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Utilization of betel leaf distillate for Ready-to-Serve (RTS) whey-based watermelon beverage

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Abstract

Whey, a nutritious by-product of dairy coagulation, was utilized as a partial water replacer in the formulation of a ready-to-serve (RTS) watermelon beverage enhanced with betel leaf (*Piper betle* L.) distillate. The study aimed to standardize a manufacturing process for whey-based watermelon beverage and evaluate its physicochemical and sensory properties of the fresh beverage. Beverages were prepared using 15% watermelon juice, 7% sugar, 78% chhana whey, and four levels of betel leaf distillate (0, 1, 2, and 3%). Results showed that the beverage containing 2% betel leaf distillate scored the highest sensory acceptability of 8.5 on a 9-point hedonic scale, exhibiting superior color, flavor, mouthfeel, and overall quality. Higher concentrations of betel leaf distillate retarded microbial activity, improving shelf stability. Betel leaf distillate functioned effectively as a natural preservative and therapeutic additive, making this beverage a promising functional food product.

Keywords: Whey beverage, watermelon juice, betel leaf distillate, ready-to-serve, herbal beverage, physico-chemical properties, sensory evaluation.

1. Introduction

Beverages are an integral part of the daily diet across all age groups, and consumer preference has steadily shifted from synthetic carbonated drinks toward fruit juice-based products with functional health benefits. The global functional beverage market has seen remarkable growth, driven by heightened consumer awareness of nutrition and preventive healthcare, and by the quest for products that offer benefits beyond basic nutrition (Ashurt, 2005). In this context, herbal plants—through their roots, flowers, extracts, and distillates—have gained considerable attention as natural additives in functional beverages.

Whey, the liquid by-product generated during the manufacture of cheese, paneer, chhana, chakka, and casein through acid or rennet coagulation of milk, contains approximately half of the total milk solids. It is rich in lactose, whey proteins, minerals, and water-soluble vitamins, making it a highly nutritious substrate for beverage formulation. Despite its nutritional richness, a large proportion of whey is still discarded as effluent in India, posing significant environmental challenges. The predicted whey production in India is approximately 4.84 million tonnes per annum, with chhana and paneer whey contributing the largest share (Raju *et al.*, 2005) [7]. Harnessing whey in the preparation of fruit-based beverages is therefore both a nutritional opportunity and an environmental imperative.

Watermelon (*Citrullus lanatus*) is one of the most widely consumed summer fruits in India. It is an excellent source of vitamins A, B6, and C, as well as lycopene, citrulline, and caffeic acid—compounds known for their antioxidant, anti-

tumor, anti-ulcer, and anti-HIV action properties (Basak, 1988) [2]. Its abundant seasonal availability, high juice yield, refreshing taste, and inherent functional properties make it an ideal candidate for beverage preparation.

Betel leaf (*Piper betle* L.) is one of the most economically important cash crops of India, cultivated extensively in West Bengal, Maharashtra, Tamil Nadu, Odisha, Madhya Pradesh, and Uttar Pradesh. Betel leaf possesses a wide array of bioactive compounds, including tannins, eugenol, chavicol, and essential oils. Chavicol—a key constituent—is a powerful antiseptic reported to be five times more potent than carbolic acid and twice as strong as eugenol (Nadkarni, 1993) [6]. The leaf also contains malic acid, which confers antibacterial and diuretic properties (Basak, 1988) [2]. Its application as a natural flavor enhancer and antimicrobial agent in food products has been explored in a limited manner, offering tremendous scope for functional food development.

Incorporating betel leaf distillate into a whey-based watermelon beverage can simultaneously enhance flavor, improve preservation, and add therapeutic value. The objective of the present investigation was therefore to: (i) standardize the process for the manufacture of a whey-based watermelon RTS beverage using betel leaf distillate; (ii) study the physicochemical and sensory characteristics of fresh beverages

2. Materials and Methods

2.1 Study Site and Raw Materials

The study was conducted in the Dairy Chemistry Laboratory, Department of Dairy Chemistry, College of

Dairy Technology, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh. Watermelon (*Citrullus lanatus*) was procured from the local market of Raipur. Betel leaves of the Meetha pan variety were procured from the local market. Chhana whey was used as a partial water replacer. Commercial-grade fine crystalline cane sugar was used.

2.2 Preparation of Raw Ingredients

Watermelon Juice: Ripe watermelons were washed thoroughly under tap water. They were sanitized in chlorine water, peeled, seeded, and cut into pieces. Juice was extracted using a juicer and filtered through muslin cloth. The juice was stored at 7 ± 1 °C until use.

Betel Leaf Distillate: Fresh betel leaves were washed with cold and hot water, sanitized with chlorine water, cut into pieces, and ground with water in a mixer. The resultant slurry was distilled using standard distillation apparatus to obtain betel leaf distillate.

Chhana Whey: Chhana was prepared from milk containing 3.5% fat and 8.5% SNF using 1.5% citric acid as coagulant at 72 °C (Bhattacharya *et al.*, 1972). The whey was filtered and centrifuged to remove fat at 45 °C, then heated to 105 °C at pH 4.6 to precipitate whey proteins. The clarified whey was filtered and stored at 7 ± 1 °C. The pH of whey was adjusted to 5.1 using 0.1 N NaOH before mixing.

2.3 Beverage Formulation and Treatment Plan

Beverages were prepared using 15% watermelon juice, 7% sugar syrup, and four levels of betel leaf distillate (0%, 1%, 2%, and 3%), with chhana whey constituting the balance (Table 1). Each batch of 2–3 liters was prepared in triplicate. The beverage mixture was filtered, bottled in 250 ml sterilized glass bottles, sealed with crown corks, and subjected to in-bottle sterilization at 121 °C for 10 minutes. Bottles were cooled to room temperature and stored under refrigeration at 7 ± 1 °C for 30 days.

Table 1: Recipe for Preparation of 200 ml of Beverage

Ingredients	T ₀ (Control)	T ₁ (1%)	T ₂ (2%)	T ₃ (3%)
Watermelon juice (ml)	30	30	30	30
Sugar syrup (ml)	14	14	14	14
Betel leaf distillate (ml)	--	2	4	6
Whey (ml)	156	154	152	150
Total (ml)	200	200	200	200

2.4 Chemical Analysis

Chemical analyses were performed at 10-day intervals (Days 0, 10, 20, and 30). Parameters measured included: (a) Total Soluble Solids (TSS): measured using a hand refractometer calibrated with distilled water and expressed in °Brix (Ranganna, 2002) ^[8]; (b) Titratable Acidity: determined by titrating 10 ml of sample against 0.1 N NaOH with phenolphthalein as indicator and expressed as percent malic acid; (c) pH: measured using a Systronic digital pH meter; (d) Total and Reducing Sugar: determined by Lane

and Eyon's method as described by Ranganna (2002) ^[8]; (e) Ascorbic Acid: determined by the 2,6-dichlorophenol indophenol dye method with metaphosphoric acid as stabilizing agent (Ranganna, 2002) ^[8].

2.5 Sensory Evaluation

Sensory evaluation of fresh beverages was performed by a panel of five semi-trained judges using a 9-point hedonic scale (BIS, 1971) at normal room temperature. The sensory attributes evaluated included color and appearance, flavor, mouthfeel, and overall acceptability.

3. Results and Discussion

3.1 Chemical Composition of Chhana Whey and Watermelon Juice

The chhana whey used in the study contained 6.30% total solids, 0.24% acidity (as lactic acid), pH 4.6, 4.80% lactose, 0.10% protein, and 0.10% fat (Table 2). These values are consistent with medium acid whey composition as reported by De (1982) ^[5]. The watermelon juice used contained 14.20% total soluble solids, 8.00% total sugars, 0.15% acidity (as malic acid), 1.00 mg/100 g ascorbic acid, and pH 5.10 (Table 3), comparable to earlier reports by Basak (1988) ^[2].

Table 2: Chemical Composition of Chhana Whey

S. No.	Component	Value
1	Total solids (%)	6.30
2	Acidity (% lactic acid)	0.24
3	pH	4.60
4	Lactose (%)	4.80
5	Protein (%)	0.10
6	Fat (%)	0.10

Table 3: Chemical Composition of Watermelon Juice

S. No.	Component	Value
1	Total soluble solids (%)	14.20
2	Total sugars (%)	8.00
3	Acidity (% malic acid)	0.15
4	Ascorbic acid (mg/100 g)	1.00
5	pH	5.10

3.2 Physico-Chemical Characteristics of Fresh Beverages

The physico-chemical characteristics of freshly prepared beverages (Table 4) showed that the TSS ranged from 20.50°Brix (T₀) to 21.26°Brix (T₃), increasing with higher betel leaf distillate concentrations. This variation was attributed to the inherent soluble solids contributed by the betel leaf distillate. The acidity was uniformly 0.16% and pH was 5.1 for all treatments, as the whey and juice were pre-neutralized before beverage preparation. Ascorbic acid content increased marginally with distillate level (0.76 to 0.78 mg/100g), while reducing sugar decreased slightly (2.95% to 2.91%) due to hydrolysis effects. Total sugar ranged from 16.26% to 16.32% across treatments.

Table 4: Physico-Chemical Characteristics of Fresh Beverages at Different Betel Leaf Distillate Levels

Treatment	Betel Leaf Distillate (%)	TSS (°Brix)	Acidity (%)	pH	Ascorbic Acid (mg/100g)	Reducing Sugar (%)	Total Sugar (%)
T ₀	0 (Control)	20.50	0.16	5.1	0.76	2.95	16.26
T ₁	1.0	20.66	0.16	5.1	0.77	2.94	16.26
T ₂	2.0	21.13	0.16	5.1	0.78	2.92	16.29
T ₃	3.0	21.26	0.16	5.1	0.78	2.91	16.32

3.3 Sensory Characteristics of Fresh Beverages

Freshly prepared beverages were evaluated for color and appearance, flavor, mouthfeel, and overall acceptability using the 9-point hedonic scale (Table 5). Color and appearance scores were uniformly 8.5 for all treatments, as the addition of betel leaf distillate did not impart any visible color change in the beverage. The beverage containing 2% betel leaf distillate (T_2) scored the highest for flavor (8.5), mouthfeel (8.4), and overall acceptability (8.5). Beverages

with 1% distillate scored 8.0 in most sensory parameters. When the distillate concentration was increased to 3%, sensory scores declined for flavor (7.6), mouthfeel (7.8), and overall acceptability (8.0), attributed to the development of bitterness and pungent aroma from concentrated essential oils in betel leaf. These findings establish 2% betel leaf distillate as the optimal concentration for the best balance of flavor enhancement and therapeutic value.

Table 5: Effect of Betel Leaf Distillate Concentration on Sensory Characteristics of Fresh Beverages

Treatment	Distillate (%)	Colour & Appearance	Flavour	Mouth Feel	Overall Acceptability
T_0	0.0 (Control)	8.5	7.5	7.6	7.8
T_1	1.0	8.5	8.0	8.0	8.0
T_2	2.0	8.5	8.5	8.4	8.5
T_3	3.0	8.5	7.6	7.8	8.0

4. Conclusion

The present investigation successfully developed and evaluated a whey-based watermelon RTS beverage incorporating betel leaf distillate as a natural flavoring and preservative agent. Based on the physico-chemical, sensory the following conclusions can be drawn:

The beverage formulated with 15% watermelon juice, 7% sugar, 2% betel leaf distillate, and 76% chhana whey was found to be most acceptable, scoring 8.5 on the 9-point hedonic scale. It was acceptable in terms of color, flavor, mouthfeel, and overall sensory quality. Betel leaf distillate contributed both therapeutic properties and improved shelf life without adversely affecting the sensory quality at concentrations of up to 2%. The presence of bioactive compounds—specifically lycopene, chavicol, and eugenol—in the final product likely enhanced antioxidant activity. Betel leaf distillate at 3% concentration, while improving shelf stability, resulted in lower sensory scores due to bitterness and pungency, reaffirming 2% as the optimal concentration.

Future research should explore the use of other fruit pulps such as guava, kinnow, banana, litchi, and orange in place of watermelon; extend storage studies beyond six months; evaluate the use of other edible medicinal plant extracts and distillates as flavor and preservation enhancers; and consider carbonation to improve palatability and consumer appeal.

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