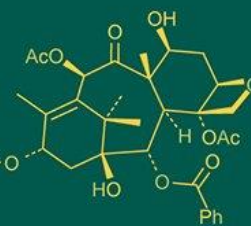
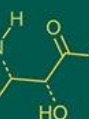
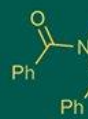
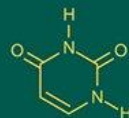


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Prerna

Department of Livestock
Products Technology, College
of Veterinary and Animal
Science, Rajasthan University
of Veterinary and Animal
Sciences, Bikaner, Rajasthan,
India

Rajkumar Berwal

Department of Livestock
Products Technology, College
of Veterinary and Animal
Science, Rajasthan University
of Veterinary and Animal
Sciences, Bikaner, Rajasthan,
India

Nitin Sharma

Department of Livestock
Products Technology, College
of Veterinary and Animal
Science, Rajasthan University
of Veterinary and Animal
Sciences, Bikaner, Rajasthan,
India

Rekha Berwal

Department of Home Science,
Ch. BRG, Govt. Girls College,
Sri-Ganganagar, Rajasthan,
India

Corresponding Author:**Rajkumar Berwal**

Department of Livestock
Products Technology, College
of Veterinary and Animal
Science, Rajasthan University
of Veterinary and Animal
Sciences, Bikaner, Rajasthan,
India

Study of formulation, sensory evaluation, proximate analysis and cost of whey beverages prepared from camel and buffalo milk

Prerna, Rajkumar Berwal, Nitin Sharma and Rekha Berwal

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Abstract

The study aimed to develop a whey-based beverage prepared from buffalo and camel milk whey enriched with Bael (*Aegle marmelos*) powder and to evaluate its sensory quality and proximate composition. Different formulations were prepared by varying whey and Bael powder levels with constant sugar content. Sensory evaluation was conducted using a nine-point hedonic scale for colour, aroma, taste, appearance and overall acceptability, while proximate analysis determined moisture, protein, fat, ash and carbohydrate contents.

Keywords: Proximate analysis, sensory evaluation, whey beverages, Bael powder

Introduction

Whey is formed during the production of cheeses, paneer, and other dairy products and is a byproduct with a high content of lactose, proteins, vitamins, and minerals. Whey has been used for thousands of years as a significant food media. It is rich source of the protein lactalbumin (22 percent of whey protein), lactoglobulin (59 percent of whey protein), serum albumin (6 percent of whey protein), water-soluble vitamin B complex and carbohydrate (lactose 4-5 percent). The primary components of whey solids are soluble proteins and lactose. Whey typically comprises approximately 94% water, 4.6% lactose, 0.8% protein, 0.6% fat and 0.75 percent mineral.

Whey proteins have several beneficial qualities, such as a nutritionally favourable profile of essential amino acids, a wide range of functional characteristics, good solubility over a wide pH range and comparatively low production costs (Kilara & Vaghela, 2018) [6]. Essential amino acids, such as branched-chain amino acids (BCAAs) like leucine, isoleucine and valine, are especially rich in whey. Compared to other dietary proteins, whey proteins have higher concentrations of sulphur-containing amino acids. Simple additions to the whey, such as sugar, colour and flavour, boost its nutritional value, acceptability and taste. Therefore, one of the most important uses for such whey would be to transform it into a delicious beverage. The potential for its use in the beverage sectors has a lot of scope for investigation. Many whey-based fruit drinks have been successfully developed in recent years and have been shown to have the requisite acceptance. For the creation of beverages, various fruit pulps or juices are utilized. The beverages contain carbohydrates, protein, vitamins, mineral and sometimes with added ingredients they are also supplemented with dietary fibres. With the inclusion of various fruits, berries and occasionally vegetable juice, the beverage can be used as a breakfast beverage, snack or as a nutritious beverage that contains vital vitamins (Alane *et al.*, 2017) [1].

Bael fruit pulp is a good source of fermentable substrates for probiotics because it is high in dietary fibre (2-7%) and carbohydrates (30-42%). Its high phenolic content (87 mg g⁻¹ dw) inhibits rancidity and colour loss which includes flavonoids (15.2 mg g⁻¹ dw), carotenoids (32.9 µg/g dw) and vitamin C (about 26 mg/100 dw) (Sarkar *et al.*, 2020; Sharma *et al.*, 2022) [9, 10].

Bael fruit pulp offers an effective method to add probiotics into food products. It has also been observed that adding Bael improves the overall acceptability of food products that contain Bael (Begum *et al.*, 2024; Chaudhary *et al.*, 2023) [2, 4].

In consideration of the well-established health-promoting properties of bael fruit (*Aegle marmelos*), the present study sought to utilize whey in combination with varying levels of bael fruit powder for the development of naturally flavoured whey-based beverages that are both nutritionally enriched and organoleptically acceptable.

Materials and Methods

Material collection

Experiment was conducted at Department of Livestock Products Technology, Department of Veterinary microbiology, College of Veterinary and Animal Science, Rajasthan University of Veterinary and Animal Sciences, Bikaner (Rajasthan). Camel milk was procured from ICAR-National Research centre on camel, Bikaner. Buffalo milk was procured from local market. Bael was procured from local market. For Bael powder.

Preparation of Paneer Whey

Fresh collected Buffalo and camel milk were blended in a 70:30 ratio. The mixed milk was heated to pasteurization temperature (72 ± 1 °C for 15 s) with continuous stirring and maintained at 70 °C for coagulation. A freshly prepared 2% citric acid solution, sterilized by boiling and cooling, was added slowly with gentle agitation until complete separation of paneer curd and clear whey occurred. The mixture was

allowed to stand for 5 min to ensure complete syneresis. The whey was separated by filtration through sterilized muslin cloth and then cooled and stored at 4 ± 1 °C until further use.

Preparation of Bael Fruit Powder

Fresh, mature bael fruits were procured from the local market and washed thoroughly under running potable water to remove adhering dirt. The fruits were manually cracked open, and the pulp was separated from the shell and seeds. The pulp was spread as a thin layer on stainless-steel trays and dried in a hot-air oven at 55-60 °C until a constant weight was obtained. The dried material was ground in a laboratory grinder to obtain a fine powder and passed through a 60-mesh sieve for uniform particle size. The Bael powder was packed in air-tight, food-grade containers and stored at ambient temperature in a dry place until use for whey beverage formulation.

Treatment Details and Product Development

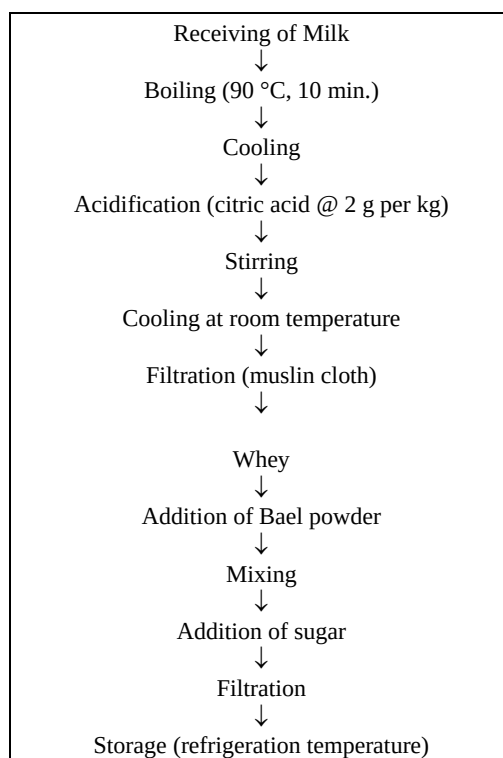
Four formulations of bael-enriched whey beverage were prepared.

T₀ (Control): Whey 100%

T₁: Whey 82% + bael powder 10% + sugar 8%.

T₂: Whey 79% + bael powder 13% + sugar 8%.

T₃: Whey 76% + bael powder 16% + sugar 8%.



Flow Diagram for the Preparation of whey drink

Sensory Evaluation

The formulated whey beverages were cooled to serving temperature before sensory analysis. Evaluation was carried out by a semi-trained panel using a 9-point hedonic scale. The attributes assessed included colour and appearance, aroma, taste and overall acceptability. All treatments were coded and presented randomly to the panellists to avoid bias. Drinking water was provided for palate cleansing between samples. Each panellist scored all samples

individually. The collected scores were compiled and used for statistical analysis to compare the treatments.

Proximate analysis

Proximate analysis including estimation of pH, moisture content, crude protein (CP), ether extract (EE), Crude fibre (CF), calcium, phosphorus and total ash of control and treatment.

Results and Discussion

The proximate composition of the developed whey beverages revealed significant ($p < 0.05$) variation among treatments. Moisture content decreased significantly from T_0 ($92.15 \pm 0.076\%$) to T_3 ($90.45 \pm 0.076\%$), which may be attributed to the increased total solids content due to ingredient incorporation.

Crude protein content increased significantly from $0.525 \pm 0.008\%$ (T_1) to $0.705 \pm 0.008\%$ (T_2 and T_3), reflecting the contribution of whey proteins and added solids. Similarly, ether extract content showed a significant rise, with the highest value recorded in T_2 ($0.418 \pm 0.006\%$), which was statistically at par with T_3 ($0.415 \pm 0.008\%$). Ash content exhibited a significant increasing trend from $0.468 \pm 0.006\%$ (T_0) to $0.695 \pm 0.008\%$ (T_3), indicating

enhanced mineral concentration. Crude fiber content also increased significantly among treatments, ranging from $0.100 \pm 0.006\%$ (T_0) to $0.475 \pm 0.008\%$ (T_3), likely due to the incorporation of plant-based ingredients. Calcium and phosphorus contents increased significantly from T_0 to T_2 , with no significant difference between T_2 and T_3 . Calcium ranged from 18.75 ± 0.099 to 21.30 ± 0.118 mg/100 ml, while phosphorus ranged from 14.35 ± 0.099 to 16.73 ± 0.112 mg/100 ml. Overall, the findings indicate that formulation significantly improved the nutritional and mineral profile of whey beverages. The results are in agreement with earlier reports on whey-based functional beverages (Gorachiya, 2018; Shukla *et al.*, 2013; Rohit *et al.*, 2020; Silva e Alves *et al.*, 2018) [5, 11, 8, 12].

Table 1: Proximate analysis (Mean $\pm$ SE) of whey-based beverages

Constituents	T ₀	T ₁	T ₂	T ₃
Moisture (%)	92.15 ^a $\pm$ 0.076	91.53 ^a $\pm$ 0.088	90.95 ^b $\pm$ 0.076	90.45 ^a $\pm$ 0.076
Crude protein (%)	0.525 ^a $\pm$ 0.008	0.625 ^b $\pm$ 0.008	0.705 ^c $\pm$ 0.008	0.705 ^c $\pm$ 0.008
Fat (Ether extract (%))	0.315 ^a $\pm$ 0.008	0.368 ^b $\pm$ 0.006	0.418 ^c $\pm$ 0.006	0.415 ^c $\pm$ 0.008
Ash (%)	0.468 ^a $\pm$ 0.006	0.565 ^b $\pm$ 0.008	0.645 ^c $\pm$ 0.008	0.695 ^d $\pm$ 0.008
Crude fiber (%)	0.100 ^a $\pm$ 0.006	0.230 ^b $\pm$ 0.006	0.352 ^c $\pm$ 0.006	0.475 ^d $\pm$ 0.008
Calcium (mg/100 ml)	18.75 ^a $\pm$ 0.099	19.95 ^b $\pm$ 0.099	21.30 ^c $\pm$ 0.118	21.22 ^c $\pm$ 0.117
Phosphorus (mg/100 ml)	14.35 ^a $\pm$ 0.099	15.55 ^b $\pm$ 0.099	16.73 ^c $\pm$ 0.112	16.67 ^c $\pm$ 0.120

Sensory Evaluation of Bael-enriched whey beverage

The experimental whey beverage samples were served to a panel of semi trained judges for sensory evaluation such as colour, appearance, aroma, taste and overall acceptability using “9 point hedonic scale”.

The results of sensory evaluation for different parameters are presented in the table-1

Colour

Table 2: Colour (Mean $\pm$ SE) of whey-based beverages

Days	T ₀	T ₁	T ₂	T ₃	Overall
Day0	8.214 $\pm$ 0.214	7.929 $\pm$ 0.13	8.786 $\pm$ 0.184	6.79 $\pm$ 0.21	7.929e $\pm$ 0.166
Day7	7.643 $\pm$ 0.18	7.429 $\pm$ 0.17	8.357 $\pm$ 0.18	6.5 $\pm$ 0.19	7.482d $\pm$ 0.153
Day14	7.143 $\pm$ 0.237	6.571 $\pm$ 0.17	7.5 $\pm$ 0.218	5.71 $\pm$ 0.15	6.732c $\pm$ 0.16
Day21	6.357 $\pm$ 0.18	5.429 $\pm$ 0.23	7 $\pm$ 0.327	4.64 $\pm$ 0.18	5.857b $\pm$ 0.206
Day28	5.786 $\pm$ 0.286	5.357 $\pm$ 0.237	6.286 $\pm$ 0.214	3.64 $\pm$ 0.18	5.268a $\pm$ 0.22
OVERALL	7.029c $\pm$ 0.176	6.543b $\pm$ 0.195	7.586d $\pm$ 0.183	5.457a $\pm$ 0.215	

On day 0, the highest colour score was recorded in T_2 (8.786) followed by T_0 (8.214), T_1 (7.929) and the lowest in T_3 (6.79). As storage progressed, a gradual decline in colour scores was observed in all treatments. At 7 days, colour scores ranged from 8.357 in T_2 to 6.50 in T_3 . Further storage up to 14 and 21 days resulted in a continuous and significant reduction in colour acceptability. On 28 days, the minimum colour score was observed in T_3 (3.64), while T_2 maintained

relatively higher colour acceptability (6.286) as compared to other treatments. Similar reductions in colour acceptability during storage have been reported by Panghal *et al.* (2017) [7], Sharma *et al.* (2020) [10], and Rohit *et al.* (2020) [8], who observed progressive deterioration in colour of whey-based fruit beverages with increasing storage period.

Appearance

Table 3: Appearance (Mean $\pm$ SE) of whey-based beverages

Days	T ₀	T ₁	T ₂	T ₃	Overall
Day0	8.143 $\pm$ 0.21	7.643 $\pm$ 0.21	8.5 $\pm$ 0.218	6.64 $\pm$ 0.14	7.732e $\pm$ 0.164
Day7	7.071 $\pm$ 0.202	6.643 $\pm$ 0.21	8.143 $\pm$ 0.18	6.11 $\pm$ 0.25	6.993d $\pm$ 0.175
Day14	6.857 $\pm$ 0.283	6.643 $\pm$ 0.18	7.571 $\pm$ 0.202	5.64 $\pm$ 0.18	6.679c $\pm$ 0.167
Day21	6.286 $\pm$ 0.214	5.643 $\pm$ 0.18	6.714 $\pm$ 0.149	4.57 $\pm$ 0.17	5.804b $\pm$ 0.177
Day28	5.5 $\pm$ 0.218	5.286 $\pm$ 0.214	6.571 $\pm$ 0.202	3.71 $\pm$ 0.21	5.268a $\pm$ 0.22
OVERALL	6.771c $\pm$ 0.178	6.371b $\pm$ 0.166	7.5d $\pm$ 0.153	5.337a $\pm$ 0.199	

On day 0, the highest overall appearance score (7.732 $\pm$ 0.164) was recorded, indicating excellent visual acceptability of the fresh product. With increase in storage duration, a gradual decline in appearance score was observed, and the lowest score (5.268 $\pm$ 0.22) was recorded on day 28. Among treatments, T_2 showed significantly

higher appearance scores throughout the storage period, followed by T_0 , T_1 and T_3 . This contention gets confirmed from the opinion of Bhatt and Singh (2014) for whey guava beverage that decreases in colour and appearance during storage temperature and interval significantly.

Taste

Table 4: Taste (Mean $\pm$ SE) of whey-based beverages

Days	T ₀	T ₁	T ₂	T ₃	Overall pd
Day0	7.357 $\pm$ 0.21	7.286 $\pm$ 0.24	8.5 $\pm$ 0.218	6.71 $\pm$ 0.18	7.464e $\pm$ 0.16
Day7	6 $\pm$ 0.289	6.571 $\pm$ 0.202	8.143 $\pm$ 0.18	6.11 $\pm$ 0.23	6.707d $\pm$ 0.197
Day14	5.357 $\pm$ 0.303	6.5 $\pm$ 0.154	7.357 $\pm$ 0.237	5.64 $\pm$ 0.18	6.214c $\pm$ 0.184
Day21	4.929 $\pm$ 0.254	5.571 $\pm$ 0.17	6.543 $\pm$ 0.188	4.57 $\pm$ 0.17	5.404b $\pm$ 0.172
Day28	4.786 $\pm$ 0.24	5.214 $\pm$ 0.184	6.214 $\pm$ 0.214	3.71 $\pm$ 0.21	4.982a $\pm$ 0.2
OVERALL	5.686b $\pm$ 0.195	6.229c $\pm$ 0.151	7.351d $\pm$ 0.175	5.351a $\pm$ 0.202	

On day 0, the overall taste score was highest (7.464 $\pm$ 0.16), indicating very good acceptability of the fresh product. As storage progressed, a gradual decline in taste score was observed, reaching 4.982 $\pm$ 0.20 on day 28, which indicates reduced sensory acceptability at the end of storage. Day0, T₁, T₂, T₃, T₄ show respectively 7.357 $\pm$ 0.21, 7.286 $\pm$ 0.24, 8.5 $\pm$ 0.218, 6.71 $\pm$ 0.18 on the day of day 28 respectively

4.786 $\pm$ 0.24, 5.214 $\pm$ 0.184, 6.214 $\pm$ 0.214, 3.71 $\pm$ 0.21 show the gradual decline in taste similar finding Panghal *et al.* (2017)^[7] observed progressive reduction in taste and flavour scores of papaya-based whey RTS beverages during storage.

Aroma

Table 5: Aroma (Mean $\pm$ SE) of whey-based beverages

Days	T ₀	T ₁	T ₂	T ₃	Overall pd
Day0	6.5 $\pm$ 0.189	7.557 $\pm$ 0.203	8.286 $\pm$ 0.184	7.14 $\pm$ 0.26	7.371e $\pm$ 0.159
Day7	6.229 $\pm$ 0.108	7.043 $\pm$ 0.113	7.829 $\pm$ 0.178	6.43 $\pm$ 0.17	6.882d $\pm$ 0.138
Day14	5.871 $\pm$ 0.189	6.843 $\pm$ 0.037	6.643 $\pm$ 0.21	6.21 $\pm$ 0.24	6.393c $\pm$ 0.114
Day21	5.229 $\pm$ 0.223	5.129 $\pm$ 0.249	6.071 $\pm$ 0.13	4.87 $\pm$ 0.23	5.325b $\pm$ 0.133
Day28	3.714 $\pm$ 0.214	4.9 $\pm$ 0.313	5.657 $\pm$ 0.215	4.57 $\pm$ 0.17	4.711a $\pm$ 0.174
OVERALL	5.509a $\pm$ 0.188	6.294c $\pm$ 0.204	6.897d $\pm$ 0.19	5.846b $\pm$ 0.19	

On day 0, the highest aroma score was recorded in treatment T₂ (8.286), followed by T₁ (7.557), T₃ (7.14) and T₀ (6.50). A gradual decline in aroma score was observed during storage, with the lowest values recorded on day 28. The overall mean aroma score was highest in T₂ (6.897), followed by T₁ (6.294), T₃ (5.846) and T₀ (5.509). The decline in aroma during storage may be attributed to

oxidative changes and loss of volatile aromatic compounds. Similar finding Sharma *et al.* (2020)^[10] and Rohit *et al.* (2020)^[8] reported significant declines in flavour perception of ginger-and kiwi-flavoured whey beverages during refrigerated storage.

Overall acceptability

Table 6: Overall acceptability (Mean $\pm$ SE) of whey-based beverages

Days	T ₀	T ₁	T ₂	T ₃	Overall pd
Day0	7.554 $\pm$ 0.098	7.604 $\pm$ 0.162	8.518 $\pm$ 0.084	6.82 $\pm$ 0.11	7.624e $\pm$ 0.128
Day7	6.736 $\pm$ 0.077	6.921 $\pm$ 0.111	8.118 $\pm$ 0.123	6.29 $\pm$ 0.16	7.016d $\pm$ 0.142
Day14	6.307 $\pm$ 0.147	6.639 $\pm$ 0.106	7.268 $\pm$ 0.145	5.8 $\pm$ 0.15	6.504c $\pm$ 0.121
Day21	5.7 $\pm$ 0.125	5.443 $\pm$ 0.137	6.582 $\pm$ 0.118	4.66 $\pm$ 0.14	5.597b $\pm$ 0.145
Day28	4.946 $\pm$ 0.154	5.189 $\pm$ 0.169	6.182 $\pm$ 0.091	3.91 $\pm$ 0.16	5.057a $\pm$ 0.17
Overall	6.249b $\pm$ 0.161	6.359b $\pm$ 0.167	7.334c $\pm$ 0.159	5.498a $\pm$ 0.193	

On day 0, the highest overall acceptability score was recorded in treatment T₂ (8.518 $\pm$ 0.084), followed by T₁ (7.604 $\pm$ 0.162), T₀ (7.554 $\pm$ 0.098) and the lowest in T₃ (6.82 $\pm$ 0.11). With advancement of storage, a gradual decline in overall acceptability was observed at all intervals. Similar results of Chavan *et al.* (2020)^[8] reported decreasing acceptability of whey-based mango beverages over 30 days of storage, while Panghal *et al.* (2017)^[7] observed significant reduction in overall acceptability scores of papayas RTS drinks with increasing whey content and storage period. Sharma *et al.* (2020)^[10].

Conclusion (Sensory Evaluation)

The present investigation demonstrated that incorporation of bael fruit powder in whey-based beverages prepared from buffalo and camel milk significantly affected the sensory attributes of the product. The panellists' scores for colour,

appearance, taste, aroma, and overall acceptability varied markedly among treatments, indicating the strong influence of formulation on consumer preference.

An intermediate level of Bael powder in combination with an optimized whey proportion resulted in superior sensory quality, producing a balanced flavour profile, appealing colour, and smooth mouthfeel. Formulations with either lower or higher Bael concentrations were comparatively less acceptable, suggesting that moderation in Bael addition is essential to achieve desirable organoleptic characteristics.

On the basis of sensory responses, it may be concluded that bael fruit powder is a promising natural ingredient for the development of functional whey beverages with enhanced palatability and consumer appeal. The optimized beverage developed in this study shows good potential for further evaluation with respect to nutritional quality, shelf-life, and large-scale production.

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