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Preparation and techno-economic feasibility of whey based watermelon beverage using betel leaves distillate

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Abstract
In the present study, efforts have been made to develop whey based watermelon beverage with the addition of betel leaves distillate *viz*., 0 – 3%. Storage study was undertaken for a period of 30 days at 7 ± 1^0C at the regular interval of 10 days. The prepared beverage was evaluated using 9 point Hedonic scale for overall acceptability. Techno-economic feasibility of beverage on small scale (250 liter/day) was worked out. The study revealed that the beverage prepared with the addition of 2% betel leaves distillate scored high i.e. 8.5 on 9-point Hedonic scale. It was prepared from watermelon juice containing 14.20% TSS, 8% total sugar, 0.15% acidity, 1.0% ascorbic acid and pH 5.1. *Chhana* whey used for beverage preparation contained 6.30% Total Solid, 0.24% acidity, pH 4.6, 4.80% Lactose, 0.10% Protein and 0.10% Fat. The fresh beverage (2% betel leaves distillate) contained 21.13% TSS, 0.16% acidity, pH 5.1, 0.78 mg/100 gm ascorbic acid, 2.92% reducing sugar and 16.29% total sugar. After 30 days interval slight variation in various parameter have been observed i.e. 21.66%TSS, 0.163% acidity, pH 5.05, 0.76 mg/100 gm ascorbic acid, 3.82% reducing sugar and 16.11% total sugar having average sensory score 8.4. It was observed that betel leaves distillate worked as a natural preservative. Techno-economic feasibility analysis suggested that beverage prepared from 2% betel leaves distillate was costing Rs 6.12/250 ml which is much lower than other similar type of drinks.

Keywords: Techno economic, whey, whey beverage, watermelon, betel leaves distillate

Introduction
Whey is the watery component obtained as a by-product after cutting of the curd in cheese manufacturing; after the drainage of curd while *shrikhand* making; and when acid coagulated dairy products like *paneer* and *chhana* are prepared. The demand of *paneer* is increasing due to increasing incomes, urbanization, and changing lifestyles leading to increased production of paneer with the market size of *paneer* increasing from INR386 billion in 2015-16 to INR654 billion in 2019-20. Such high production of *paneer* leads to enormous amounts of whey. On the basis of titrable acidity and pH, whey is classified as sweet, sour or acidic. Whey contains almost all water soluble nutrients present in milk, particularly lactose, whey proteins, vitamins and minerals (Goyal and Gandhi, 2009) [5]. The Indian dairy industry is looking for new product ideas and technologies to meet the consumers requirement and to increase the profitability of the products. Product diversification is quite feasible using whey as water is replaced without much change in the composition.
The present study was contemplated to make whey useful by supplementing it with watermelon and betel leaves. The watermelon fruit pulp/juice may increase the deliciousness of the product and addition of betel leaf extract provides preventive and curative properties to the product along with its extended shelf-life.

Material and Methods
The study was carried out in year 2008. The raw materials such as cow milk (Amul brand), watermelon, betel leaves and sugar were purchased from local market.

Preparation of *Chhana* whey
The *chhana* whey was obtained during the manufacture of chhana using milk containing 3.5 per cent fat and 8.5 percent solid not fat (SNF). Milk was coagulated using 1.5 percent citric acid (Eagle Brand) solution as coagulant. The whey was filtered and centrifuged to remove the fat. Fat separation was done at 45°C. To precipitate proteins, whey was heated to 105°C at pH 4.6 and then was filtered and stored under refrigerated condition until use.

Preparation of watermelon juice

The watermelon juice was prepared from ripened watermelon. Fruits were washed thoroughly under tap water and dipped in chlorine water for sanitation; then wiped with sterile, clean and dry cloth and then kept under room temperature in a dry place. After cleaning, the fruits were peeled and cut into pieces. The juice was extracted by juicer and it was filtered through the muslin cloth. The juice was kept under refrigerated condition for further use.

Preparation of betel leaves distillate

Fresh betel leaves were washed under tap water to remove dust and dirt and were sanitized by chlorine water. Afterwards, leaves were cut into pieces and grinded in a mixer. The distillate was collected after the distillation of crude betel leaves extract. The distillate was kept under refrigerated condition for further use method shown in Fig 1.

Fig 1: Preparation of Betel Leaves Distillate

Preparation of whey based watermelon beverage using betel leaves distillate

The whey-based watermelon beverages were prepared by method indicated in Fig.2 for which main ingredients were watermelon juice (15%), different levels of betel leaves distillate (0-3%), whey (75-78%) and sugar (7%). In each lot, about 2-3 lit. of beverage was prepared and experiment was repeated for three times. During the preparation of beverages different amount of betel leaves distillate were added to get different concentration in the final product. Whey was heated to dissolve sugar. Thereafter, juice was mixed thoroughly with above mixture and then whole mixture was filtered. The beverage obtained was filtered and filled into glass bottles then sealed by crown corking. In-bottle sterilization was done at 121°C for 10 minutes. Bottles were cooled at room temperature and then stored under refrigerated conditions (7±1°C) (Sirohi *et al.*, 2005; Patel *et al.*, 2007 and Sahu 2003) [11, 8, 10].

Fig 2: Preparation of Whey Based Watermelon Beverage using betel leaves distillate

Storage studies

Bottles containing beverages were stored at refrigerated temperature 7±1^{0}C 30 days. Samples were drawn at the regular interval of 10 days and evaluated for physico-chemical and sensory properties.

Physico-chemical Analysis

The ingredients *viz*., watermelon juice, whey and beverage were analyzed for their different physico-chemical properties. Total soluble solids were determined with hand Refractometer (0-32^{o}C) and the value was expressed as ^{o}Brix. Acidity of whey in terms of lactic acid and malic acid for watermelon juice and WBWB by titrating against 0.1 normal of NaOH as per (IS: 1479, Part-I, 1960) [2] and Ranganna (2002) [9], respectively. The Reducing sugar, Total sugar and Ascorbic acid were determined by the method as prescribed by Ranganna (2002) [9].

Sensory analysis of beverage

The sensory evaluation of fresh and stored beverages was performed by the panel of judges based on 9-point hedonic scale (BIS, 1971) [3]. The sensory evaluations of the samples were done at 10^{o}C temperature of an interval of 10 days during the storage period of 30 days.

Statistical analysis

Data obtained during the course of investigation were subjected to statistical analysis to test the effect of different levels of betel leaves distillate and storage periods on the physico-chemical properties and sensory quality of the product. Statistical analysis technique of split-plot design as proposed by Snedecor and Cochran (1994) was carried out on the data, with main plot as four level of betel leaves distillate with three replications. The statistical model followed is given as under:

$$Y_{ijk} = \mu + S_i + \delta_{ij} + T_k + (SxT)_{ik} + \varepsilon_{ijk}$$

Where, Y_{ijk} is response of k_{th} betel leaves distillate level in the j^{th} replication of i^{th} storage period (i =1, 2, 3, 4; k = 1, 2, 3, 4; j = 1, 2, 3).μ is General mean. S_i kept up Effect of i^{th} storage period of factor S (i = 1, 2, 3, 4) and δ_{ij} = Response for j^{th} replication for i^{th} betel leaves distillate level (Error-I). T_k is effect of k^{th} level of betel leaves distillate of factor T (K = 1, 2, 3, 4). $(SxT)_{ik}$ is interaction effect of i^{th} storage period of factor S and k^{th} level of betel leaves distillate of factor T. ε_{ijk} is residual effect in Y_{ijk} for the k^{th} betel leaves distillate in the j^{th} replication of i^{th} storage period.

Results and discussion

Physico-chemical characteristics of whey and watermelon juice

The whey and watermelon juice were analyzed for their physico-chemical properties. Whey showed 6.30 ^{o}Brix TSS, 0.24% acidity (measured as% lactic acid), 4.80% lactose 0.10% protein and 4.6 pH. The watermelon juice showed 14.20^{o}Bri TSS, 8.0% Total sugar, 0.15% Acidity (measured as% malic acid) and 5.10% ascorbic acid (mg/100gm).

Effect of different levels of betel leaves distillate concentration on Physico-chemical and sensory characteristics of whey based watermelon beverage

The initial average values of TSS of different samples (T_0, T_1, T_2 and T_3) were 20.50, 20.66, 21.13 and 21.26 percent,

respectively whereas the corresponding values of TSS at the end of 30 days of storage period were 20.83, 21.00, 21.66 and 21.73 percent, respectively (Table 1). The increase in TSS content was found to be nearly same for all the samples (T_1, T_2 and T_3). This smaller increase in TSS content on storage of beverages may be attributed to partial hydrolysis of complex carbohydrates. The results are in agreement with the finding reported by Pal *et al.* (2007) [7], Kumar and Manimegalai (2003) [6], and Sahu (2003) [10].

Table 1 indicates that the effect on TSS for the interaction between betel leaves concentration and storage period was found to be significant but the interaction between betel leaves concentration and storage period on TSS content of the beverages over a storage period of 30 days was found to be non-significant.

Acidity of each preparation of beverages at different period of storage at 7±1ºC is presented in Table 1. The initial average value of acidity of all the samples (T_0, T_1, T_2 and T_3) was 0.16 percent, whereas the corresponding values of acidity of respective samples *viz*., T_0, T_1, T_2 and T_3 at the end of 30 days of storage period were found to be 0.18, 0.17, 0.17 and 0.17 percent, respectively indicating slight increase.

This increase in acidity was due to the conversion of lactose to lactic acid, and formation of other organic acid by ascorbic acid and malic acid inherently present in the watermelon juice. On storage, some of the protein also gets converted into amino acid. These findings are in agreement with the observations made by Pal *et al.* (2007) [8], Kumar and Manimegalai (2003) [6], Patel *et al.* (2007) [8] and Sirohi *et al.* (2005) [11]. Table 1 also shows that the effect on acidity was significant for the interaction between storage periods and betel leaves distillate concentration, and both have significant effect at 5 percent level over a storage period of 30 days.

Table 1: Effect of betel leaves distillate concentrations and storage period on TSS and acidity (%) of beverages

S. No.	Betel leaves Distillate Conc. (%)	TSS (ºBrix)					Acidity (%)				
		Storage period (Days)									
		Fresh	10	20	30	Avg.	Fresh	10	20	30	Avg.
1	Control(T_0)	20.50	20.66	20.53	20.83	20.63	0.160	0.163	0.166	0.171	0.165
2	1%(T_1)	20.66	20.83	20.80	21.0	20.82	0.160	0.161	0.163	0.165	0.163
3	2%(T_2)	21.13	21.20	21.33	21.66	21.31	0.160	0.160	0.162	0.163	0.162
4	3%(T_3)	21.26	21.4	21.53	21.73	21.48	0.160	0.160	0.161	0.162	0.161
5	Average	20.89	21.02	21.05	21.29		0.160	0.161	0.163	0.165	
Effect		CD			SE±		CD			SE±	
Storage (S)		0.362**			0.104		0.0009**			0.0003	
Treatment (T)		0.215**			0.073		0.0006**			0.0002	
(S) x (T)		-			0.147		0.0012**			0.0004	

**Significant at 5% level

The initial average values of pH of different samples (T_0, T_1, T_2 and T_3) were 5.1 percent for all the treatments, whereas the corresponding values for pH at the end of 30 days storage period were determined to be 4.95, 5.02, 5.05 and 5.05 percent, respectively. This is lower than the values after 10 and 20 days period of storage i.e., 5.07 and 5.04. The effects of storage period on pH of beverages with different concentration of betel leaves distillate is shown in Table 2 in which it can be seen that there is a decrease order in the pH vales of beverages. These results are in agreement with the findings of Kumar and Manimegalai (2003), Patel *et al.* (2007) [8] and Sirohi *et al.* (2005) [11] reported for fruit beverages as they were determined pH after 90 and 30 days for storage of whey based pineapple and mango beverages, respectively.

Table 2 shows that interaction between storage periods and betel leaves distillate concentration cause significant decrease in pH.

The initial average values of reducing sugar of different samples (T_0, T_1, T_2 and T_3) were estimated to be 2.95, 2.94, 2.92 and 2.91 percent, respectively, whereas at the end of 30 days of storage period the corresponding values were found to be 3.85, 3.49, 3.82 and 3.85 percent, respectively. Increase in reducing sugar was due to hydrolysis of non-reducing sugars into reducing sugars during storage. Similar increasing trend have also been reported by Pal *et al.* (2007) [7], Sirohi *et al.* (2005) [11] and Kumar and Manimegalai (2003) [6] in case of watermelon nectar, mango and pineapple beverages.

Table 2 illustrates increase in reducing sugar during the storage period due to interaction between storage periods and betel leaves distillate concentration and both reducing sugar and treatment have significant effect on storage period at 5% level.

Table 2: Effect of betel leaves distillate concentrations and storage period on pH and reducing sugar (%) of beverages

S. No.	Betel leaves Distillate Conc. (%)	pH					Reducing Sugar (%)				
		Storage period (Days)									
		Fresh	10	20	30	Avg.	Fresh	10	20	30	Avg.
1	Control(T_0)	5.10	5.05	5.00	4.95	5.03	2.95	3.27	3.57	3.85	3.41
2	1%(T_1)	5.10	5.05	5.05	5.02	5.05	2.94	3.23	3.49	3.49	3.36
3	2%(T_2)	5.10	5.10	5.05	5.05	5.07	2.92	3.22	3.52	3.82	3.37
4	3%(T_3)	5.10	5.10	5.05	5.05	5.07	2.91	3.29	3.58	3.85	3.40
5	Average	5.10	5.07	5.04	5.02		2.93	3.25	3.54	3.82	
Effect		CD			SE±		CD			SE±	
Storage (S)		0.0014**			0.0004		0.035**			0.010	
Treatment (T)		0.0012**			0.0004		0.007**			0.002	
(S) x (T)		0.0024**			0.0008		0.015**			0.005	

**Significant at 5% level

The initial average values of total sugar of fresh samples (T_0, T_1, T_2 and T_3) were estimated to be 16.26, 16.26, 16.29 and 16.32 percent, respectively, whereas the corresponding values of total sugar of respective samples *viz*., T_0, T_1, T_2 and T_3 at the end of 30 days storage period were found to be 15.72, 15.88, 16.11 and 16.26 percent, respectively with an average value of 15.87%. This indicates that there was no appreciable change in total sugar content in the samples with the progress of storage period. Similar findings have also been reported by Bawa and Bains (1977) [4] and Sirohi *et al.* (2005) [11] for watermelon juice and mango beverage from various local mango varieties. During the investigation they stored the sample for 120 days and one month, respectively.

However, Table 3 shows a non- significant difference of total sugar content for the interaction between storage periods, betel leaves distillate concentration and both storage period and betel leaves distillate at 5% level.

The ascorbic acid content in fresh beverage samples are 0.76 (T_0), 0.77 (T_1), 0.78 (T_2) and 0.78 (T_3) mg/l00g, whereas the corresponding values of ascorbic acid of respective samples at the end of 30 days storage were found to be 0.74, 0.75, 0.76 and 0.75 mg/l00g for T_0, T_1, T_2 and T_3. Same trend have also been observed after 10 and 20 days of storage period. This decrease in ascorbic acid may be due to increase in acidity of stored product caused by the degradation of ascorbic acid to carbolic acid under high acidic condition. Similar results have also been reported by Pal *et al.* (2007) [7], Sirohi *et al.* (2005) [11], Patel *et al.* (2007) [8] and Sahu (2003) [10] for watermelon nectar and fruit beverages.

Table 3 illustrated that the decrease in ascorbic acid for the interaction between storage periods, betel leaves distillate concentration and both have significant effect on storage period at 5% level.

Table 3: Effect of betel leaves distillate concentrations and storage period on total sugar and ascorbic Acid (%) of beverages

S. No.	Betel leaves Distillate Conc. (%)	Total Sugar (%)					Ascorbic Acid (%)				
		Storage period (Days)									
		Fresh	10	20	30	Avg.	Fresh	10	20	30	Avg.
1	Control(T_0)	16.26	16.21	16.19	15.72	16.09	0.76	0.76	0.75	0.74	0.75
2	1%(T_1)	16.26	16.18	16.17	15.88	15.99	0.77	0.76	0.76	0.75	0.76
3	2%(T_2)	16.29	16.27	16.27	16.11	16.24	0.78	0.77	0.76	0.76	0.77
4	3%(T_3)	16.32	16.28	16.28	16.26	16.28	0.78	0.77	0.76	0.75	0.76
5	Average	16.28	16.24	16.23	15.87		0.77	0.76	0.76	0.75	
Effect		CD			SE±		CD			SE±	
Storage (S)		0.035			0.359		0.0507**			0.014	
Treatment (T)		0.007			0.277		0.0119**			0.004	
(S) x (T)		0.015			0.555		0.0239**			0.008	

**Significant at 5% level

Effect of betel leaves distillate concentrations and storage period on sensory characteristics of beverages

The beverages prepared by blending of whey, watermelon juice and different concentration of betel leaves distillate were analyzed for various sensorial attributes for their acceptance by using 9 point hedonic scale. The sensory scores obtained with the following sensory attributes like flavor, color and appearance, mouth feel and overall acceptability are presented in figure 3.

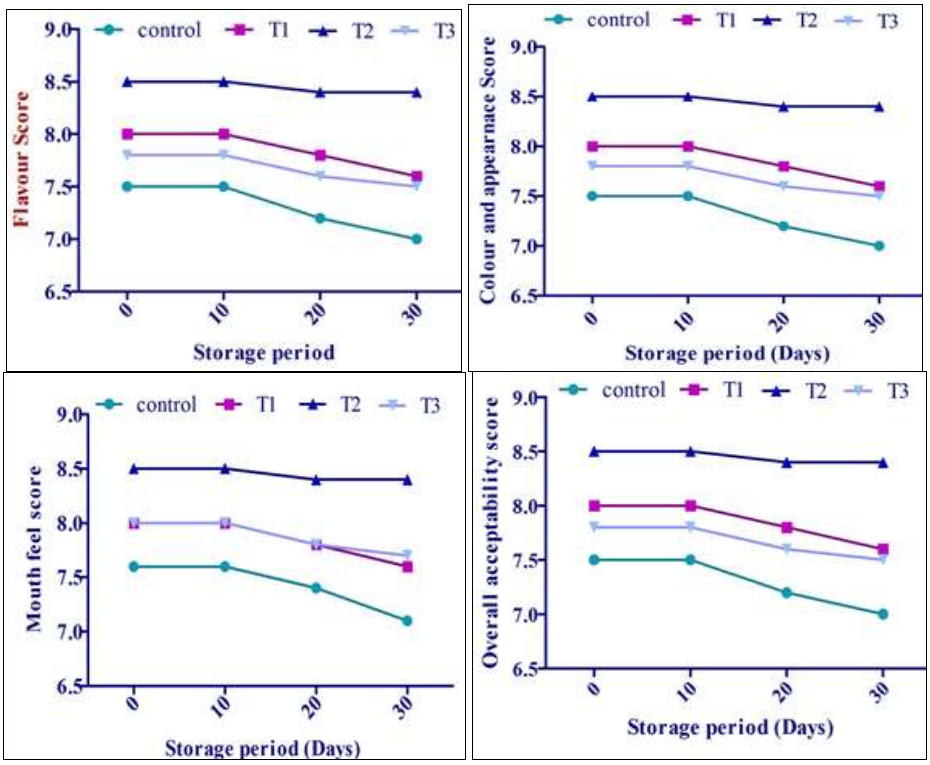

Fig 3: Effect of betel leaves distillate concentrations and storage period on sensory characteristics of beverages

It was observed that beverage sample prepared by addition of 2% (T2) betel leaves distillate was liked most by sensory panel members as compared to the other combinations. The color, flavor and taste of T2 beverage maintained the highest sensory score other than the T1 and T3 beverages, respectively. The figure shows gradual decrease of overall acceptability scores for all the beverages prepared with different concentration of betel leaves distillate with the progress of storage period. This was due to its increased in viscosity, darkening of the colour, and pungent taste. These results are in agreement with Pal *et al.* (2007) [7], Sirohi *et al.* (2005) [11], Patel *et al.* (2007) [8] and Sahu (2003) [10] in case of fruit/whey beverage or nectar.

Techno economic feasibility of Whey Based Watermelon Beverage using betel leaves distillate

The analysis revealed that the cost of 250 ml of beverage having 2 percent betel leaves distillate was Rs. 6.12 at 15 percent profit margin. The cost of beverages may be increased to Rs. 6.66, Rs.7.19 and Rs. 7.46 for 250 ml of product taking 25 percent, 35 percent and 40 percent profit margin, respectively. Break-even-point in terms of production came out to be 42955.62 lit. The table 4 indicates that the payback period of the projected plant would be 2.01 years indicating that the total investment can be recovered in a period of 2 year and 2 months.

Table 4: Techno economic feasibility of Whey Based Watermelon Beverage using betel leaves distillate

S. No.	Particulars	Cost in Rs.
1.	**Capital investment**	
A.	**Fixed capital**	374400.00
	1. Cost of machinery and equipment including installation charges	254400.00
	2. Cost of building (60 m2)@ 2000perm2	120000.00
B	Working capital for 30 days	127275.00
C	Total capital investment (A+B)	501675.00
D	Capital to be taken as loan(75% of total capital)	376256.25
E	Capital share of entrepreneur	125418.75
2.	**Cost Analysis**	
A.	Annual fixed cost	137458.00
I	Depreciation @10% equipment cost	25440.00
II	Depreciation @10% building cost	6000.00
III	Insurance	
	1. @ 2% building cost	2400.00
	2. @ 2% equipment cost	5088.00
IV	Interest @ 18% of total capital investment	92530.00
V	Repair and maintenance @ 5% building cost	6000.00
B.	**Variable Cost (Rs. Per year)**	1533352.50
I	Raw material cost	1327902.50
II	Staff salary	127200.00
III	Electric Charges	52000.00
IV	Other expenditure	10000.00
V	Publicity/Advertisement and marketing charges @ Rs. 0.20 Per lit. of product	16250.00
C.	Total Cost (A+B)	1670810.50
D	Production per lit. of the product (for 78250 lit.)	21.34
E	Cost per 250 ml of product	5.33
F	Ex. Factory price per lit. (Assuming 15% profit margin)	24.54
G	Ex. Factory price per 250 ml of product	6.12
H	Total sale revenue per year	1920255.00
I	Gross Profit	249444.50
J	Net Profit assuming 50% income tax	124722.25
K	Return on investment	24.86
L	Payback period	2.01
M	Breakeven point (BEP)	
	I. In terms of production	42955.62
	II. In terms of no. of days of production	171.82
	III. At BEP, the sale revenue	1054130.91

Conclusion

From the present investigation Beverage prepared from 15 percent watermelon juice, 7 percent sugar, 2 percent betel leaves distillate, 76 percent whey was found quite acceptable to the consumers. Whey contains about half of the milk solids in which nutritional components such as lactose, protein and minerals are present. Higher level of lycopene in watermelon increases the deliciousness and nutritional value of the product. The addition of betel leaf distillate which contains active ingredients like chavicol and eugenol provides preventive and curative properties to the product
along with extended shelf-life. The beverage prepared with 2 percent betel leaves distillate would cost Rs. 6.12/250 ml which is way cheaper than other similar beverages. It can be concluded from the study that the beverage offers viable business opportunity and can encourage entrepreneurship in the whey utilization.

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