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Physicochemical and sensorial characterization of special flavored athlete rehydration drink

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Abstract
The present study aims to develop an athlete rehydration drink with various flavours and electrolytes. The inclusion level of flavor and electrolytes was standardized based on sensory evaluation of panelist. The electrolytes viz., sodium bicarbonate, potassium chloride, sugar and calcium carbonate were utilized in rehydration drink with the concentration of 0.20, 0.10, 10 and 0.05 percent respectively. The drink also prepared with different flavors of mango, green apple and jaljeera were added with 0.15%, 0.1% and 0.075% respectively. Developed rehydration drink was stored at refrigerated condition for further analysis. Among the three flavours, mango flavour obtained highest overall acceptability value of 8.50. The proximate parameters such as fat, total protein, lactose, ash, total solids, moisture, acidity, pH, carbohydrate and energy value of mango flavoured rehydration obtained were 0.089%, 2.74 %, 2.45%, 0.45%, 12.60%, 87.50%, 0.062, 6.57, 9.56% and 50.07 kcal respectively. During storage period acidity and pH were significantly changed (P<0.01) and protein concentration observed no change throughout storage period.

Keywords: Rehydration drink, whey, minerals, vitamins, electrolytes, storage study

Introduction
The purpose of consumption of sports drink is to prevent dehydration, supply carbohydrates to augment available energy, provide electrolytes to replace losses due to perspiration, conform to requirements imposed by regulatory authorities and probably the most important to be highly palatable. Sports drinks can be classified as having either a low carbohydrate concentration (<10%) or a high carbohydrate concentration (≥10%). Sports beverages are formulated, based on speculation, to contain nutrients (carbohydrate, protein, fat, vitamin, minerals, amino acids, water) and other substances (herbs, caffeine) in proportions that are intended to optimize energy levels, hydration, recovery, muscle growth/repair and ultimately to increase physical performance (Maurer. 2005) [11]. The higher carbohydrate content drinks are marketed for carbohydrate loading rather than for general consumption before and during exercise (Coombes and Hamilton. 2000) [4]. Imbalanced fluid intake and fluid losses may lead to a body water deficit that decreases in sport performance when water lose become apparent when hypo hydration exceeds 2% of body weight that performance decrements become substantial when fluid losses exceed 5% of body weight and when fluid losses approach 6-10% of body weight, heat stroke and heat exhaustion become life-threatening (Naghii. 2000) [13]. Greater degrees of dehydration can lead to medical emergencies such as heat exhaustion. Adequate hydration translates into lower heart rate, lower core body temperature, lower rating of perceived exertion, higher stroke volume, higher cardiac output, higher skin blood flow, and, ultimately, better performance (Powers and Howley, 2004) [14]. Electrolytes commonly found in sports beverages, like sodium, chloride, and potassium, play key roles in preventing muscle cramps. Further, sodium replacement is critical in the prevention of hyponatremia, a condition of dangerously low blood sodium levels, resulting from both over hydration from fluids devoid of electrolytes (plain water) and excessive loss of sodium through sweat in the absence of sodium replacement (Manore *et al.*, 2000) [10]. Athletes should aim to achieve carbohydrate intakes to meet the fuel requirements of their training programme and to optimize restoration of muscle glycogen stores between workouts. Carbohydrate rich foods with a moderate to high glycemic index provide a readily available source of carbohydrate for muscle glycogen synthesis, and should be the major carbohydrate choices in recovery meals (Burke *et al.*, 2004). Minerals and vitamins also has impact on the exercise routine, supplementation of iron increases work capacity and reduces exercise heart rate and lactate

concentration (Gardner *et al.,* 1975) [6]. Vitamin C on enhancing physiologic functions and decreased body temperature as compared with men treated with placebo (Kotze *et al.,* 1977) [9]. Historical reports indicate that sailors and soldiers with scurvy (vitamin C deficiency) experienced shortness of breath during physical exertion, and reduced energy and endurance during work (Keith, 1997) [8].

Whey is a predominant ingredient employed in sports and energy drink due to their health benefits. Whey has a high concentration of branched-chain amino acids (BCAAs) – leucine, isoleucine, and valine. BCAAs, particularly leucine, are important factors in tissue growth and repair. Leucine has been identified as a key amino acid in protein metabolism during the translation-initiation pathway of protein synthesis (Anthony *et al.,* 2001) [1]. *Channa* whey contains 0.60 % fat, 0.50% ash, 4 % lactose, 0.42% crude protein, 6.8% total solids, 6.16% non-fat solids, 0.22% acidity and 5.2 pH and found that whey can also be used as an effective electrolyte solution to replace most of the organic and inorganic salts during loss of body fluids and also found that nutritional potency of whey protein is high as it has excellent protein efficiency ratio, biological value and easy digestibility (Jindal *et al.,* 2004) [7]. Men engaged in resistance training programs while supplementing with whey protein concentrates showed greater improvements in strength than men using resistance training alone. Men who received whey protein or the multi-ingredient whey protein sports supplement in combination with resistance training showed greater improvements in one of four muscle strength measurements. In addition, whey supplemented groups showed greater improvements in lean tissue mass over the placebo group (Burke *et al.,* 2001) [2]. This study aims to develop rehydration drink for athletes through technological process using RO (Reverse osmosis), UF(Ultra Filtration) and analysis of electrolytes, vitamins using high end instruments like HPLC(High Performance Liquid Chromatography) for minerals inductively coupled plasma optically emission spectrometer (ICP-OS).

Materials and Methods

In the present research work of rehydration drink preparation was done with standard material and methods and work was carried out at Department of Food Processing Technology, College of Food and Dairy Technology, Chennai. Fresh *Channa* (Acid) whey was collected from Local sweet manufacturer, Electrolytes, minerals and vitamins were purchased of I.P grade. Flavours Mango Flavour Emulsion 2178, Green Apple Flv 0885 and Jaljeera Flv Emulsion 1010-23were purchased from M/s. CEC Flavour and Fragrances Pvt. Ltd, India in preparation of rehydration drink.

Preparation procedure for rehydration drink

Channa whey was collected which is further passed through cream separator to remove casein fines and residual lipids then pasteurized at 80°C for 5 mins and cooled immediately to 40°C. The Reverse Osmosis (RO) membrane system typically of spiral wound design is used for pre-concentration of whey to 12 – 14 per cent total solids. The pre-concentrated whey is then passed through the UF membrane in which diafiltration process is done to remove more of the lactose, ash and raise the concentration of protein by the method of Bylund (2003) [3]. Standardized concentration of whey was mixed to water at different ratios to improve organoleptic and characteristic quality as base material for preparation of rehydration drink. The optimized level of electrolyte sodium carbonate and potassium chloride is added along with sugar and calcium in a rehydration drink during preparation. Vitamins such as vitamin A, B_1, B_2, B_6, B_9, B_{12}, C and D along with minerals like iron and zinc were fortified based on RDA value requirement in a rehydration drink. Finally, different natural identical flavours of mango, green apple and jaljeera were added before in-bottle pasteurization at 85°C suggested by Meena (2008) [12]. After pasteurization, the drink is cooled to room temperature and stored at different storage temperatures viz., 4°C in a refrigerator and 37ºC in room temperature. The detailed flow chart for the preparation of rehydration drink was given in Fig. 1.

Identification of electrolytes, calcium and natural identical flavours levels

The rehydration drink was prepared after incorporation of different levels of electrolyte namely sodium (0.15 per cent 0.20 per cent and 0.25 per cent) and potassium (0.075 per cent 0.10 per cent and 0.125 per cent) and also mineral like calcium (0.025 per cent 0.05 per cent and 0.10 per cent) with sugar (8 per cent 10 per cent and 12 per cent) and natural identical flavour mango (0.10 per cent 0.15 per cent and 0.20 per cent), green apple (0.075 per cent0.10 per cent and 0.15 per cent), jaljeera (0.050 per cent 0.075 per cent, 0.10 per cent) in an optimized whey concentrate to water ratio (60:40, 50:50, and 40:60) based on their sensory evaluation. Electrolyte, sugar, calcium and flavours were added to the standardized whey concentrate before bottle pasteurization. The pasteurized drinks were subjected to sensory evaluation and among this best were taken for the further rehydration drink study. Different flavours rehydration drink was given in Fig 2.

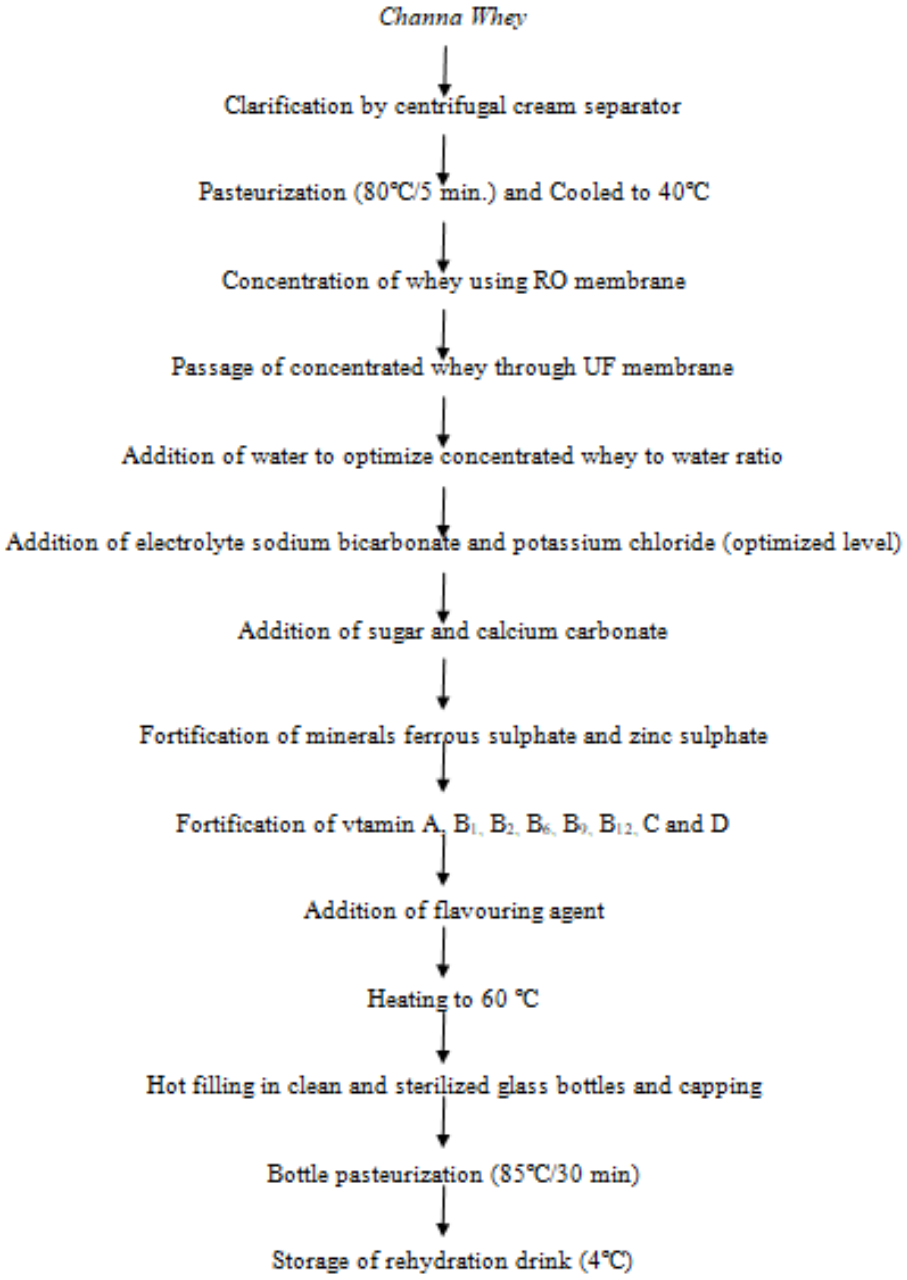

Fig 1: Flow chart for preparation of rehydration drink

Green apple flavored drink Mango flavored drink Jaljeera flavored drink

Fig 2: Different flavoured rehydration drink

Storage studies of rehydration drink

Prepared rehydration drink (with optimized levels of ingredients) were stored at refrigerated temperature 4ºC and samples were analyzed on 0^{th}, 7^{th}, 14^{th}, 21^{st}, 28^{th} day of storage for the analytical parameters such as pH, acidity and colour values.

Statistical analysis

Statistical analysis was carried out to study the effect of different parameters on all the dependent variables. The data were tabulated and subjected to statistical analysis performed using IBM SPSS® 20.0 for Windows® software as per the standard procedure of Snedecor and Cochran, (1994). Analysis of variance (ANOVA) was conducted to determine whether significant effect exists on nutritional values, texture and colour values.

Results and discussions

Effect of whey concentrate to water ratio on sensory scores of rehydration drink

The average sensory score values for the rehydration drink affected by different concentration of whey to water ratio were represented in Table 1. The sensory attributes such as taste, colour and appearance, mouth feel and flavour for whey to water ratio of 50:50 had a mean value of 6.50, 6.50, 6.33 and 6.50 respectively. For a whey concentrate to water ratio of 50:50, the overall acceptability sensory score ranged from 6.25 to 7.12 with a mean value of 6.67. Corresponding values for control with ratio of 60:40 and 40:60 were 6.00, 5.83 and 6.00 respectively. The combination of whey concentrate and water 50:50 had a maximum overall acceptability of 6.67. Studies by Das, (1999) [5] also showed that among different whey to water ratio 50:50 was found to be highly acceptable as compared to other ratio which improved the quality characteristic of drink.

Table 1: Effect of whey concentrate to water ratio on sensory scores of rehydration drink

Whey concentrate : water ratio	Sensory attributes (9-point hedonic scale)				
	Taste	Colour and appearance	Mouthfeel	Flavour	Overall acceptability
Control	5.17±0.30^{a}	6.17±0.16^{a}	5.17±0.30^{a}	5.33±0.21^{a}	5.83±0.30^{ab}
60:40	6.33±0.21^{b}	6.17±0.30^{a}	5.33±0.20^{a}	5.83±0.30 ^{ab}	6.00±0.20^{ab}
50:50	6.50±0.22^{b}	6.50±0.22^{a}	6.33±0.33^{b}	6.50±0.22^{a}	6.67±0.20^{b}
40:60	5.50±0.23^{a}	6.00±0.25^{a}	5.50±0.22^{a}	6.00±0.36^{ab}	6.00±0.36^{ab}
F value	5.513**	0.736^{NS}	3.580*	2.874 ^{NS}	3.830*

Average @ 6 trials, ** highly significant; * significant; NS – No significant differences

Effect of different level of electrolyte on Sensory scores for the rehydration drink

Table 2 shows the sensory scores of rehydration drink prepared with different level of electrolytes. The sensory attributes such as taste, colour and appearance, mouth feel and flavour for electrolytes such as 0.15 per cent sodium bi carbonate and 0.075 per cent potassium chloride had a mean value of 6.50, 6.67, 6.33 and 6.17 respectively. For electrolytes containing 0.20 per cent sodium bicarbonate and 0.10 per cent potassium chloride had overall acceptability in a sensory score ranged from 6.17 to 7.05 and a mean was value of 6.67. For other samples such as control, electrolytes 0.15 per cent sodium bicarbonate and 0.075 per cent potassium chloride and sodium bicarbonate 0.25 per cent and potassium chloride 0.125 per cent the mean value were 6.00, 6.00 and 5.33 respectively.

Table 2: Effect of different level of electrolyte on Sensory scores for the rehydration drink

Inclusion level of electrolyte (percent)	Sensory attributes (9-point hedonic scale)				
	Taste	Colour and appearance	Mouthfeel	Flavour	Overall acceptability
Control	6.17±0.21^{b}	6.33±0.33^{a}	5.17±0.30^{a}	5.67±0.33^{a}	6.00±0.30^{ab}
0.15 $NaHCO_3$ + 0.075 KCl	6.33±0.30^{b}	6.17±0.16^{a}	5.83±0.20^{b}	5.83±0.30^{a}	6.00±0.25^{ab}
0.20 $NaHCO_3$ + 0.10 KCl	6.50±0.22^{b}	6.67±0.21^{a}	6.33±0.33^{b}	6.17±0.30^{a}	6.67±0.21^{b}
0.25 $NaHCO_3$ + 0.125 KCl	5.50±0.22^{a}	6.33±0.21^{a}	5.50±0.22^{a}	5.33±0.21^{a}	5.33±0.42^{a}
F value	13.760*	0.772 ^{NS}	3.680*	1.398 ^{NS}	3.164*

Average @ 6 trials, ** highly significant, * significant, NS – No significant differences, $NaHCO_3$ - Sodium bicarbonate, KCl - Potassium Chloride

Effect of different flavors on Sensory scores for the rehydration drink

Table 3 shows the organoleptic scores of rehydration drink prepared with different flavour viz., mango, green apple and jaljeera. The sensory attributes such as taste, colour and appearance, mouth feel and flavour for mango flavour added rehydration drink had a mean value of 8.33, 8.00, 7.67 and 8.17 respectively. For the mango flavour, the overall acceptability in a sensory score ranged from 7.65 to 9.02 and had a maximum mean value of 8.50. The mean organoleptic scores for control, green apple, jaljeera flavoured rehydration drink were 6.83, 7.67 and 7.00 respectively. The scores shows that the mango flavour added rehydration drink have the highest mean overall acceptability of 8.50 and next comes the green apple flavour with mean overall acceptability of 7.67. In the study the highly significant difference were observed in mean taste, flavour and overall acceptability within the flavour. Jaljeera flavour ranked third in overall acceptability with mean value of 7.00. The control had lowest mean overall acceptability value.

Table 3: Effect of different flavors on Sensory scores for the rehydration drink

Inclusion level of Different Flavour (per cent)	Sensory attributes (9-point hedonic scale)				
	Taste	Colour and appearance	Mouth feel	Flavour	Overall acceptability
Control	7.17±0.16^{a}	6.67±0.21^{a}	6.33±0.33^{a}	6.17±0.30^{a}	6.83±0.16^{a}
Green Apple	7.50±0.22^{a}	7.33±0.21^{b}	7.33±0.21^{b}	7.50±0.22^{bc}	7.67±0.21^{b}
Mango	8.33±0.21^{b}	8.00±0.36^{c}	7.67±0.21^{b}	8.17±0.30^{c}	8.50±0.22^{c}
Jaljeera	7.00±0.25^{a}	7.00±0.42^{b}	7.00±0.21^{ab}	7.17±0.40^{b}	7.00±0.33^{ab}
F value	7.451**	2.963*	3.241*	6.944**	8.413**

Average @ 6 trials, ** highly significant, * significant, NS - No significant differences

Proximate characterization of different flavoured rehydration drink

The proximate analysis of rehydration drink prepared with different flavour was shown in Table 4. The mean value of fat for content for control, mango, green apple and jaljeera flavoured drink were 0.0, 0.089, 0.083 and 0.089 respectively. The corresponding mean values of control, mango, green apple and jaljeera flavoured drink of total protein values were 0.0, 2.74, 2.75 and 2.75, for lactose content 0.0, 2.45, 2.40 and 2.44, for total ash 0.36, 0.45, 0.44 and 0.45 for total solids 2.18, 12.60, 12.83 and 13.04, for moisture 97.41, 87.50, 87.08 and 86.88 for acidity 0.083, 0.062, 0.062 and 0.062 and pH value 5.03, 6.57, 6.56 and 6.57 respectively for control, mango, green apple and jaljeera flavoured drink. The mean energy value (Kcal) of control, mango, green apple and jaljeera flavoured drink were 5.39, 50.07, 50.06 and 50.07 respectively. The control had lowest value compared to other three different flavoured rehydration drink.

Table 4: Proximate analysis of the rehydration drink with different flavour (Mean±SE)[@]

Parameters in %	Control	Mango	Green Apple	Jaljeera	F value
Fat	0.0±0.0^{a}	0.089±0.02^{b}	0.083±0.004^{b}	0.089±0.0023^{b}	223.107**
Total protein	0.0±0.0^{a}	2.74±0.05^{b}	2.75±0.07^{b}	2.75±0.09^{b}	50.793**
Lactose	0.0±0.0^{a}	2.45±0.4^{b}	2.40±0.2^{b}	2.44±0.7^{b}	100.982**
Ash	0.36±0.04^{a}	0.45±0.06^{a}	0.44±005^{a}	0.45±0.06^{a}	0.448**
Total solids	2.18±0.09^{a}	12.60±0.12^{b}	12.83±0.05^{ab}	13.04±0.11^{c}	2097.489**
Moisture	97.41±0.25^{b}	87.50±0.20^{a}	87.08±0.13^{a}	86.88±0.26^{a}	545.671**
Acidity	0.083±0.003^{b}	0.062±0.004^{a}	0.062±0.005^{a}	0.062±0.004^{a}	5.508**
pH	5.03±0.08^{a}	6.57±0.17^{b}	6.56±0.13^{b}	6.57±0.23^{b}	48.638**
Carbohydrate	1.34±0.09^{a}	9.56±0.06^{b}	9.55±0.12^{b}	9.56±0.06^{b}	2498.558**
Kcal	5.39±0.14^{a}	50.07±0.17^{b}	50.06±0.16^{b}	50.07±0.14^{b}	21086.394**

Average @ 6 trials, ** highly significant, * significant, NS – No significant difference

Sensory characterization of different flavoured rehydration drink during storage

The sensory score value of different flavoured rehydration drink during storage at 4°C was represented in Table 5. The overall acceptability of rehydration drink for control, mango, green apple and jaljeera on 0th day during storage at 4°C were 6.83, 8.50, 7.66 and 7.00 respectively. During storage of 7th day, the overall acceptability was 6.50, 8.33, 7.50 and 6.83 were obtained respectively for control, mango, green apple and jaljeera at 7th day. Mean overall acceptability values 6.33, 7.83, 7.33 and 6.50 were obtained respectively for control, mango, green apple and jaljeera at 14th day. On storage of 21st and 28th days the control mango, green apple and jaljeera added samples shown overall acceptability value of 6.16, 7.66, 7.00, 6.33 and 6.00, 7.00, 6.83, 6.33 respectively. During storage for 28 days the overall acceptability of mango, green apple and jaljeera decreased from 8.50 to 7.00, 7.66 to 6.83 and 7.00 to 6.33 which can be attributed to changes in colour and appearance. Sen (2010) [15] also experience similar change in overall acceptability in sensory evaluation during storage period of 30 days.

Table 5: Sensory scores of different types of flavoured rehydration drink during storage (Mean±SE)[@]

Sensory Parameter	Storage Days at 4°C																			
	0th day				7th day				14th day				21st day				28th day			
	C	M	GA	J	C	M	GA	J	C	M	GA	J	C	M	GA	J	C	M	GA	J
Taste	7.16±0.1	8.33±0.2	7.50±0.2	7.00±0.0	7.00±.25	8.16±0.3	7.33±0.2	6.83±0.1	6.83±0.4	7.66±0.3	7.16±0.3	6.83±0.1	6.50±0.5	7.5±0.2	7.00±0.3	6.50±0.3	6.33±0.4	7.00±0.2	6.83±0.3	6.33±0.2
Colour and Appearance	6.66±0.2	8.00±0.3	7.33±0.2	7.00±0.0	6.50±.2	8.00±0.3	7.33±0.2	6.83±0.1	6.50±0.3	7.50±0.2	7.16±0.3	6.83±0.16	6.16±.40	7.00±0.2	7.00±0.2	6.83±0.16	5.83±.40	5.83±0.3	6.83±0.3	6.67±0.3
Mouth feel	6.33±0.3	7.66±0.2	7.33±0.2	6.83±0.1	6.16±0.3	7.50±0.2	7.33±0.2	6.66±0.2	6.00±0.4	7.00±0.2	7.00±0.2	6.66±0.2	5.66±0.3	7.00±0.2	7.16±0.3	6.50±0.3	5.50±0.3	6.16±0.3	7.16±0.3	6.50±0.3
Flavour	6.16±0.3	8.16±0.3	7.50±0.2	7.16±0.1	6.00±0.3	8.00±0.2	7.33±0.2	6.83±0.1	5.83±0.4	7.66±0.2	7.16±0.3	6.83±0.1	5.83±0.3	7.66±0.2	7.00±0.3	6.50±0.2	5.83±0.3	6.66±0.5	6.83±0.4	6.33±0.4
Overall Acceptability	6.83±0.1	8.50±0.2	7.66±0.2	7.00±0.0	6.50±0.3	8.33±0.2	7.50±0.3	6.83±0.1	6.33±0.3	7.83±0.1	7.33±0.3	6.50±0.3	6.16±0.4	7.66±0.2	7.00±0.3	6.33±03	6.00±0.2	7.00±0.2	6.83±0.3	6.33±0.4

Note: Average @ 6 trials, ** highly significant; * significant; NS – No significant differences; C- Control; M- Mango; GA- Green Apple; J- Jaljeera;

Conclusion

The physicochemical characterization of whey based rehydration drink results many advantages. During storage the titratable acidity and pH value for mango, green apple and jaljeera flavoured rehydration drink increased and decreased steadily at 4 °C throughout storage period. There was no growth observed in yeast, molds and coliform throughout the storage period of 28 days. The overall acceptability changes significantly (P<0.01) throughout the storage period of 28 days. Commercialization of these products help in utilizing whey-based products containing nutritionally superior whey proteins with an additional appeal to consumers and simultaneously helps sports person to rehydrate during physical activity.

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