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Physico-chemical and microbial quality of curd rice prepared using probiotic curd (*Lactobacillus casei*)

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Abstract
The present study was conducted at the Dairy Science Laboratory, Department of Animal Husbandry and Dairy Science, College of Agriculture, Dapoli, Dist. Ratnagiri (M.S.) to evaluate the physico-chemical and microbial quality of curd rice prepared using probiotic curd. Probiotic curd was prepared from cow milk (Konkan Kapila) using freeze-dried *Lactobacillus casei* (NCDC-26) @ 1.5% and incorporated into tempered rice (variety Karjat-9) at five levels, viz., 20% (T_1), 30% (T_2), 40% (T_3), 50% (T_4) and 60% (T_5) (w/w), in a completely randomized design with five replications. With increasing levels of probiotic curd, fat, protein, titratable acidity and ash contents increased, whereas total solids, crude fibre, pH and total carbohydrates decreased significantly. The treatment found most acceptable on sensory evaluation (T_4; reported separately) contained 28.19% total solids, 4.05% fat, 5.24% protein, 0.28% crude fibre, 0.64% acidity, pH 4.54, 0.80% ash and 18.13% carbohydrates, and showed a probiotic count of 89.0 × 10^7 cfu/g, with coliforms and yeast and mould not detected in the fresh product.

Keywords: Curd rice, probiotic curd, *Lactobacillus casei*, physico-chemical composition, microbial quality, fermented milk product

1. Introduction

Probiotics are live microorganisms which, when administered in adequate amounts, confer a health benefit on the host (FAO/WHO, 2002) [1], and their benefits have encouraged the development of a wide range of probiotic-enriched functional foods, particularly dairy products (Anwer *et al.*, 2024) [2]. Lactic acid bacteria (LAB) play a vital role in fermented dairy products through glycolysis, lipolysis and proteolysis, and synthesize organic acids, exopolysaccharides and antimicrobial compounds, which makes them indispensable as starter cultures (Bintsis, 2018) [3]. Following the taxonomic revision of the genus *Lactobacillus*, *L. casei* is now designated *Lacticaseibacillus casei* (Zheng *et al.*, 2020) [4]; the earlier name is retained in this paper for consistency with the culture designation.

Dahi (curd) is an essential component of the traditional Indian diet and is a rich natural source of probiotics; regular consumption supports mucosal and systemic immune responses (Ashraf *et al.*, 2014) [5]. Curd rice is a traditional fermented dairy-based dish, widely consumed in southern India, prepared by blending cooked rice with curd and adding condiments and garnishes to improve flavour, texture and sensory appeal (Prajapati, 2015) [6]. It combines the carbohydrates of rice with the protein, calcium, B-complex vitamins and lactic acid bacteria of curd, and the probiotics in curd help maintain a healthy intestinal microbiota and improve nutrient absorption (He *et al.*, 2023) [7].

Curd is a suitable matrix for probiotic microorganisms, and the survival of probiotic cultures in dairy foods and their effect on product characteristics have been widely investigated (Kailasapathy, 2006; Hill *et al.*, 2014) [9, 8]. Incorporating probiotic curd into curd rice can therefore add a functional component to a familiar traditional food; however, published work on probiotic curd rice is limited. The present investigation was therefore undertaken to study the physico-chemical composition of curd rice prepared with different levels of probiotic curd and to study the microbial quality of the most acceptable level of fresh probiotic curd rice.

2. Materials and Methods

The research was carried out at the Department of Animal Husbandry and Dairy Science, College of Agriculture, Dapoli, Dist. Ratnagiri (M.S.), India.

2.1 Raw materials

Cow milk. Fresh cow milk (Konkan Kapila) was procured from the Instructional Dairy Farm, College of Agriculture, Dapoli.

Probiotic starter culture. Freeze-dried *Lactobacillus casei* (NCDC-26) was procured from the National Collection of Dairy Cultures, ICAR-NDRI, Karnal (Haryana), and was activated and maintained weekly in

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the microbiology laboratory of the Department. For maintenance, sterilized skim milk tubes were inoculated, incubated at 37 °C for 18 h and then stored under refrigeration (Shankar, 1975) [10].

Rice. Good quality raw rice of variety Karjat-9 (K-9) was obtained from the Department of Agronomy, College of Agriculture, Dapoli.

Spices and herbs. Mustard seeds, coriander leaves, salt, curry leaves and raw ginger were purchased from the local market; herbs were washed under running water and rinsed in distilled water before use.

Media and chemicals. De Man, Rogosa and Sharpe (MRS) agar, violet red bile agar (VRBA) and potato dextrose agar (PDA) were procured from HiMedia Laboratories, Mumbai, for enumeration of lactobacilli, coliforms, and yeasts and moulds, respectively. Analytical grade reagents and Borosil glassware were used for all analyses.

2.2 Preparation of probiotic curd rice

Cow milk was pre-heated to 40 °C, filtered through two-fold muslin cloth, heated at 90 °C for 15 min and cooled to 37 °C. It was inoculated with *L. casei* @ 1.5%, mixed properly and incubated at 37 °C for 8 h to obtain probiotic curd, which was stored at 5 °C. For the rice component, Karjat-9 rice was cleaned, soaked in water for 10 min and cooked in water (rice : water, 1 : 2) on low heat for 15–20 min. Cumin seeds, green chilli, mustard seeds, dry red chillies and curry leaves were lightly fried in oil, the cooked rice and salt were added and mixed well, and the tempered rice was garnished with coriander leaves. The tempered rice was then mixed with probiotic curd as per treatment to obtain ready-to-serve probiotic curd rice (Fig. 1).

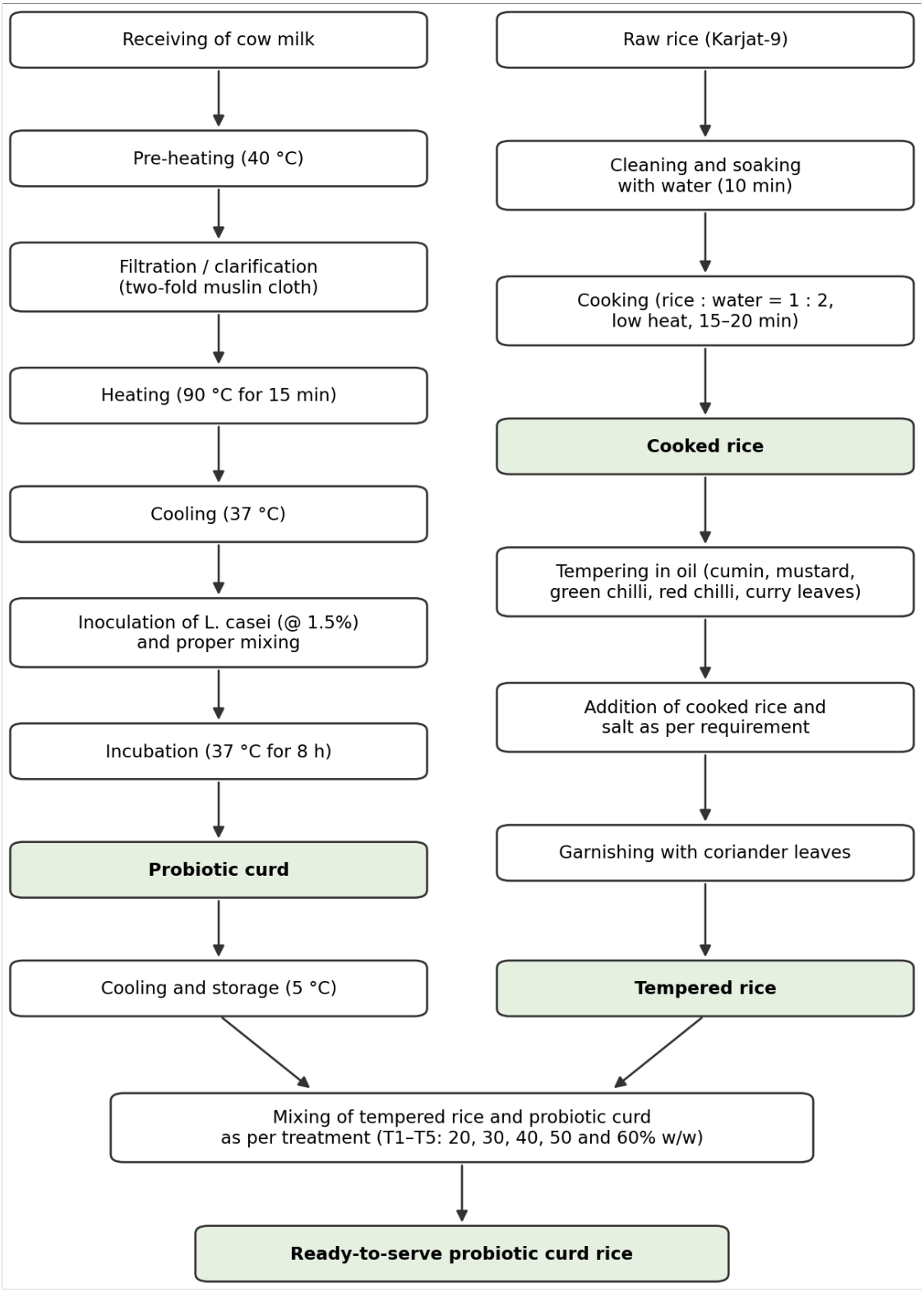


Figure 1. Flow diagram for the preparation of probiotic curd rice

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2.3 Treatments and experimental design

The quantity of rice was fixed and probiotic curd (prepared with *L. casei* @ 1.5%) was added to tempered rice at five levels: T_1, 20%; T_2, 30%; T_3, 40%; T_4, 50% and T_5, 60% (w/w). The experiment was laid out in a completely randomized design (CRD) with five treatments and five replications.

2.4 Chemical analysis

Cow milk, probiotic curd and curd rice were analysed for total solids (gravimetric method, IS: 1479 Part-II, 1961) [11], protein (micro-Kjeldahl nitrogen × 6.38; IS: 1479 Part-II, 1961) [11], acidity as per cent lactic acid (IS: 1479 Part-I, 1960) [12] and ash (A.O.A.C., 2005) [13]. Fat in milk and curd was determined by the Gerber method (IS: 1224 Part-I, 1977) [14] and in curd rice using the Mojonnier fat extraction flask (ISI, 1981) [15]. Lactose in milk was determined as per IS: 1479 Part-II (1961) [11] and in curd by the Lane–Eynon method (ISI, 1981) [15]. Crude fibre (A.O.A.C., 2010) [16] and pH (IS: 1479 Part-II, 1961) were determined in curd rice. Total carbohydrate was calculated by difference: 100 − (protein + fat + ash + moisture).

2.5 Microbial analysis

The most acceptable treatment (T_4, selected on the basis of sensory evaluation) was analysed as a fresh sample. Ten grams of curd rice were homogenized in 99 mL of sterile phosphate buffer and serially diluted. Lactobacilli were enumerated on MRS agar (pH 6.4) using the pour-plate method (1 mL of 5th–7th dilutions in duplicate; 37 °C for 48 h). Coliforms were enumerated on VRBA with an overlay (1st and 2nd dilutions; 37 °C for 24 h), and yeasts and moulds on PDA acidified to pH 3.5 with 10% sterile tartaric acid (25 °C for 5 days). Counts were expressed as cfu/g.

2.6 Statistical analysis

Data were tabulated and analysed by analysis of variance for CRD, and treatment means were compared using critical difference (CD) at 5% and 1% levels.

3. Results and Discussion

3.1 Chemical composition of cow milk and probiotic curd

The composition of the cow milk and of the probiotic curd prepared with *L. casei* is presented in Table 1. The milk contained 13.14% total solids, 4.53% fat, 3.35% protein, 4.52% lactose, 0.70% ash and 0.13% titratable acidity, values indicating suitable composition for curd making. Similar values were reported by Najib *et al.* (2020) [17] (12.60% total solids, 3.60% fat, 3.20% protein, 4.70% lactose, 0.70% ash), Unde (2024) [18] (13.21% total solids, 4.19% fat, 3.06% protein, 4.33% lactose, 0.13% acidity, 0.71% ash) and Sapkal (2025) [19] (13.21% total solids, 4.19% fat, 3.15% protein, 4.36% lactose, 0.70% ash, 0.14% acidity). The composition may be attributed to the balanced feeding and recommended management practices followed at the Instructional Dairy Farm.

Table 1. Chemical composition of cow milk (Konkan Kapila) and probiotic curd (*L. casei*) (per cent; average of five replications)

Constituent	Cow milk	Probiotic curd
Total solids	13.14	13.26
Fat	4.53	4.32
Protein	3.35	3.56
Lactose	4.52	3.96
Ash	0.70	0.63
Titratable acidity (% lactic acid)	0.13	0.69

The probiotic curd contained 13.26% total solids, 4.32% fat, 3.56% protein, 3.96% lactose, 0.63% ash and 0.69% acidity. Ramod (2012) [20] reported a comparable composition for synbiotic dahi (12.62% total solids, 3.48–3.52% fat, 3.96% lactose, 3.20–3.38% protein and 0.73% acidity), and Patil *et al.* (2015) [21] reported 3.35–3.51% fat, 3.23–3.31% protein, 0.65–0.83% acidity and 12.00–15.03% total solids in probiotic custard apple dahi.

3.2 Physico-chemical composition of probiotic curd rice

The physico-chemical composition of curd rice prepared with different levels of probiotic curd is presented in Table 2 and Fig. 2. All parameters were significantly influenced by the level of probiotic curd at both 5% and 1% levels of significance.

Table 2. Physico-chemical composition of probiotic curd rice prepared with different levels of probiotic curd (mean of five replications)

Parameter (%)	T_1	T_2	T_3	T_4	T_5	SE±	CD (5%)
Total solids	35.08^a	33.05^b	30.62^c	28.19^d	25.80^e	0.1171	0.2443
Fat	3.20^e	3.48^d	3.77^c	4.05^b	4.34^a	0.0074	0.0155
Protein	4.90^e	5.07^d	5.17^c	5.24^b	5.37^a	0.0144	0.0302
Crude fibre	0.43^a	0.38^b	0.33^c	0.28^d	0.22^e	0.0075	0.0155
Acidity (as lactic acid)	0.52^e	0.55^d	0.60^c	0.64^b	0.69^a	0.0039	0.0082
pH (no unit)	4.74^a	4.68^b	4.60^c	4.54^d	4.46^e	0.0053	0.0112
Ash	0.60^e	0.66^d	0.73^c	0.80^b	0.88^a	0.0098	0.0205
Total carbohydrates	26.30^a	23.85^b	20.95^c	18.13^d	15.20^e	0.0986	0.2057

T_1–T_5 = tempered rice with 20, 30, 40, 50 and 60% (w/w) probiotic curd. Means in a row followed by different superscript letters differ significantly ($p < 0.05$). All treatment effects were significant at both 5% and 1% levels.

3.2.1 Total solids

Total solids decreased from 35.08% in T_1 to 25.80% in T_5. Probiotic curd has a higher moisture content than cooked rice, so a greater proportion of curd diluted the solids of the final product. A similar decrease in total solids with increasing probiotic curd was reported by Meshram (2025) [22] in probiotic ambil.

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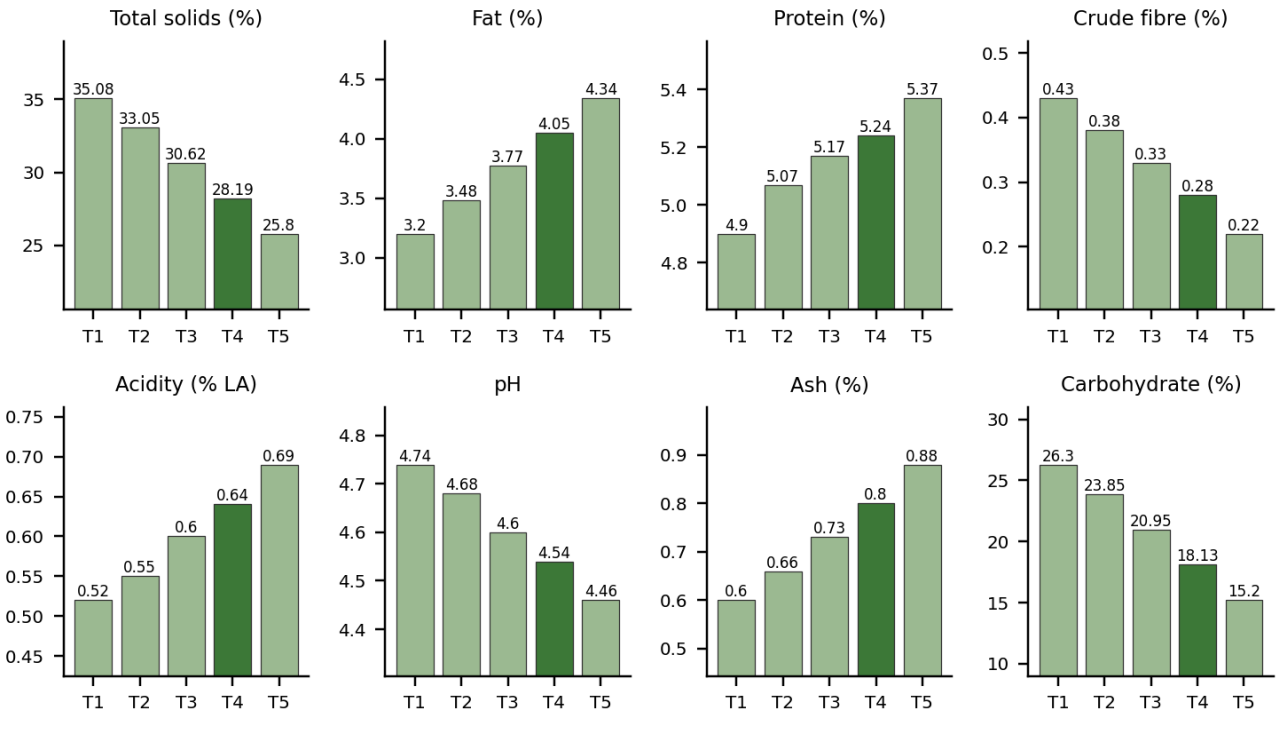


Figure 2. Physico-chemical composition of probiotic curd rice at different levels of probiotic curd (T_4 highlighted as the most acceptable treatment)

3.2.2 Fat

Fat increased progressively from 3.20% (T_1) to 4.34% (T_5), as rice contains little fat whereas curd contributes milk fat. Rashmi *et al.* (2003) [23] reported fat contents of 2.17 to 3.19% in curd rice sold in the Bangalore market.

3.2.3 Protein

Protein rose from 4.90% (T_1) to 5.37% (T_5), which is attributable to the casein and whey proteins of curd. Gandhi (2021) [24] reported a protein content of 1.64–6.29% in probiotic curd rice.

3.2.4 Crude fibre

Crude fibre decreased from 0.43% (T_1) to 0.22% (T_5), because cooked rice contributes a small amount of fibre whereas curd contains little or none; a higher curd proportion therefore lowered the relative contribution of rice. Kusmiyati *et al.* (2019) [25] reported 0.43–1.83 g/100 g crude fibre in cooked rice, while Preveneson *et al.* (2019) [26] and Masih *et al.* (2020) [27] found nil crude fibre in control samples devoid of a fibre source.

3.2.5 Acidity and pH

Titratable acidity increased from 0.52% (T_1) to 0.69% (T_5) and pH fell correspondingly from 4.74 to 4.46, owing to the lactic acid produced by *L. casei* during fermentation of milk; more curd meant more lactic acid in the product. Prajapati (2015) [6] and Gandhi (2021) [24] each reported an acidity of 0.53% in curd rice; Prajapati (2015) [6] reported a pH of 5.05 and Gandhi (2021) [24] a pH of 4.55–4.58.

3.2.6 Ash

Ash content increased from 0.60% (T_1) to 0.88% (T_5), reflecting the higher concentration of minerals such as calcium, phosphorus, potassium and magnesium in curd than in cooked rice. Prajapati (2015) [6] and Gandhi (2021) [24] reported higher ash contents of 1.25% and 1.08%, respectively, in which added table salt was an important contributor.

3.2.7 Total carbohydrates

Carbohydrates decreased from 26.30% (T_1) to 15.20% (T_5), since starch-rich cooked rice was replaced by curd, which contains much less carbohydrate. Prajapati (2015) [6] and Gandhi (2021) [24] reported 15.51% and 14.18% carbohydrate in curd rice, respectively; Prajapati (2015) [6] attributed the low value to moisture added during cooking and contributed by milk.

3.3 Microbial quality of the most acceptable treatment

The microbial quality of fresh T_4 (tempered rice + 50% probiotic curd) is given in Table 3. The product showed a probiotic count of 89.0×10^7 cfu/g (about 8.95 log cfu/g), indicating good viability of *L. casei*, while coliforms and yeasts and moulds were not detected, indicating satisfactory microbiological quality and hygienic preparation. Prajapati (2015) [6] reported coliform and yeast and mould counts of less than 10 cfu/g in fresh curd rice, and Gandhi (2021) [24] reported viable counts of *Lactobacillus rhamnosus* CRD 11 of 8.32–10.55 log cfu/g in fresh probiotic curd rice.

Table 3. Microbial quality of the most acceptable treatment (T_4) of fresh probiotic curd rice

Storage	Probiotic count ($\times 10^7$ cfu/g)	Coliform count ($\times 10^1$ cfu/g)	Yeast and mould count ($\times 10^1$ cfu/g)	Overall acceptability (9-point scale)
Day 0	89.0	ND	ND	8.86

ND = not detected.

4. Conclusion

With increasing levels of probiotic curd in tempered rice, fat, protein, titratable acidity and ash increased, whereas total solids, crude fibre, pH and total carbohydrates decreased significantly. The most acceptable treatment, T_4 (50% probiotic curd), contained 28.19% total

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solids, 4.05% fat, 5.24% protein, 0.28% crude fibre, 0.64% acidity, pH 4.54, 0.80% ash and 18.13% carbohydrates. Fresh T_4 had a high probiotic count (89.0×10^7 cfu/g), with no coliforms or yeasts and moulds detected. This was a laboratory-scale study of fresh product.

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References

1. FAO/WHO. Guidelines for the evaluation of probiotics in food. Report of a joint FAO/WHO working group on drafting guidelines for the evaluation of probiotics in food. London, Ontario, Canada; 2002.
2. Anwer M, Wei MQ. Harnessing the power of probiotic strains in functional foods: Nutritive, therapeutic, and next-generation challenges. Food Science and Biotechnology. 2024;33:2081–2095.
3. Bintsis T. Lactic acid bacteria as starter cultures: An update in their metabolism and genetics. AIMS Microbiology. 2018;4(4):665–684.
4. Zheng J, Wittouck S, Salvetti E, *et al.* A taxonomic note on the genus *Lactobacillus*: Description of 23 novel genera, emended description of the genus *Lactobacillus* Beijerinck 1901, and union of Lactobacillaceae and Leuconostocaceae. International Journal of Systematic and Evolutionary Microbiology. 2020;70:2782–2858.
5. Ashraf R, Shah NP. Immune system stimulation by probiotic microorganisms. Critical Reviews in Food Science and Nutrition. 2014;54(7):938–956.
6. Prajapati RK. Process optimization for production of curd rice with extended shelf life (M.Sc. thesis). ICAR-National Dairy Research Institute (Deemed University), Karnal, Haryana, India; 2015.
7. He J, Li W, Deng J, Lin Q, Bai J, Zhang L, Fang Y. An insight into the health beneficial of probiotics dairy products: A critical review. Critical Reviews in Food Science and Nutrition. 2023;63(32):11290–11309.
8. Hill C, Guarner F, Reid G, Gibson GR, Merenstein DJ, Pot B, Sanders ME. Expert consensus document: The International Scientific Association for Probiotics and Prebiotics consensus statement on the scope and appropriate use of the term probiotic. Nature Reviews Gastroenterology and Hepatology. 2014;11:506–514.
9. Kailasapathy K. Survival of free and encapsulated probiotic bacteria and their effect on the sensory properties of yoghurt. LWT - Food Science and Technology. 2006;39(10):1221–1227.
10. Shankar PA. Microbiology of starter cultures. In Robinson RK, editor. Dairy microbiology. London: Applied Science Publishers; 1975. p. 128.
11. IS: 1479 Part-II. Method of test for dairy industry: Chemical analysis of milk. Indian Standard Institution, Manak Bhavan, New Delhi, India; 1961.
12. IS: 1479 Part-I. Methods of test for dairy industry: Chemical analysis of milk. Indian Standard Institution, Manak Bhavan, New Delhi, India; 1960.
13. A.O.A.C. Official methods of analysis (18th ed.). Association of Official Analytical Chemists, Washington DC, USA; 2005.
14. IS: 1224 Part-I. Determination of fat by Gerber's method (Revised). Indian Standard Institution, Manak Bhavan, New Delhi, India; 1977.
15. ISI. BIS Handbook of food analysis: Dairy products (SP:18, Part XI). Indian Standards Institution, New Delhi, India; 1981.
16. A.O.A.C. Official methods of analysis (18th ed.). AOAC International, Gaithersburg, Maryland, USA; 2010.
17. Najib M, Hallab MW, Hallab K, Hallab Z, Hamze M, Chihib N. Thermal processing of milk as a main tool in the production of oishta, Khoa and kajmak. Journal of Materials and Environmental Science. 2020;11(2):294–309.
18. Unde DN. To study sensory quality and production cost of khoa modak blended with jaggery and pumpkin seeds. Asian Journal of Food Research and Nutrition. 2024;3(4):1089–1101.
19. Sapkal S. Studies on utilization of jackfruit (*Artocarpus heterophyllus* L.) pulp for preparation of *Bhapa dahi* (M.Sc. thesis). Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Maharashtra, India; 2025.
20. Ramod S. Preparation of synbiotic dahi from cow milk (Ph.D. thesis). Mahatma Phule Krishi Vidyapeeth, Rahuri, Maharashtra, India; 2012.
21. Patil MS, Dhole PT, Chavan KD. Studies on quality evaluation of probiotic custard apple (*Annona reticulata*) dahi. Indian Journal of Nutrition. 2015;2(1):1–6.
22. Meshram T. Process standardization for preparation of probiotic ambil using finger millet (*Eleusine coracana*) flour (M.Sc. thesis). Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Ratnagiri, Maharashtra, India; 2025.
23. Rashmi BS, Ghosh BC, Kulkarni S, Jayaraj Rao K, Balasubramanyam BV. Quality evaluation of curd rice sold in Bangalore market. Indian Journal of Dairy Science. 2003;56:295–298.
24. Gandhi G. Process development and shelf-life enhancement of probiotic curd rice (Ph.D. thesis). ICAR-National Dairy Research Institute, Karnal, Haryana, India; 2021.
25. Kusmiyati F, Lukiwati DR, Kristanto BA, Herwibawa B. Glycemic index of ten commercially Indonesian rice cultivars. IOP Conference Series: Earth and Environmental Science. 2019;250(1):012028.
26. Preveneson D, Das A, Susngi SR, Gupta DK, Kumar B, Upadhyay S, David J. Studies on quality characteristics on sweetened stirred dahi prepared by using honey and flaxseed powder. International Journal of Current Microbiology and Applied Sciences. 2019;8(9):2262–2269.
27. Masih A, Broadway AA, Rani R, Wasnik P, Bharti BK. Studies on the utilization of maize milk for the preparation of Shrikhand. International Research Journal of Engineering and Technology. 2020;7(1):793–799.

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