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Development of fruit enriched whey beverage

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Abstract
The investigation was aimed at developing nutritious health beverage by utilising whey with incorporation of fruit juices such as pineapple and orange juice. Paneer whey was blended with pineapple juice and orange juice at a proportion of 0 to 30 per cent the physico chemical sensory attribute studies revealed that pineapple juice blended to whey at a level of 30 per cent and orange juice at a proportion of 25 per cent to prepare a most acceptable beverage. Out of that whey blended with 30 per cent of pineapple juice level was optimised. The most acceptable beverage was stored in glass bottles at 4±1 ºC and it was observed that the beverage prepared as above stored for period of 12 to 16 days as revealed by physico chemical and microbiological attribute studies during period of storage.

Keywords: whey, pineapple and orange juice

1. Introduction
Whey is a valuable by-product from dairy industries obtained during manufacture of cheese, chhana, paneer, casein and shrikhand and is not being utilized to its full extent on the other hand whey presents interesting nutritional value as food supplement and its discard is increasingly frowned upon by environmentalists (Jindal *et al*., 2004). It is a major output of cheese industry. It carrying precious nutrients like lactose, whey protein, minerals, and vitamins. These nutrients have an indispensable value in human dietary requirement (Prendergast, 1985; Mathur *et al*., 1988) [8]. Currently, total world production of whey is approximately 85 million tonnes in which India contributes approximately 2, 80, 000 tonnes of the total global production (Shukla *et al*., 2004; Raju *et al*., 2005; Mishra, 2008) [17, 12, 9]. About 40% of the total global production of whey is disposed as raw whey (Reddy *et al*., 1987) [14] causing serious problems of environmental pollution due to high organic matter content. It has been estimated by the Water Pollution Research Laboratory that whey has a Biological Oxygen Demand (BOD) of 38,000 to 46,000 ppm, even in some cases it reaches up to 76000 ppm as compared to 200 ppm permissible limit for domestic sewage (Mishra, 2008) [9]. Whey disposal is a serious problem for dairy industry. In order to reduce pollution load, whey should be treated to obtain commercial products (Gupta and Nair, 2010) [5]. The Government of India has promulgated the Environmental Protection Act-1986 that makes it obligatory to pre treat whey before discharge in inland water or rivers.
Consumption of the whey can supplement much of the lost organic and inorganic nutrients to the extra cellular fluid and utilization of these fluids can be targeted to the people working with strenuous occupation like sportsman, body builders, competitive athletes, exercising for pleasure and other people with similar kind of activity (Prendergast *et al*., 1985; Singh *et al*., 2009) [18]. Presence of electrolytes in whey is an important criteria before going for healthy whey drink because it can be used as a source of replenishment for the loss minerals (Goyal and Ghandhi 2009) [4]. Most of the work regarding utilization of whey has been carried out worldwide in the production of Whey.
Fruit juices are well recognized for their nutritive value, mineral and vitamin content. They are beverages that are consumed for their nutritional value, thirst-quenching properties and stimulating effect or for their medicinal values (Fawole and Osho, 2002) [2]. The low pH of fruit juices greatly limits the number and the type of bacteria that can survive. (Ryu and Beuchat, 1998) [15]. At present bulk of the beverages are generally synthetic flavoured, that are made available in market. If this could be substituted with fruit juice and dairy by product, results in beneficial contribution to the consumer, dairy industries and beverage manufacturers as well as fruit growers.

With the above considerations the present investigation has been taken up, keeping in view of the following objectives: To optimize blending of whey with fruit juice on the quality of whey based health beverage.

2. Materials and methods

The following materials and ingredients were used in this investigation for the preparation of dairy by product-based beverage. Milk: Fresh cow milk was procured from the Student's Experimental Dairy Plant (SEDP) for the preparation of paneer and the resultant whey was used for the research work. Whey - Panner whey procured obtained from Students Experimental Dairy Plant (SEDP), Dairy Science College, Hebbal, Bengaluru, was used in this investigation. Fruit juice - The fruits (Pineapple and Orange) were procured from local market and juice was extracted in an hygienic condition. Sugar - Good quality cane sugar was procured from the local market.

Chemicals

All the chemicals used for chemical analysis were of analytical grade

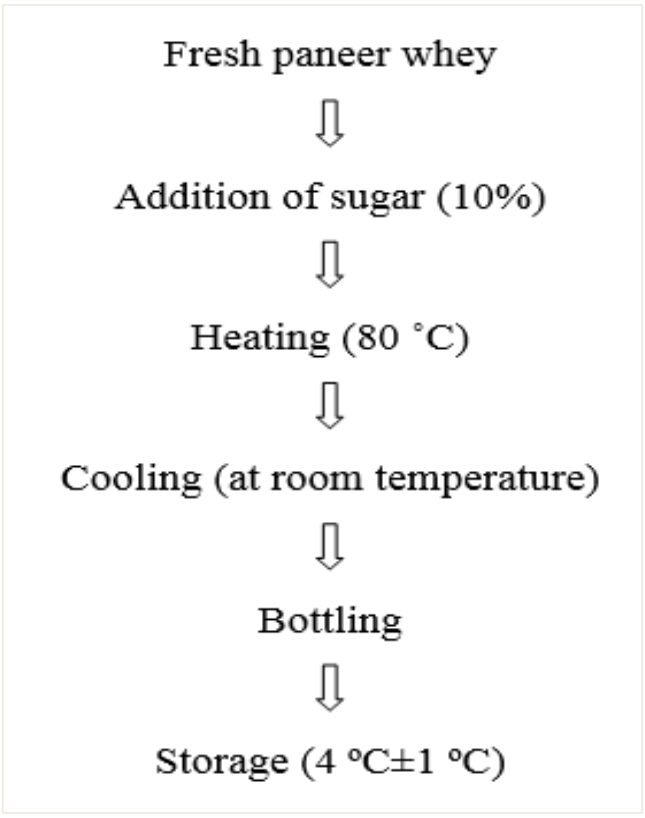
Media used for microbiological study

Standard Plate Count Agar (SPCA) was used for enumeration of total count. Whereas Violet Red Bile Agar (VRBA) and Malt Extract Agar (MEA) for enumeration of coli forms and yeast and mold respectively.

Methods

2.1 Preparation of whey beverage

Whey has procured from Student Experimental Dairy Plant, and whey beverage has prepared by following procedure

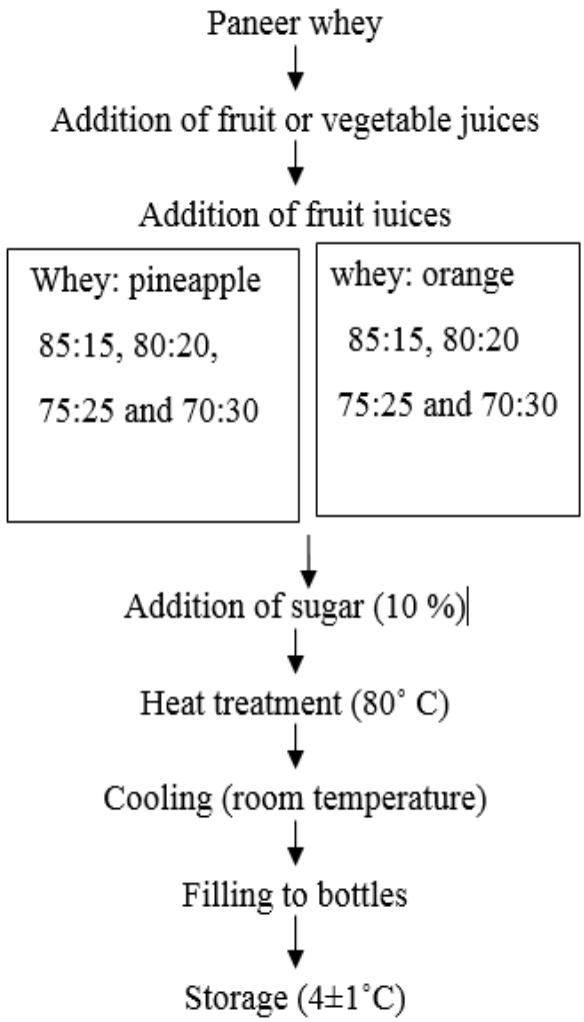


2.2 Preparation of fruit juices

Fresh ripened and matured pineapple of medium size was selected for extraction of juice. The outer skin was removed with the help of a stainless steel knife and the fruit was washed with, clean water and cut into small pieces. The pieces were then grinded in a blender and the juice was extracted. The extracted juice was filtered through a muslin cloth to remove musts and to get clear juice. Similarly well ripened oranges of good quality were procured from the market for the extraction of juice. The outer skin was peeled off and only inner juicy portion of the fruit was utilized for juice extraction. The juicy portion was placed into blender and the juice was extracted. The extracted juice was filtered through a muslin cloth to remove musts and to get clear juice.

2.3 Process optimization for preparation of beverage with its admixture of whey and fruit juices based beverage.

Whey based beverage is prepared by blending fruit (Orange, Pineapple) juices at 15, 20, 25 and 30 per cent level to whey. The resultant blends were added with 10 per cent sugar, pasteurized, cooled. The beverage thus prepared was subjected to various physico-chemicals and sensory attributes studies to adjudge the optimum level of blending.



Flow chart for Preparation of fruit juice based whey beverage

3. Result and discussion

3.1 Effect of blending fruit juices to whey on Physico-chemical and sensory properties of formulated whey beverage

In this study, various blends of whey and pineapple and orange juice were tried. The effect of blending pineapple juice/orange juice on various physico-chemicals and sensory properties of beverage was evaluated and the results are delineated in the following sections

3.1.1 Effect of blending fruit juices to whey on Physical properties of formulated whey beverage

Pineapple and orange juice was blended with whey at various proportions. The effect of blending pineapple and orange juice on pH, acidity, specific gravity and viscosity of the blend is presented table 1.

With increasing in the level of blending from 0 to 30 per cent, there was study decrease in pH of pineapple and orange juice blended whey beverage. The pH of control was 5.32, whereas pineapple juice whey beverage was 5.10, 5.0, 4.99 and 4.92 at 15, 20, 25 and 30 per cent blending of pineapple juice to whey respectively and for orange juice whey beverage it was recorded to be 5.25, 5.23, 5.21 and 5.19 respectively at 15, 20, 25, and 30 per cent blending. The pH of Pineapple juice (4.0) and Orange juice (4.9) blended beverage was lower as compared to plain whey beverage (5.32).

With increase in the incorporation of pineapple/ orange juice in whey, there was significant increase in acidity. The acidity of control was 0.22 per cent whereas pineapple juice blended whey was 0.32, 0.34, 0.35 and 0.36 at 15, 20, 25 and 30 per cent blending of pineapple juice to whey respectively and for orange juice blended whey beverage it was 0.25, 0.26, 0.27, and 0.28 per cent acidity at 15, 20, 25 and 30 per cent blending respectively. The acidity of fruit juice (Pineapple and Orange) beverage was found to be higher as compared to control. It is evident from the results that with increasing level of blending of pineapple and orange juice to whey there was significant increase in specific gravity of blends. The specific gravity of control was 1.024 whereas for pineapple juice blended with whey it was 1.024, 1.039, 1.042, 1.045 and 1.046 at 15, 20, 25 and 30 per cent, respectively. As against 1.038, 1.041, 1.042 and 1.043 for orange juice whey beverage respectively, at the same respective level of blending.

Table 1: Effect of blending fruit juices to whey on Physical characteristics of formulated whey beverage

Parameter	Control (100:0)	Proportion of blending								CD (P≤0.05)
		Whey: Pineapple juice				Whey: Orange juice				
		(85:15)	(80:20)	(75:25)	(70:30)	(85:15)	(80:20)	(75:25)	(70:30)	
Acidity (%LA)	0.22^{a}	0.32^{b}	0.34^{b}	0.35^{b}	0.36^{b}	0.25^{b}	0.26^{b}	0.27^{b}	0.28^{b}	0.02
pH	5.32^{a}	5.10^{b}	5.00^{b}	4.99^{b}	4.92^{b}	5.25^{b}	5.23^{b}	5.21^{b}	5.19^{b}	0.05
Specific gravity	1.024^{a}	1.039^{b}	1.042^{b}	1.045^{b}	1.046^{b}	1.038^{b}	1.041^{b}	1.042^{b}	1.043^{b}	0.012
Viscosity (cP)	1.068^{a}	1.12^{b}	1.15^{b}	1.21^{c}	1.28^{d}	1.10^{b}	1.12^{b}	1.19^{c}	1.20^{c}	0.022

With increase in the incorporation of pineapple and orange juice to whey, there was significant increase in viscosity. The viscosity of control was 1.068 cP whereas pineapple juice blended whey it was 1.12, 1.15, 1.21 and 1.28 cP at 15, 20, 25 and 30 per cent blending respectively. In case of orange juice whey beverage the viscosity was observed to be 1.10, 1.12, 1.19, and 1.20 cP at 15, 20, 25 and 30 per cent blending respectively.

3.1.2 Effect of blending fruit juices to whey on chemical composition of formulated whey beverage

The chemical composition of pineapple and orange juice blended formulated whey beverage are presented in table 2

In the formulated whey beverage the level fat significantly decreased with an increase in the level of pineapple juice from 0.15 per cent to 0.127, 0.12, 0.11 and 0.105 per cent respectively at 15, 20, 25 and 30 per cent blending respectively. Where as in orange juice blended whey beverage the fat level decreased to 0.126, 0.12, 0.119 and 0.102 per cent respectively in the above level of blending.

Protein content significantly increased to 0.392, 0.40, 0.41 and 0.42 at 15, 20, 25, and 30 per cent pineapple juice blended beverage from an initial value of 0.39. Where as in orange juice whey beverage the protein content increased to 0.45, 0.47, 0.49, and 0.51 percent at 15, 20, 25 and 30 per cent respectively from an initial protein content of 0.39 per cent. Total carbohydrate is inclusive of lactose, fructose, and added sugar, was 14.5 per cent in control whereas, it was 16.30, 16.74, 17.175 and 17.61 at 15, 20, 25, and 30 per cent in pineapple juice blended whey beverage at respectively. Increase in the pineapple juice from 15 to 30 per cent there was significant increase in the carbohydrate content. Similarly total carbohydrate content in orange juice blended whey beverage increased with increase in the level of blend from 15 to 30 per cent as could be observed from table 2.Similarly the ash content in pineapple juice blended whey beverage significantly increased with increase in the level of pineapple juice as well as orange juice from 15 to 30 per cent as depicted in table 2.

Table 2: Effect of blending fruit juices to whey on chemical composition of formulated whey beverage

Parameter (%)	Control (100:0)	Proportion of blending								CD (P≤0.05)
		Whey: Pineapple juice				Whey: Orange juice				
		(85:15)	(80:20)	(75:25)	(70:30)	(85:15)	(80:20)	(75:25)	(70:30)	
Fat	0.15^{a}	0.127^{b}	0.12^{b}	0.11^{b}	0.105^{b}	0.126^{b}	0.12^{b}	0.119^{b}	0.102^{b}	0.020
Protein	0.39^{a}	0.392^{b}	0.40^{c}	0.41^{d}	0.42^{e}	0.45^{b}	0.47^{c}	0.49^{d}	0.51^{e}	0.001
Total carbohydrate	14.5^{a}	16.30^{b}	16.74^{b}	17.175^{b}	17.61^{b}	15.75^{b}	16.00^{b}	16.25^{b}	16.5^{b}	1.10
Ash	0.60^{a}	0.62^{b}	0.63^{c}	0.65^{d}	0.66^{e}	0.61^{b}	0.62^{c}	0.63^{d}	0.64^{e}	0.008
Total solids	15.64^{a}	17.43^{b}	17.89^{b}	18.34^{b}	18.79^{b}	16.93^{b}	17.21^{b}	17.48^{b}	17.75^{b}	0.59

*10% sugar level is maintained for all the samples

**Average of three trials

As the level of incorporation of fruit juices increased in whey there was correspondingly increase in the ash content both in case of orange and pineapple blended beverage.

Total solids content in pineapple juice blended whey beverage significantly increased with an increase in the level of pineapple juice the total solids content was it was 17.43, 17.89, 18.34 and 18.79 per cent in pineapple juice based beverage, where as it was 16.93, 17.21, 17.48 and 17.75 per cent in orange juice blended beverage, respectively at 15, 20, 25 and 30 per cent blending as against the control which had 15.64 per cent total solids.

3.1.3 Effect of blending fruit juices to whey on sensory characteristics of formulated whey beverage

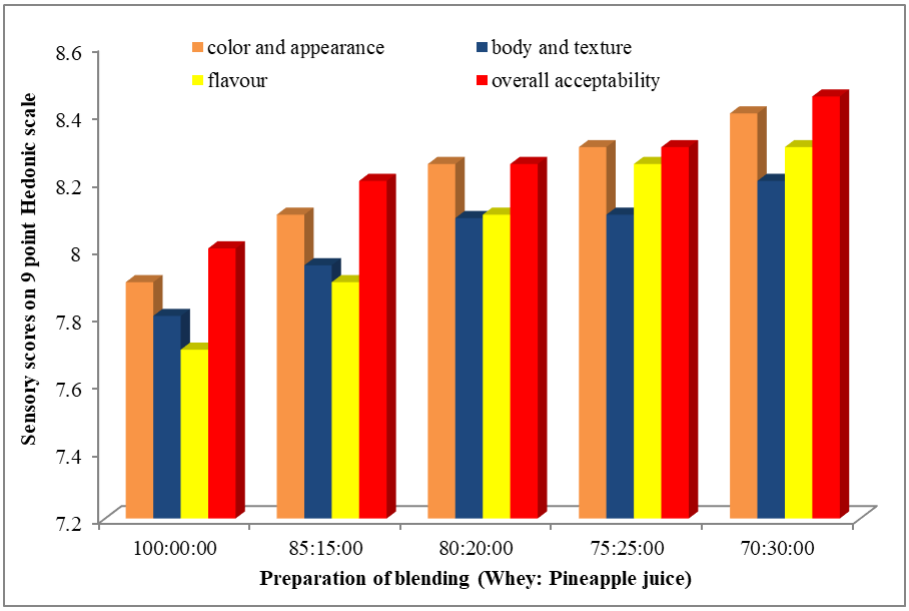
Pineapple and orange juices were blended with whey at various proportions. The effect of blending these juices to whey on the sensory characteristics of the beverage is presented in Table 3 and Fig1.

With increase in the level of incorporation of pineapple juice from 15 to 30 per cent, there was significant increase in the sensory scores of the beverages. There was being 8.0 for control and 8.45 at 30 per cent blend, whereas with the increase in the level of incorporation of orange juice from 15 to 25 per cent, there was significant increase in the sensory scores of the beverages. Whereas at 30 per cent level there was significant decrease in scores for overall acceptability attributes. At 30 per cent secured highest sensory score with respect to overall acceptability score (8.45) as compared to other level of blending of fruit juices. Whereas for orange juice blend the maximum score attained for small acceptable attribute was at 25 per cent level (8.30).

Table 3: Effect of blending fruit juices to whey on sensory characteristics of formulated whey beverage

	(Whey: Juice)	Color and appearance	Body and texture	Flavour	Overall acceptability
Control	100:0	7.90^{a}	7.80^{a}	7.70^{a}	8.00^{a}
Whey: Pineapple juice	85:15	8.10^{b}	7.95^{b}	7.90^{b}	8.20^{b}
	80:20	8.25^{c}	8.09^{c}	8.10^{c}	8.25^{b}
	75:25	8.30^{c}	8.10^{c}	8.25^{c}	8.30^{b}
	70:30	8.40^{b}	8.20^{c}	8.30^{c}	8.45^{c}
Whey: Orange juice	85:15	8.00^{b}	8.07^{b}	8.10^{b}	8.17^{b}
	80:20	8.10^{b}	8.10^{b}	8.12^{b}	8.20^{b}
	75:25	8.15^{b}	8.12^{b}	8.20^{b}	8.30^{b}
	70:30	7.75^{c}	7.69^{c}	7.50^{c}	7.60^{c}
CD(P≤0.05)		0.14	0.10	0.15	0.14

*10% sugar level is maintained for all the samples
**Average of three trials



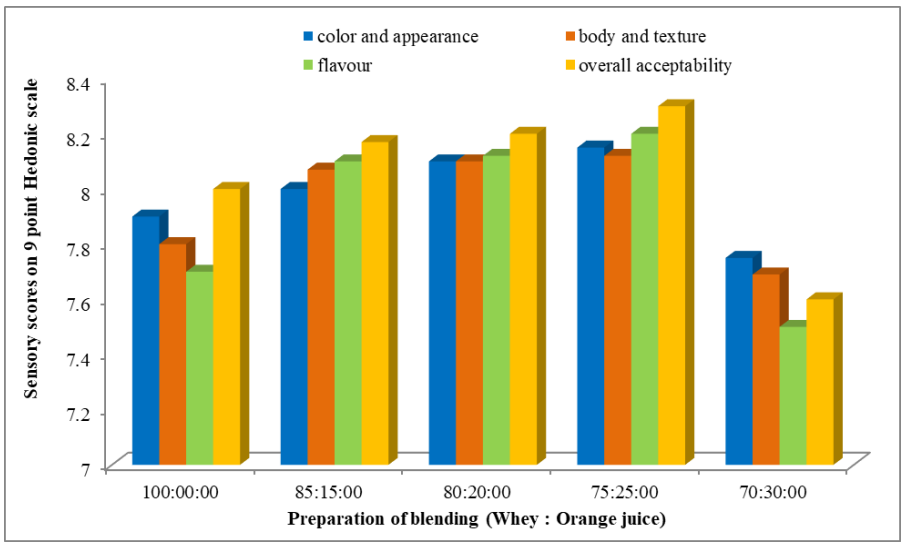


Fig 1: Effect of blending fruit juices to whey on sensory characteristics of formulated whey beverage

3.2 Shelf life assessment of optimised whey enriched with pineapple juice

3.2.1. Effect of storage on Acidity and pH of optimised whey enriched with pineapple juice (4±1 ºC)

The physical quality pH of optimized dairy by product based health beverage has evaluated in terms of acidity are presented in table 4.

As could be seen from the Table 4, the acidity and corresponding pH values of sample at 0th day for was observed to be 0.36 with a corresponding pH of 4.92 respectively. These sample after 4 days of storage as shown acidity of 0.38 with a corresponding pH of 4.85. Similarly after 8th day of storage corresponding acidity and pH for the above samples were found to be 0.40 and pH 4.75 respectively. With increase in the duration from 0th day to 12th day there was significant increase in the acidity (per cent lactic acid) and corresponding decrease in pH in sample as could be seen from table 4 there was progressive increase in acidity and decrease in pH of all the samples during storage.

Table 4: Effect of storage on Acidity and pH of optimised whey enriched with pineapple juice (4±1º C)

Optimised Beverage	Acidity (% LA)						pH					
	0	4	8	12	16	17	0	4	8	12	16	17
Whey Enriched With Pineapple Juice	0.36	0.38	0.40	0.44	0.51	Not accepted	4.92	4.85	4.75	4.70	4.65	Not accepted

3.2.2 Effect of storage on microbiological quality of optimised whey enriched with pineapple juice (4±1º C)

The microbiological quality of optimized dairy by product beverage during storage as the evaluated in terms of total bacterial count, coli form and yeast and mold count are presented in table 5.

On 0th day of storage the total bacterial count in optimised beverage was 0.58 log $_{10}$ cfu/ml. whereas coliform, yeast and mold were found to be absent in all the fresh samples. On 4th day coliform count were found to be absent in all the samples, whereas the total bacterial count was 1.09 log $_{10}$ cfu/ml and yeast and mold count was 0.30log $_{10}$ cfu/ml. Similarly on 8th day of storage, the total bacterial count for optimised beverage was 1.22 log $_{10}$ cfu/ml and coliform count was found to be 0.11 log $_{10}$ cfu/ml, whereas yeast and mold count were 0.52 log $_{10}$ cfu/ml for T_1, T_2, T_3, T_4, T_5 and T_6. On Similarly on 12th day of storage, the total bacterial count was found to be 1.56 log $_{10}$ cfu/ml and coliform count was found to be 0.14 log $_{10}$ cfu/ml, whereas yeast and mold count was 0.74 log $_{10}$ cfu/ml. Similarly on 16th day of storage the total bacterial count was found to be 2.65 log $_{10}$ cfu/ml and coliform count was found to be 0.24 log $_{10}$ cfu/ml, whereas yeast and mold count was found to be 0.87 log $_{10}$ cfu/ml for optimised whey pineapple juice. There was off flavour development in samples and finally sample was not acceptable on 17th day.

Table 5: Effect of storage on microbiological quality of optimised whey enriched with pineapple juice (4±1º C)

Beverages	Storage (log $_{10}$ cfu /ml)																	
	0th day			4th day			8th day			12th day			16th day			17th day		
	TBC	Coli	Y&M	TBC	Coli	Y&M	TBC	Coli	Y&M	TBC	Coli	Y&M	TBC	Coli	Y&M	TBC	Coli	Y&M
Whey Enriched With Pineapple Juice	0.58	NIL	NIL	1.09	NIL	0.30	1.22	0.11	0.52	1.56	0.14	0.74	2.65	0.24	0.87	Not accepted		

4. Discussion

This investigation was undertaken to develop health beverage blending with fruit juices (pineapple, orange). The results obtained during the process of product development have been discussed here under along with suitable justification and support of literature.

4.1 Physico – chemical and sensory characteristics of formulated whey beverage with fruit juices

During the course of experiment whey was blended with pineapple and orange juice at 15, 20, 25 or 30 per cent levels. The results pertaining to the effect of blending juices on physico- chemical and sensory properties of blend are presented in Tables 1, 2 and 3.

The decrease in pH and increase in acidity with increasing in the level of blend is due to initial lower pH and higher acidity of pineapple juice (pH-4) and orange juice (pH -4.9) which have been used to blend with paneer whey. With the increase in the level of pineapple and orange juices from 0 to 30 per cent was proportionate decrease in pH and increase in acidity. The pH of fruit juice (Pineapple – 4.0 and Orange – 4.9) was found to be lower as compare to control. The pH of pineapple blended beverage at 30 per cent blend was 4.92 and corresponding acidity was 0.36. whereas the respective pH and acidity of orange blended beverage at 25 per cent blend was 5.21 and 0.27 per cent as against the control which has depicted pH of 5.32 and acidity of 0.22 per cent.

There was increase in specific gravity and viscosity of both pineapple blended and orange blended beverage. With increasing the level of juices from 0 to 30 per cent there was proportionate decrease in fat level. The decrease in fat content of beverages with the increasing in the level of incorporation of fruit juices (Pineapple and Orange) as compared to control which had a fat content of 0.15.With increasing in the level of blending fruit juices to whey beverage, there was increase in the protein content, if fruit juices blended whey beverage, which could be attributed to the higher protein content of both pineapple and orange juice. The protein content of whey (control) beverage was 0.39 per cent. Whereas the protein content of pineapple and orange juice was found to be 0.4 and 1per cent respectively.

Similarly with increasing in incorporation of fruit juices to whey, there was corresponding increasing in ash content of beverage. This is due to higher ash content of pineapple juice (0.8%) and orange juice (0.7%) as compared to whey which had shown ash content of (0.6%). As the level of incorporation fruit juices is increased there was corresponding increase in the carbohydrate content of the beverage, which could be attributed to the initial higher carbohydrate content of pineapple juice and orange juice (pineapple-13.5% & orange – 10%) as compare to plain whey (4.5). Similarly was the trend in respect of total solid content of pineapple and orange based beverage as the initial total solid content of pineapple juice and orange juice was found to be 13 and 12 per cent respectively, as compare to whey (6.32%).

The changes in physical and chemical properties as a result of incorporation of fruit juices have been reported by several workers and our results are in agreement with the earlier

workers. Bhavasagar *et al.*, (2010) [1] observed that with increasing in the level of incorporation fruit juices to whey results in decreasing in pH and corresponding increase in acidity besides resulting in increased specific gravity and viscosity. They also reported that increasing in the level of incorporation of fruit juices to whey results in decreased fat content and increased protein, carbohydrate, ash and total solid content of the blend. Similar observation have been made by Nairu *et al*., (2011) [10] when orange pulp was incorporated to whey during the preparation of orange pulp blended whey beverage.

From among various proportions of pineapple and orange juice (15, 20, 25 or 30 per cent) blended to whey, the beverage prepared with pineapple juice of 30 per incorporation and orange juice at 25 per cent incorporation as compared to all other combinations. The variation in the scores awarded for various fruit juice blends on overall acceptability could be attributed to the personnel preference of consumers to the particular flavour. Some of the earlier workers reported that sensory evaluation panel preferred pineapple based whey beverage followed by moosambi and orange based whey beverage. Shashidhar, (2007) [16] reported that beverage prepared with pineapple flavour at 30 per cent secured highest sensory score as compare to all the other combinations. Shukla *et al*., (2013), tried various levels of pineapple juice with whey (80:20, 75:25, 70:30 and 65:35) and reported that 65:35 blend secured highest score. The present experimental results are similar to the results reported by Suresha (2002), wherein he observed that pineapple flavoured whey permeate beverage is highly acceptable followed by mango and orange permeate beverage.

4.2 Shelf life assessment of optimised whey enriched with pineapple juice

4.2.1 Effect of storage on Acidity and pH of optimised whey enriched with pineapple juice (4±1° C)

Acidity and pH of formulated dairy by-products based health beverage during storage are presented in table 4. The pH of the beverage decreased with the corresponding increase in acidity with the progress and storage.

The decrease in pH and corresponding increase in acidity of optimised whey enriched with pineapple juice could be attributed to the production of organic acids and amino acids due to action of ascorbic acid on sugar and protein content of beverages. Lactose and proteins are converted into lactic acid and amino acids leading to increase in acidity and decrease in the pH of the beverages. Similar results have also been reported by Sikder *et al.*, (2001), Sirohi *et al*., (2005) [19] and Yadav *et al*. (2010) [21] for mango RTS and banana whey beverage. Garg and Goyal (2006) reported that the increase in acidity of aonla cider was due to the accelerated degradation of pectic substances or due to formation of organic acids by ascorbic acid degradation. Similar observation also recorded by Rashmi, (2011) [13] who reported that acidity increases with corresponding decrease in pH during storage in development of amla whey drink

4.2.2 Effect of storage on microbiological quality of optimised whey enriched with pineapple juice (4±1° C)

The results pertaining to the microbiological quality with respect to total bacterial count, coli forms and yeast and mold count of various formulated dairy by-products based health beverages during storage at 4 ± 1 ˚C are presented in Table 5.

The initial bacterial count for optimised whey enriched with pineapple juice beverages was found to be 0.58 log $_{10}$cfu/ml, and there was no presence of coliform and yeast and mold with the progress of storage period there was increase in total bacterial count, coli forms and yeast and mold count. On 16th day of storage optimised whey enriched with pineapple juice was having bacterial count of 2.65 log $_{10}$cfu/ml, coliform count of 0.24 log $_{10}$cfu/ml and yeast and molds was found to be 0.87 log $_{10}$cfu/ml respectively. The increase in total bacterial count increase may be with regard to acidophilic bacteria. Yeast and mold may be the major contributor due to aciduric nature of them in fruit and vegetable formulated dairy by product based health beverage. The results are in agreement with Mandal *et al.*, (1997) who reported that the increase in standard plate count of channa whey beverages on storage. Krishnaiah *et al.*, (1989) [7] reported standard plate count of channa whey beverage stored under refrigeration condition increased from 2 to 7.9 SPC/ml for 30 days. Kumari and Rajorhia, (1998) [6] reported that beverage acidification preserves the product from microbial growth and hence the product had shelf life as high as 16 days.

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