, potassium, sodium, magnesium and phosphorus content in the prepared drink. Mango was better source for potassium and magnesium comparing to strawberry, whereas strawberry was better one with respect to calcium and phosphorus. Sensory evaluation indicated that the two sports drinks with fruits had better acceptability as a compared to the plain (control) one.

Key words: Milk permeate. Mango, Strawberry, Sport drink.

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 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 permeate. The permeate would contain about 80% of the original lactose, whilst the other components would pass into the permeate in various proportions. Concerning the use of permeate in food industry, there are several procedures may be applied to obtain products which are modified in some properties to be better

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usable. This is quite important since permeate itself has a limited use, primarily because lactose has low sweetness, low solubility and troublesome digestibility by lactose-intolerant people. Some pretreatments were given in the literature aiming to hydrolysis of lactose including the use of lactase enzyme (Geilman *et al.,* 1992; Beucler *et al.,* 2005) to produce an electrolyte beverage and different drinks respectively or carrying out fermentation using yogurt culture or different starters (Abd El-Salam *et al.,* 1991) or LAB containing Lactobacillus helveticus, LH100 (Abd El-Khair, 2009) to produce fruit beverages and sports drink respectively.

Owing to the average electrolyte composition of milk permeate resembles that of human sweat given by Konopoka (2001) for the most electrolytes and relatively differs for few elements, the electrolyte beverage industry is a growing market sector, especially for sports drinks which are considered as functional beverage category (Williams, 2001). Some research were carried out in this respect by Geilman et al.(1990), (1992) and by Abd El-Khair (2009) and also whey permeate was used for the products by Girsh (1999); Djuric *et al.,* (2004) and Beucler *et al.,* (2005).

Therefore, the present study was conducted to use milk permeate after certain fermentation in making sports drinks (SD) of different being plain or fruit SD. The local fruits used in this respect were strawberry and mango.

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 50^0C 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 80^0C for 10 min. and cooled to 4^0C, and kept frozen at -20^0C until use.

Fruits

Strawberry and mango were collected from the local market.

Additional ingredients

Commercially available sucrose and sodium benzoate were also collected from the local market.

Milk permeate pretreatment

The frozen permeate was thawed at 4^0C and heated in a water bath at 42^0C for 24h. *Lactobacillus helveticas* LH100 (Chr. Hansen's Lab, Copenhagen, Denmark) was added at the rate of 0.5g/100mL. This process was aimed to reduction of lactose content in permeate to avoid problems with lactose absorption that could have resulted if unhydrolyzed lactose was consumed and to increase sweetness (Geilman *et al.,* 1992). The 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 cold to be used directly in manufacturing the final product or kept at -20^0C 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 heat treated to 80^0C for 10 min in a water bath and then cooled to room temperature, while sodium benzoate was added at the rate of 0.05%. Storage was done in refrigerator (4 ± 1^0C). The treated drink without adding fruit was served as a control.

Chemical Analysis

The pH of the permeate was measured using a pH-meter. (HANNA, HI8519pH-METER).Total Solids was determined by the 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 8-10 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

It was reported elsewhere in the present study that lactose in the prepared permeate was nearly fermented into glucose and galactose which by the same process were the source of lactic acid and other materials responsible for decreasing the pH. However, this is a quite important and save for people with lactose intolerance, whereas absence of casein also in UF permeate gives an advantage for such liquid to be used in making sports beverages, since avoiding milk proteins allergy is also should be taken into consideration from the health point of view. 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 43.3^0C 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 the judges. More recently, Abd El-Khair (2009) carried the fermentation process of the permeate using thermophilic lactic acid culture (Lactobacillus helveticus, LH100) at 42^0C for 24h. This was followed by heating at 80^0C for 5 min, adding activated charcoal for clarification and centrifugation for 30 min at 3000rpm.

Results revealed that pH and composition of the different prepared fresh sports drinks (SD) as seen in Table. 1. The pH of the plain SD (control) was 6.31. This was mainly due to the pH of permeate that was adjusted after fermentation process using a food -grade ammonium hydroxide. However, the pH values of fruit SD were significantly lower than that of the plain one being

5.90 and 5.95 for the strawberry and mango SD respectively. This may be due to the natural acidity of the used fruits.

TS content of the plain SD was 6.09% whereas those of strawberry and mango SD were 6.41 and 6.56% respectively (Table 1). Such figures were mainly due to the addition of sugar and the fruit homogenates to the pre-treated permeate.

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 within the same row with different superscripts differed significantly ($P<0.05$).

The prepared SD was nearly fat-free. The traces given in Table 1 was 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 with minerals. The composition of SD was due to the corresponding composition of the permeate used which in general agrees with the figures given in the literature for permeate composition. Renner and Abd El-Salam (1991) gave 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. The corresponding figures given by Abd- El khair (2009) were 6.1, 5.3, 0.54 and 0.26 % respectively. However, Abd El-Salam *et al.,* (1991) gave the values of 0.09 %, 6.64 %, 5.87 %, 0.037 % and 6.51 for acidity, total solids; lactose, total nitrogen and pH of permeate prepared from reconstituted skim milk. The values were greatly changed to 0.29 %, 6.55%, 5.47 %, 0.048 % and 4.81 when the permeate was fermented at 42^{0}C for 24 hours using yoghurt starter.

The keeping quality of the prepared SD was followed by measuring the pH during storage period of 15 days in the refrigerator (Table 2). The pH gradually decreased in all drinks with more decreasing rate in 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 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 within the same column with different superscripts differed significantly (P<0.05).

Result revealed that minerals content in SD expressed as mg/100 g (Table 3). The recorded values for Na, K, Ca, P and Mg were 50, 150, 40, 40 and 6 mg/100g respectively in the plain drink (control). The values given by Abd El-khair (2009) and Konopka (2001) for milk permeate and human sweat in order were 45, 145, 35.7, 34.6 and 7.8 mg/100 ml in order for milk permeate, which resemble human sweat in terms of electrolyte composition, but sodium level of sweat was greatly higher 120 mg/100 ml) than that of permeate, whereas potassium – in particular was dramatically higher (~142 mg/100 ml) Geilman *et al.*, (1992), produced an electrolyte beverage from milk permeate and compared it is composition with label statements 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 in between (~25 mg/100 ml). Mg content was nearly the same (~8 mg/100 ml).

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 within the same column with different superscripts differed significantly (P<0.05).

The same comparison was recorded by Abd El-khair (2009) who diluted the milk permeate with double deionized water (1:10 ratio) to provide a potassium level that of Gatorade thirst quencher (125 mg / L). 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/100mL. 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 which were greatly less than our results given in Table (3) and were also different with the values given by Konopka (2001) for human sweat.

Adding strawberry homogenate significantly increased the minerals content in the prepared SD. Result showed that the recorded values for Na, K, Ca, P and Mg were 56, 344, 65, 87 and 22 mg/100g respectively (Table 3). Significant increased figures were observed when mango homogenate was used in this respect. The recorded values were 68, 374, 60, 62 and 28 mg/100g 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/100g of strawberry and 3, 214, 10, 10 and 18 mg/100g of mango with respect to Na, K, Ca, P and Mg contents respectively.

The organoleptic scores of the different formulations of sports drinks (SD) were given in Table 4. In fresh drinks the plain drink ranked the lower scoring points 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 ont significant.

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 within the same column with different superscripts differed significantly ($P<0.05$).

All the given organoleptic scores gradually decreased during storage reaching the lowest values at the end of storage period It is conclude that milk permeate can be successfully used in the preparation of sports drinks that used for the replacement of minerals particularly those lost in sweat. Addition of strawberry or mango produced more acceptable drinks.

References

Abd El-Khair, A. A. (2009). Formulation of milk permeates for utilization as electrolyte beverages. Australian J. Basic and App. Sci. 3: 572-578.

Abd El-Salam, M. H.; Mahran, G. A.; Haggag, H. F; Mahfouz, M. B. and Zaglol, A. (1991). Manufacture and properties of beverages based on fermented permeate and natural fruit juices. Chem. Mikrobiol. Technol. Lebensm. 13:95-101.

Allen, R. J. L. (1940). The estimation of phosphorus. Biochem. J. 34: 858.

A.O.A.C., Official Methods of Analysis, (2007). 18th Ed. The Association of Official Analytical Chemists. Washington, D.C.

Beucler.A, Drake, M and Foegeding, E.A. (2005). Design of a beverage from whey permeate.J.Food Sci., 70:S277-S285.
British Standards Institution (1952). Methods for chemical analysis of liquid milk. B.S, I. Pub. No. 1741.
British Standards Institution (1955). Apparatus and methods for determining the percentage of fat in milk and products by Gerber method B.S.I.pub.No.696.
Chen, S. C., (1992). Physicochemical principles for the concentration and freezing of fruit juices. In Fruit Processing Technology, Nagy, S., Chen, C.S. and Shaw, P.E. Editors.Agscinence.INC. Auburndale, Florida.23-25.
Djuric, M., Caric, M; Milanovic, S; Tekic, M., and Panic, M., (2004). Development of whey – based beverages. Eur.Food Res.Technol.219:321-328.
Geilman, W. G; Schmidt, D; Herfurth-Kennedy, C. and Path, J. (1990). Potential of milk permeates as an electrolyte beverage.J.Dairy Sci. 73(supply 1):94.
Geilman, W. G; Schmidt, D; Herfurth-Kennedy, C; Path, J. and Cullor, J. (1992). Production of an electrolyte beverage from milk permeates. J. Dairy Sci.75.2364-2369.
Girsh, L. S. (1999). Process of making a dairy permeate-based. U.S. patent No. 5912040.
Jeon, I. J; Galitzer, S. J and Hennessy, k. J. (1984). Rapid determination of lactose and its hydrolyzates in whey and whey permeate by high performance liquid chromatography.J.Dairy Sci. 67: 884-887.
Konja, G. and Lovric, T. (1993). Berry Fruit Juices Processing Technology, Ed.By Seven Nagy.Chin Shu Chen and Philip, E.Shaw, Agscience, Inc.Aubrandale, Florida.
Konopka, P. (2001). BLV Verlagsgesellschaft, mbH, Munchen.CF.AbdEl-kheir, A.A. (2009).
Hegazi, N.A.; AboelEinen, K.A.M and El-Nawawy, M.A. (2009).Production of low calories highly antioxidant thirst quenching fruit beverage using milk permeate.J.Biol.Sci. 4: 857-868.
Renner, J. E. and Abd El-Salam, M. H. (1991). Application of Ultrafiltration in the Dairy Industry. Elsevier App. Sci., London and New York.
SPSS (1999). SPSS for Windows. Release 10 (27Oct. 1999). Standard Version. Copyright SPSS Inc., 1989-1999.
Williams, L. A. (2001).Trend setting drinks. The new developments and trends that will be shaping their industry in the years to come. The World Food Ing.50: 45-48.

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