International Journal of Advanced Biochemistry Research

ISSN Print: 2617-4693
ISSN Online: 2617-4707
NAAS Rating (2025): 5.29
IJABR 2025; SP-9(12): 1102-1107
www.biochemjournal.com
Received: 07-09-2025
Accepted: 12-10-2025

AV Gharatkar
Ph.D. Scholar, Department of Animal Husbandry and Dairy Science, Post Graduate Institute, Mahatma Phule Krishi Vidyapeeth, Rahuri, Maharashtra, India

DK Kamble
Head, Department of Animal Husbandry and Dairy Science, Post Graduate Institute, Mahatma Phule Krishi Vidyapeeth, Rahuri, Maharashtra, India

AT Lokhande
Assistant Professor, Department of Animal Husbandry and Dairy Science, Post Graduate Institute, Mahatma Phule Krishi Vidyapeeth, Rahuri, Maharashtra, India

DD Patange
Associate Professor, Department of Animal Husbandry and Dairy Science, Rajarshi Chhatrapati Shahu Maharaj College of Agriculture, Kolhapur, Maharashtra, India

BD Patil
Professor (CAS), Deputy Director of Research, Directorate of Research, Mahatma Phule Krishi Vidyapeeth, Rahuri, Maharashtra, India

PK Lokhande
Associate Professor, Department of Biochemistry, Mahatma Phule Krishi Vidyapeeth, Rahuri, Maharashtra, India

MR Patil
Associate Professor, Department of Statistics, Mahatma Phule Krishi Vidyapeeth, Rahuri, Maharashtra, India

Corresponding Author:
AV Gharatkar
Ph.D. Scholar, Department of Animal Husbandry and Dairy Science, Post Graduate Institute, Mahatma Phule Krishi Vidyapeeth, Rahuri, Maharashtra, India

Optimization of levels of wood apple pulp and sweeteners in whey beverage

AV Gharatkar, DK Kamble, AT Lokhande, DD Patange, BD Patil, PK Lokhande and MR Patil

DOI: https://www.doi.org/10.33545/26174693.2025.v9.i12Sn.6670

Abstract
During the present investigation, optimization of ingredients for the preparation of whey beverage blended with wood apple pulp was undertaken, which included selection of type of whey, selection of type of sweetener and optimization of levels of wood apple pulp and sugar. For selection of suitable sweetener, four types of sweeteners *viz*. sugar (S_1), jaggery (S_2), stevia (S_3) and aspartame (S_4) were evaluated in the whey beverage. During this phase, the level of wood apple pulp was maintained constant at 12 per cent and sweetener equivalent to 8 per cent sugar was standardized for all treatments. Based on sensory evaluation, the most acceptable type of whey and sweetener were selected for further studies. Subsequently, optimization of levels of wood apple pulp and sugar was carried out by incorporating three levels of wood apple pulp *viz*. 10 per cent (W_1), 12 per cent (W_2) and 14 per cent (W_3) and three levels of sugar *viz*. 7 per cent (S_1), 8 per cent (S_2) and 9 per cent (S_3) of whey. These levels were finalized on the basis of preliminary trials to study the combined effect of varying concentrations of wood apple pulp and sugar on the sensory attributes of the whey beverage. The results revealed that whey beverage prepared with 12 per cent wood apple pulp and 8 per cent sugar was found to be most acceptable, indicating its potential for the development of a quality, nutrition-rich whey-based beverage.

Keywords: Whey beverage, wood apple pulp, sensory evaluation, optimization, type of whey, type of sweetener, sugar

1. Introduction
Milk is regarded as one of the most wholesome foods and plays a vital role in the Indian diet by supplying essential nutrients such as proteins, fats, minerals and vitamins. In recent years, changing lifestyles and rapid urbanization have increased consumer demand for processed and value-added dairy products, thereby creating opportunities for diversification within the dairy sector.

Whey is a major by-product obtained during the manufacture of cheese, chhana, paneer, casein and shrikhand. Despite its high nutritional value, whey is often discarded, resulting in economic loss and environmental concerns. A substantial proportion of milk solids remains in whey, which is rich in lactose, minerals, whey proteins such as β-lactoglobulin and α-lactalbumin and B-complex vitamins (Ghosh, *et al.*, 1995) [4]. These characteristics make whey a suitable base material for the development of nutritious beverages and other value-added products. Wood apple (*Limonia acidissima* L.) is an underutilized indigenous fruit that has recently gained attention for its potential application in functional and health-oriented beverages. The fruit possesses a characteristic flavour, pleasant aroma and appreciable nutritional value (Lande *et al*., 2010) [7]. Its soft, aromatic pulp possesses notable thirst-quenching properties and serves as a rich source of essential nutrients, including vitamins A, B1 and B2, along with trace quantities of vitamin C (Poongodi *et al*., 2013) [10]. In addition to its nutritional attributes, wood apple is also associated with several therapeutic properties, which further enhances its suitability for incorporation into natural beverage formulations (Ilango and Chitra, 2009) [5]. The development of a whey-based wood apple beverage offers a promising opportunity for value addition in both the dairy and fruit processing sectors. India is endowed with a wide range of indigenous fruits that remain underexploited despite their nutritional merits. Incorporation of wood apple pulp in whey beverage not only

improves the nutritional quality of the product but also creates additional income opportunities for fruit growers and dairy farmers. Such an approach aids in effective utilization of whey, reduces environmental pollution and supports sustainable food production. Considering the nutritional richness and therapeutic potential of wood apple along with the increasing interest in whey-based beverages, the present study was undertaken to develop and optimize a whey beverage blended with wood apple pulp.

2. Materials and Methods

2.1 Materials

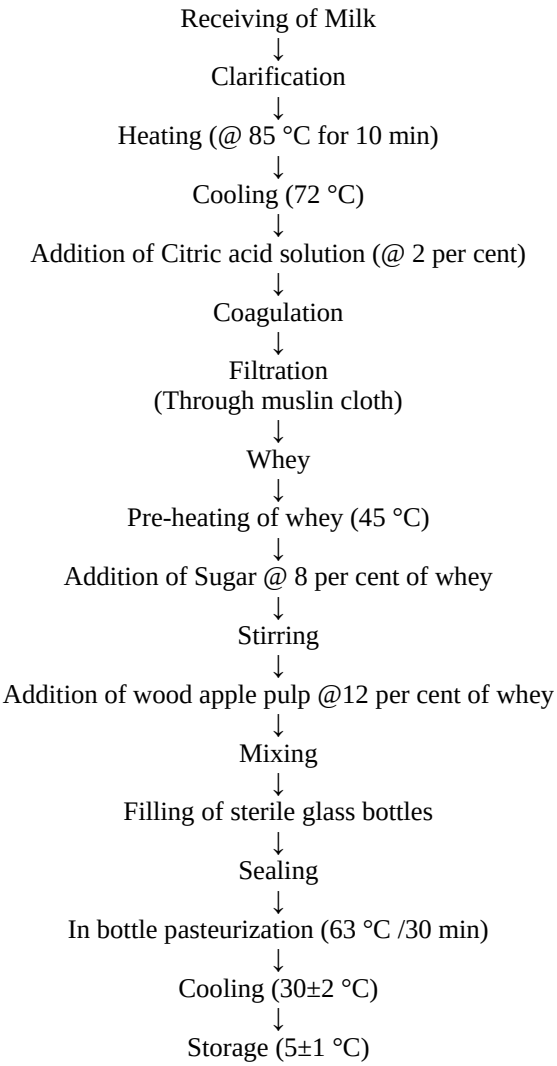
2.1.1 Materials

The wood apple whey beverage was prepared using fresh cow milk obtained from the RCDP, Department of Animal Husbandry and Dairy Science, MPKV, Rahuri. Fully matured wood apple fruits along with sugar and jaggery were procured from the local market. Citric acid used during the study was available in the Dairy Science laboratory. Stevia extract was procured from Shubham Ayurvedalaya, Ahilyanagar. Aspartame (Sugar-Free Gold), permitted by FSSAI for use in food products, was obtained from an authorized retail outlet.

2.2 Method of Preparation

The wood apple blended whey beverage was prepared as per the method of Dhamsaniya and Varshney (2013) [2] with minor modifications.

Whey was pre-heated to 45 °C, filtered and blended with sugar and wood apple pulp as per treatment combinations. The beverage was filled into pre-sterilized glass bottles, sealed and in-bottle pasteurized at 63 °C for 30 minutes. After cooling to 30 ± 2 °C, the samples were stored at 5 ± 1 °C under refrigerated conditions.



Flow diagram for preparation of whey beverage enriched with wood apple pulp

2.3 Optimization of Ingredients

During the phase of investigation, optimization of ingredients *viz*. selection of type of whey, selection of type of sweetener and optimization of levels of wood apple pulp and sugar for preparation of whey beverage blended with wood apple pulp was carried out.

2.3.1 Selection of type of whey

For this purpose, three types of whey, *viz*. chhana whey (C_1), chakka whey (C_2) and cheese whey (C_3), were used in the preparation of the whey beverage. The level of wood apple pulp (12 per cent) and sugar (8 per cent) was kept constant for all the treatments.

The treatment combinations were as follows:

- **C_1:** Chhana Whey + 12 per cent wood apple pulp + 8 per cent sugar
- **C_2:** Chakka whey + 12 per cent wood apple pulp + 8 per cent sugar
- **C_3:** Cheese whey + 12 per cent wood apple pulp + 8 per cent sugar

From the above treatments, the most acceptable type of whey was selected on the basis of sensory evaluation for further study.

2.3.2 Selection of type of sweetener

For selection of suitable sweetener, four sweeteners *viz.* sugar (S_1), jaggery (S_2), stevia (S_3) and aspartame (S_4) were evaluated in the whey beverage. During this stage, the level of wood apple pulp was kept constant at 12 per cent and sweetener equivalent to 8 per cent of sweetness of sugar was maintained for all treatments. Sugar and jaggery were added on a weight basis at 8 per cent. Thus, stevia and aspartame were incorporated in calculated quantities to maintain uniform sweetness equivalent to 8 per cent sugar across all treatments.

The treatment combinations were as follows:

- **S_1:** Whey + 12 per cent wood apple pulp + 8 per cent sugar
- **S_2:** Whey + 12 per cent wood apple pulp + 8 per cent Jaggery
- **S_3:** Whey + 12 per cent wood apple pulp + Sweetness equivalent of 8 per cent sugar using Stevia
- **S_4:** Whey + 12 per cent wood apple pulp + Sweetness equivalent of 8 per cent sugar using Aspartame

From the above treatments, the most acceptable sweetener was selected on the basis of sensory evaluation for further study.

2.3.3 Optimization of level of wood apple pulp and sugar

After selection of suitable whey and sweetener, optimization of wood apple pulp and sugar levels was carried out using three levels of wood apple pulp (10, 12 and 14 per cent) and three levels of sugar (7, 8 and 9 per cent of whey). These levels were finalized based on preliminary trials to evaluate the combined effect of wood apple pulp and sugar on sensory attributes of the whey beverage.

The treatment combinations were as follows:

- **W_1S_1:** Chhana Whey + 10 per cent wood apple pulp + 7 per cent sugar
- **W_1S_2:** Chhana Whey + 10 per cent wood apple pulp + 8 per cent sugar
- **W_1S_3:** Chhana Whey + 10 per cent wood apple pulp + 9 per cent sugar
- **W_2S_1:** Chhana Whey + 12 per cent wood apple pulp + 7 per cent sugar
- **W_2S_2:** Chhana Whey + 12 per cent wood apple pulp + 8 per cent sugar
- **W_2S_3:** Chhana Whey + 12 per cent wood apple pulp + 9 per cent sugar
- **W_3S_1:** Chhana Whey + 14 per cent wood apple pulp + 7 per cent sugar
- **W_3S_2:** Chhana Whey + 14 per cent wood apple pulp + 8 per cent sugar
- **W_3S_3:** Chhana Whey + 14 per cent wood apple pulp + 9 per cent sugar

On the basis of sensory evaluation, the most acceptable combination of wood apple pulp and sugar level was selected as the optimized formulation for further physico-chemical, microbial and storage studies.

3. Results and Discussion

3.1 Effect of different types of whey on sensory attributes of whey beverage blended with wood apple pulp

Table 1: Effect of different types of whey on sensory (score*) attributes of whey beverage blended with wood apple pulp

Treatment	Sensory attributes			
	Colour & Appearance	Flavour	Consistency	Overall acceptability
C_1	8.22	8.25	8.13	8.22
C_2	6.98	7.01	6.87	6.95
C_3	7.50	7.56	7.48	7.52
SE(m)	0.012	0.007	0.009	0.027
CD (P<0.05)	0.037	0.022	0.027	0.083

The sensory scores of whey beverage blended with wood apple pulp prepared using different types of whey are presented in Table 1. Significant differences (P<0.05) were observed among treatments for colour and appearance, body and texture, flavour and overall acceptability. The colour and appearance scores for treatments C_1, C_2 and C_3 were 8.22, 6.98 and 7.50, respectively. With wood apple pulp maintained at 12 per cent, only minor variations in colour were observed, and the beverage prepared with chhana whey (C1) was found to be more visually appealing and better accepted.

The beverage prepared with chhana whey (C_1) recorded the highest flavour score (8.25), followed by cheese whey (C_3) with a score of 7.56, while chakka whey (C_2) showed the lowest score (7.01). The superior flavour acceptability of chhana whey may be attributed to its mild taste, which blended well with wood apple pulp, whereas the higher acidity of chakka whey and the distinct milky note of cheese whey possibly reduced flavour acceptability.

The beverage prepared with chhana whey (C_1) recorded the highest consistency score (8.13), while lower scores were observed for cheese whey (6.87) and chhakka whey (7.48). The superior consistency of chhana whey may be attributed to its smoother body and balanced solids content, whereas the higher acidity and lower solids of chhakka whey possibly resulted in a thinner body and reduced mouthfeel.

The beverage prepared with chhana whey (C_1) recorded the highest overall acceptability score (8.22), followed by cheese whey (7.52), while chakka whey showed the lowest score (6.95). The higher acceptability of chhana whey may be attributed to its mild acidity and balanced composition, which contributed to improved colour, flavour and consistency, whereas the milky note of cheese whey and higher acidity of chakka whey possibly reduced overall sensory perception.

3.2 Effect of different types of sweetener on sensory attributes of whey beverage blended with wood apple pulp

Table 2: Effect of different types of sweetener on sensory (score*) attributes of whey beverage blended with wood apple pulp

Treatment	Sensory attributes			
	Colour & Appearance	Flavour	Consistency	Overall acceptability
S_1	8.21	8.28	8.12	8.20
S_2	7.98	8.03	7.87	7.96
S_3	7.47	7.54	7.38	7.46
S_4	6.92	7.01	6.80	6.91
SE(m)	0.03	0.009	0.01	0.01
CD (P<0.05)	0.10	0.027	0.03	0.03

Among the sweeteners, sugar (S_1) recorded the highest colour and appearance score (8.21), followed by jaggery (7.98), while stevia (7.47) and aspartame (6.92) showed lower scores. The superior score for sugar may be attributed to its ability to maintain a natural and uniform appearance without imparting undesirable colour.

The beverage sweetened with sugar (S_1) recorded the highest flavour score (8.28), followed by jaggery (8.03), while stevia (7.54) and aspartame (7.01) showed lower acceptability. The superior flavour of sugar may be attributed to its smooth sweetness complementing the wood apple and whey flavour, whereas the characteristic taste of jaggery and the residual aftertaste of stevia and aspartame possibly reduced flavour perception.

The beverage sweetened with sugar (S_1) recorded the highest consistency score (8.12), followed by jaggery (7.87), while stevia (7.38) and aspartame (6.80) showed lower scores. The superior consistency observed with sugar may be attributed to its contribution to improved thickness and uniformity, resulting in a smoother mouthfeel.

The beverage sweetened with sugar (S_1) recorded the highest overall acceptability score (8.20), followed by jaggery (7.96), while stevia (7.46) and aspartame (6.91) showed lower acceptability. The higher acceptability of sugar may be attributed to its balanced sweetness, pleasant flavour and desirable mouthfeel. Although jaggery showed acceptable sensory scores, its characteristic flavour slightly influenced the natural taste of the beverage. The lower scores for stevia and aspartame were possibly due to their residual aftertaste and limited contribution to mouthfeel. Based on overall sensory evaluation, sugar (S_1) was selected as the most acceptable sweetener for further formulation.

3.3 Effect of levels of wood apple pulp and sugar on sensory attributes of whey beverage blended with wood apple pulp

Table 3: Effect of levels of wood apple pulp and sugar on sensory (score*) attributes of whey beverage blended with wood apple pulp

Treatment	Sensory attributes			
	Colour & appearance	Flavour	Consistency	Overall acceptability
W_1S_1	7.51	7.52	7.57	7.53
W_1S_2	8.06	8.11	8.05	8.07
W_1S_3	7.05	7.05	7.06	7.05
W_2S_1	7.82	7.85	7.84	7.83
W_2S_2	8.26	8.28	8.24	8.26
W_2S_3	7.44	7.48	7.47	7.47
W_3S_1	6.72	6.73	6.71	6.72
W_3S_2	7.27	7.24	7.25	7.26
W_3S_3	6.26	6.25	6.27	6.26
SE (m)	0.02	0.03	0.03	0.01
CD (P<0.05)	0.08	0.11	0.11	0.03

The colour and appearance scores of the treatment combinations ranged from 6.26 to 8.26, indicating a significant influence of wood apple pulp and sugar levels. The highest score was recorded for W_2S_2 (12 per cent pulp and 8 per cent sugar), attributed to optimum pulp concentration and balanced sweetness, which imparted a uniform and appealing colour. Treatments with higher pulp levels (14 per cent) showed lower scores due to darker appearance and slight sedimentation, while lower pulp levels resulted in moderate colour intensity and acceptability. Similarly, Londhepatil (2024) [8] reported that the colour and appearance scores of pomegranate-based whey beverages were markedly affected by the proportion of pomegranate juice used in the formulation. The flavour scores ranged from 6.25 to 8.28 among the treatment combinations, indicating a marked effect of wood apple pulp and sugar levels. Higher pulp concentrations beyond the optimum reduced flavour acceptability due to the pronounced tangy and astringent taste of wood apple, while lower sugar levels were insufficient to balance acidity. The highest flavour score was recorded for W_2S_2 (12 per cent pulp and 8 per cent sugar), suggesting that this combination provided a balanced sweetness and acidity, resulting in improved flavour acceptability. Sanap (2004) and Madavi (2024) [9] reported the similar fidings. The consistency scores of the treatment combinations ranged from 6.27 to 8.24, indicating a significant influence of pulp and sugar levels. The highest score was recorded for W_2S_2 (12 per cent pulp and 8 per cent sugar), followed by W_1S_2, reflecting a desirable body and smooth texture at moderate pulp levels. Higher pulp levels resulted in a thicker and heavier consistency with lower acceptability, while lower pulp or unsuitable sugar levels produced thinner beverages with reduced consistency scores. These results are in agreement with the observations of Waghmare *et al.* (2020) [12] and Dhadge (2022) [1]. Significant differences were observed among the treatment combinations, with overall acceptability scores ranging from 6.26 to 8.26. The lowest score was recorded for W_3S_3, while the highest was obtained for W_2S_2, indicating a strong influence of pulp and sugar levels on sensory quality. Treatments with higher pulp levels (14 per cent) showed lower acceptability due to increased acidity and heavier texture, whereas unsuitable sugar levels failed to provide a balanced sensory profile. In contrast, W_2S_2 (12 per cent wood apple pulp and 8 per cent sugar) achieved the highest scores across colour, flavour and consistency, resulting in superior overall acceptability. Therefore, this combination was identified as the optimum formulation for preparation of wood apple blended whey beverage. Likewise, Dhadge (2022) [1] noted that the overall acceptability of banana beverages containing lemongrass distillate varied between 7.90 and 8.55 across different formulations. Khupse (2019) and Waghmare *et al.* (2020) [12] shows similar findings.

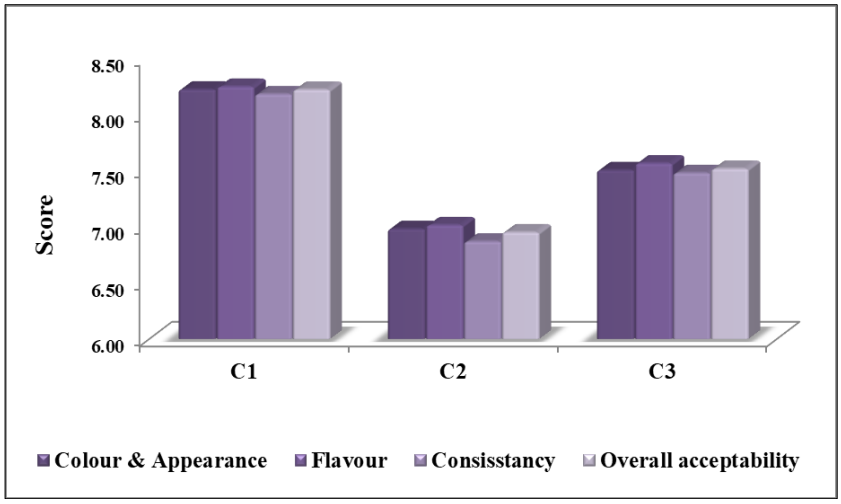


Fig 1: The bar chart shows that sample C1 scored highest for all sensory attributes, followed by C3, with C2 scoring the lowest.

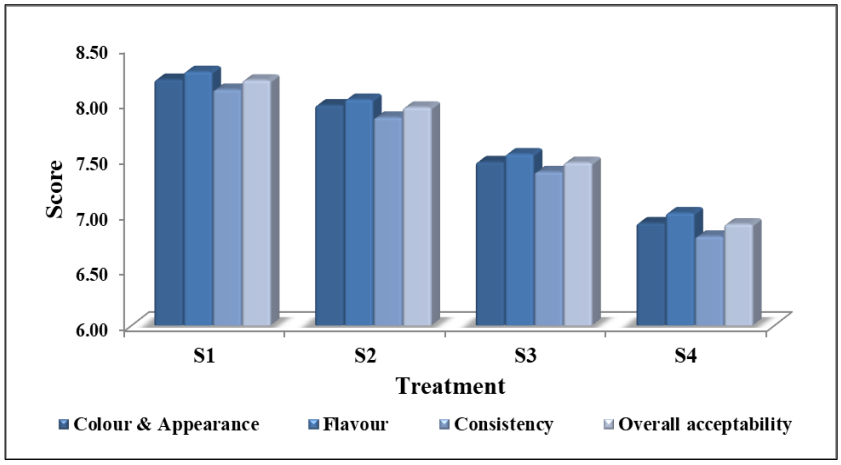


Fig 2: The bar chart shows that treatment S1 received the highest sensory scores across all attributes, with scores decreasing progressively from S2 to S4.

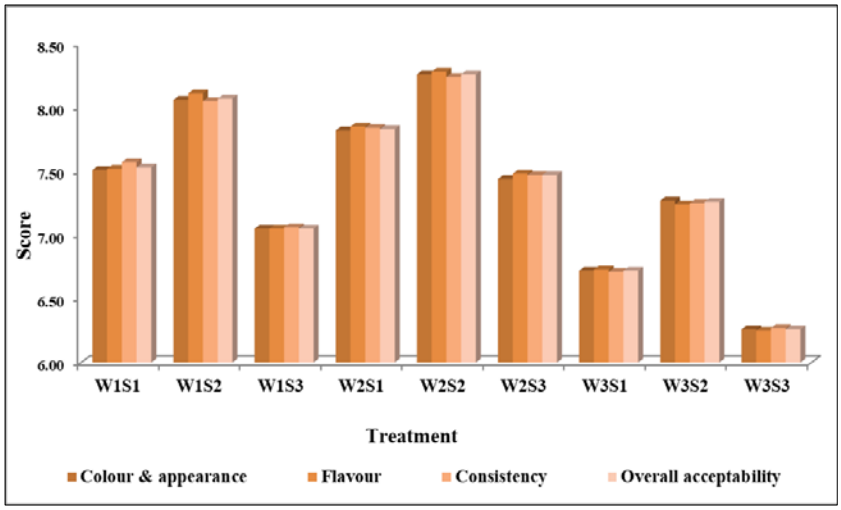


Fig 3: The chart shows that treatments W2S2 and W1S2 scored highest in all sensory attributes, while W3S3 received the lowest scores.

4. Conclusion

The present study revealed that the sensory quality of whey beverage was significantly influenced by the type of sweetener and the levels of wood apple pulp and sugar. Among the sweeteners evaluated, sugar was found to be the most acceptable, providing balanced sweetness, pleasant flavour and desirable mouthfeel compared to jaggery, stevia and aspartame. Optimization of wood apple pulp and sugar levels indicated that incorporation of 12 per cent wood apple pulp with 8 per cent sugar resulted in the highest sensory scores for colour and appearance, flavour, consistency and overall acceptability. This combination offered an optimum balance of sweetness and acidity, along with a smooth and uniform texture. Therefore, the formulation containing 12 per cent wood apple pulp and 8 per cent sugar was identified

as the most suitable for preparation of a high-quality whey beverage blended with wood apple pulp.

References

1. Dhadge N. Studies on preparation of banana based whey beverage with lemongrass distillate. Ph.D. Thesis, Mahatma Phule Krishi Vidyapeeth, Rahuri, Maharashtra, India; 2022.
2. Dhamsaniya NK, Varshney AK. Development and evaluation of whey based RTS beverage from ripe banana juice. J Food Process Technol. 2013;4:203.
3. FSSAI. Food Safety and Standards Regulations, 2011. Food Safety and Standards Authority of India, Ministry of Health and Family Welfare, Government of India, New Delhi; 2011.
4. Ghosh S, Kanawjia SK, Singh S. Recent advances in whey permeate based soft drinks. Beverage and Food World. 1995;22(1):24-26.
5. Ilango K, Chitra V. Wound healing and anti-oxidant activities of the fruit pulp of *Limonia acidissima* Linn (Rutaceae) in rats. Tropical Journal of Pharmaceutical Research. 2010;9(3):[page numbers not provided].
6. Khupse S. Preparation of moringa powder whey beverage. Ph.D. (Agri) Thesis, Mahatma Phule Krishi Vidyapeeth, Rahuri, Maharashtra, India; 2019.
7. Lande SB, Nirmal VS, Kotecha PM. Studies on preparation of ready-to-serve beverages from wood apple pulp. Beverages and Food World. 2010;37(4):69-70.
8. Londhepatil PB. Standardization of pomegranate based whey beverage from cow and goat milk. Ph.D. Thesis, Mahatma Phule Krishi Vidyapeeth, Rahuri, Maharashtra, India; 2024.
9. Madavi VS. Process standardization for preparation of whey beverage added with jamun (*Syzygium cumini*) juice. M.Sc. Thesis, Mahatma Phule Krishi Vidyapeeth, Rahuri, Maharashtra, India; 2024.
10. Poongodi Vijayakumar T, Punitha K, Banupriya L. Drying characteristics and quality evaluation of wood apple (*Limonia acidissima* L.) fruit pulp powder. International Journal of Current Trends in Research. 2013;2(1):147-150.
11. Sanap KM. Development of chakka whey beverage using mango concentrates. M.Sc. Thesis (Unpublished), Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola; 2004.
12. Waghmare A. Development of nutmeg (*Myristica fragrans*) whey based beverage. M.Sc. Thesis, Mahatma Phule Krishi Vidyapeeth, Rahuri, Maharashtra, India; 2020.