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Development and Performance Evaluation of Synbiotic Red Banana Yoghurt

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Aims: The present study aimed at the production of yoghurt with different levels of red banana pulp (5, 7.5, 10, 12.5, 15%)
Study Design: Development of red banana pulp incorporated probiotic yoghurt and its performance evaluation.

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Place and Duration of Study: Department of Dairy Microbiology, Dairy Science College, Hebbal, Bengaluru, Karnataka Veterinary, Animal and Fisheries Sciences University, Bidar, Karnataka, India. Between June 2022 and March 2023.
Methodology: The red banana pulp incorporated probiotic yoghurt was developed and subjected to sensory analysis by the panel of judges using 9-point hedonic scale, analyzed for milk set time, acidity and viability and the best combination was selected.
Results: The 10% concentration of red banana pulp was selected which showed 2.3 h of milk set time, acidity of 0.74% LA, viable log count/g was 9.50 and overall acceptability score was 8.25. The contaminants like coliforms and yeast and molds were absent. The 10% concentration showed no significant difference (*P* =.05) with the control sample in milk set time and acidity, while significant difference was observed in viability among the different concentrations. The samples were analyzed for synerisis which was 9.30%, water activity was 0.939, viscosity was 6.08cP and color intensity L* was 80.17, a* was -0.85 and b* was 8.68, for the developed red banana pulp incorporated probiotic yoghurt.
Conclusion: The developed product improves the acceptability and provides benefits of both probiotics and red banana for the consumers.

Keywords: Kamalapur red banana; probiotic; yoghurt; GI tag; Lactobacillus acidophilus; banana yoghurt; Streptococcus thermophilus.

1. INTRODUCTION

Yoghurt is the most popular and widespread fermented milk product in the world which is fermented with *Lactobacillus bulgaricus* and *Streptococcus thermophilus* is regarded as standard. The functionality of yoghurt increases with addition of probiotic cultures and incorporation of varieties of fruits in yoghurt boosts the consumption among people of all age groups.

Red banana is a special variety of banana with a red skin and creamish coloured pulp with an enjoyable taste. It is a monocotyledonous perennial, gaint herb belonging to family musaceae and genus musa. These are grown in Kamalapur taluk in Kalaburagi district, Karnataka state, India which has been recognized under the Geographical Indication (GI) Certification and has got its GI tag in 2009 with a tag number of 133. It is also known as the 'Rich man's fruit' as it is marketed at a higher price than other varieties of banana, as mentioned in Draft District Export Action plan: Kalaburagi (Gulbarga), 2021 [1]. A Geographical Indication is a designation or sign used on particular products which refers to a particular geographic area or origin, it serves as a certification that a product has particular characteristics or has a particular reputation that is largely due to their geographic origin. Milk is devoid of dietary fibers, the addition of red banana serves as a prebiotic component by supplying dietary fibers in the form of Fructo Oligo Saccharides (FOS), it contains about 40g per 100g [2]. As per a study reported [3], taking 8g of FOS per day for 2 weeks increases the beneficial gut bacterial population by 10 times. It may help manage type-2 diabetes by inhibiting the alpha-amylase enzyme [4], may stop the growth of breast cancer cells [5], the richness of potassium and magnesium helps in relaxing the blood vessels and thus reduce blood pressure [6], presence of antioxidants like lutein and zeaxanthin protects the eyes from damage, due to age related muscular degeneration. Synbiotic foods have gained popularity in recent years due to their functional, nutritional, physiological and therapeutic characteristics. The current trend of health-conscious consumers and healthy food habits prompts researchers to explore developing food products with synbiotic benefits. It is essential to assess the characteristics of a newly developed food product. The purpose of this research is to explore a GI tagged fruit Kamalapur red banana in food industries by value addition. Also it contributes to Vocal for local concept. The developed red babana pulp incorporated probiotic yoghurt would serve as a synbiotic product (probiotic + prebiotic) and mark a place in the dairy industry with the therapeutic benefits to the consumers.

2. MATERIALS AND METHODS

All the experiments were conducted at the post graduate laboratory of Dairy Microbiology Department, Dairy Science College, Hebbal, Bengaluru, Karnataka Veterinary, Animal and Fisheries Sciences University, Regional Campus.

2.1 Materials

2.1.1 Raw milk

The raw milk with 3.5% fat and 8.5% SNF was procured from ILFC (Institutional livestock farm complex), KVAFSU, Hebbal, Bengaluru.

2.1.2 Starter cultures

The starter cultures *Streptococcus thermophilus*, *Lactobacillus bugaricus* and probiotic culture *Lactobacillus acidophilus* maintained in the department of Dairy Microbiology, Dairy Science College, Hebbal, Bengaluru, were used.

2.1.3 Red banana

The ripened red banana was procured from Kamalapur market, Kalaburagi, Karnataka, India.

2.1.4 PET cups

Disposable Polyethylene Terephthalate (PET) cups of 50 ml capacity with lid procured from local market were used for serving samples to panel of judges during sensory evaluation.

- Lamy viscometer (Viscosity), LabSwift-a_w instrument (water activity), Spectrophotometer -3nh (Colour)

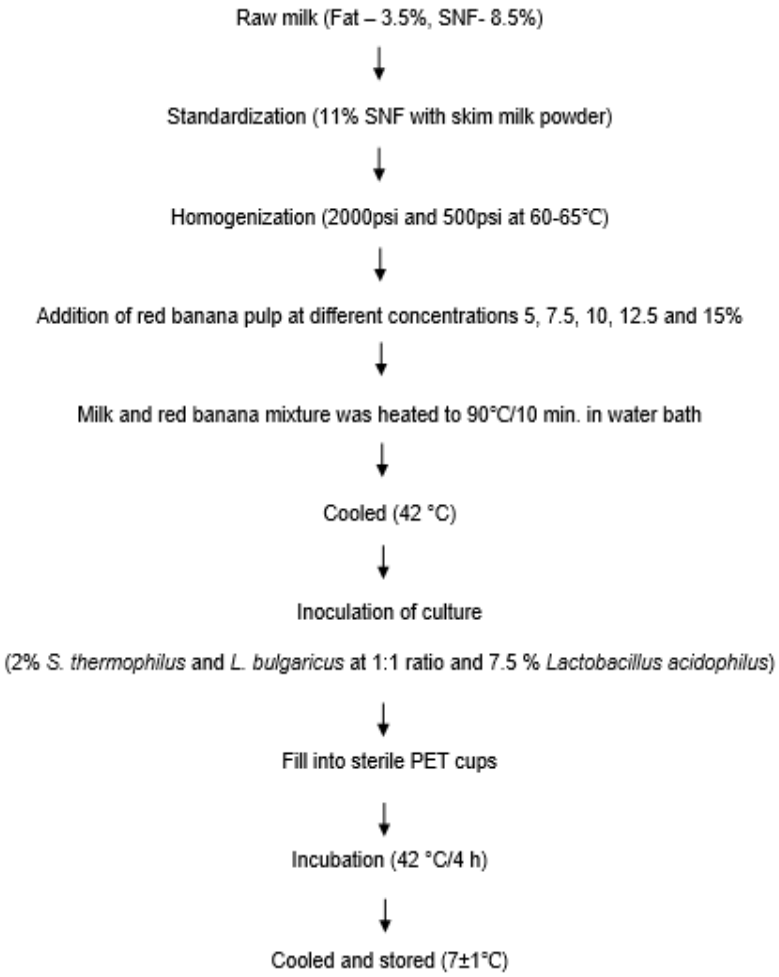
2.2 Methods

2.2.1 Preparation of red banana pulp

The pulp was obtained by peeling the ripened red banana and blending it in a sterile blender (UV sterilization) and filtered through a sterile muslin cloth.

2.2.2 Preparation of red banana incorporated probiotic yoghurt

Flow chart 1. Preparation of red banana



2.2.3 Analysis of red banana pulp incorporated probiotic yoghurt

The prepared red banana pulp incorporated probiotic yoghurt was analyzed for titratable acidity, sensory, viability and milk set time was noted. The titratable acidity was determined by titration method as per FSSAI 01.035:2022 [7]. A 9-point hedonic scale was used by the selected panel of trained judges to evaluate the generated study sample's sensory qualities, including colour and appearance, body and texture, flavour, and overall acceptability. The viability of the cultures was determined using pour plate method [8]. Viscosity was evaluated by Lamy viscometer (B-one plus LR module), Water activity was determined by LabSwift-a_w instrument, Colour of the sample was determined by a Spectrophotometer (3nh), a light-sensitive instrument in Rheology laboratory, Department of Dairy Technology, Dairy Science college, Hebbal, Bengaluru, Karnataka, India.

3. RESULTS AND DISCUSSION

The results obtained for the prepared red banana pulp incorporated probiotic yoghurt analyzed for acidity, viability, sensory and milk set time were tabulated and discussed.

3.1 Performance of Red Banana Pulp Incorporated Probiotic Yoghurt

The red banana pulp incorporated probiotic yoghurt was prepared by adding different levels of red banana pulp at 5, 7.5, 10, 12.5 and 15% and heat treated to 90℃ in water bath for 10 min. and probiotic culture *L. acidophilus* along with 2% yoghurt cultures were inoculated and incubated at 42℃ till milk gets set. The milk set time (h), acidity (%LA) and the viable log count/g of the developed product were tabulated in Table 1. The coliforms and yeast and molds which are regarded as contaminants were absent in the product. There was no significant difference observed in the acidity among the samples whereas there was a statistical significance (P = .05) in the viable counts among the samples and had 9.50 log count/g of viable counts in the sample with 10% red banana pulp and 2% yoghurt cultures and 7.5% *L. acidophilus*.

The results were in line with the study reported by Shashikumar et al. [9] where kamalapur red banana pulp was added at different levels of 5, 7.5, 10 and 12% along with control (without banana pulp) and 2% of the yoghurt cultures were inoculated to the heat treated milk with 11% total solids. The acidity of yoghurt with 10% banana pulp was optimum (0.72% LA) compared to other levels which were 0.71 % LA for control, 0.79 % LA for 5% banana pulp, 0.72 % LA for 12.5% banana pulp. They also found that coliform counts were absent in all the samples and yeast and mold counts were 1.10 cfu/g in control, 1.30 cfu/g in 5% banana pulp, 1.47 cfu/g in 7.5 % banana pulp, 1.60 cfu/g in 10% banana pulp and 1.70 cfu/g in 12.5% banana pulp which were within the limits of the BI standards for yoghurt [10], coliforms should be 10 cfu/g (1 log cfu/g) and yeast and molds should be 100 cfu/g (2 log cfu/g). Among these 10% of red banana pulp was optimized.

In accordance with the study done by Songul et al. [11] on probiotic properties of banana yoghurts made with 15% of banana puree and equal quantity of sucrose along with probiotic cultures *L. acidophilus* and *Bifidobacterium bifidum* at 3% level. The probiotic cultures were inoculated at 37℃ and were incubated at 43±1℃. The yoghurt with *L. acidophilus* had acidity of 0.85% LA and yoghurt with both *L. acidophilus* and *Bifidobacterium bifidum* had 0.85% LA. The yoghurt with *L. acidophilus* had average viable log counts/g of 7.20 and the yoghurts mixed with *L. acidophilus* and *Bifidobacterium bifidum* had 8.04 viable log counts/g of *L. acidophilus*. The higher viable counts in the current study of red banana pulp incorporated probiotic yoghurt might be due to addition of yoghurt cultures along with *L. acidophilus.*

- All the values are average of three trials, CD - Critical Difference, Same superscripts within the column indicate no significant difference, Different superscripts in the same column indicates significant difference.

3.2 Sensory Scores of Red Banana Pulp Incorporated Probiotic Yoghurt

The red banana pulp incorporated probiotic yoghurt samples were subjected to sensory analysis using 9-point hedonic scale by the panel of judges which was depicted in Table 2. The sample with highest score for overall acceptability (8.25) was optimized. The significant differences (P = .05) were observed among the sensory scores of red banana pulp incorporated probiotic yoghurt.

Table1. Performance of red banana pulp incorporated probiotic yoghurt

Red banana pulp (%)	Milk set time (h)	Acidity (% LA)	Viability	Contaminants	
				Coliforms	Yeast and mold
				log_{10} cfu/g	
Control	2.53[a]	0.67[a]	8.60[a]	Nil	
5	2.45[a]	0.75[a]	9.10[ab]		
7.5	2.40[ab]	0.73[a]	9.03[ab]		
10	2.30[abc]	0.74[a]	9.50[b]		
12.5	2.15[bc]	0.72[a]	8.56[a]		
15	2.05[c]	0.74[a]	9.23[b]		
CD (*P*=.05)	**0.29**	**0.09**	**0.54**		

Table 2. Sensory scores of red banana pulp incorporated probiotic yoghurt

Red Banana pulp (%)	Sensory profiles			
	Colour and appearance	Body and texture	Flavor	Overall acceptability
Control	7.70[a]	7.70[a]	6.5[a]	7.25[a]
5	7.50[b]	7.50[b]	7.25[b]	7.25[a]
7.5	7.50[b]	7.50[b]	7.50[c]	7.50[b]
10	7.80[c]	8.25[c]	8.25[d]	8.25[c]
12.5	7.80[c]	8.00[d]	8.00[e]	8.00[d]
15	7.50[b]	6.50[e]	7.25[b]	7.25[a]
CD (*P*=.05)	**0.01**	**0.01**	**0.10**	**0.08**

Note: Same superscripts within the column indicate no significant difference, Different superscripts in the same column indicates significant difference

Table 3. Physico–chemical characteristics of optimized red banana pulp incorporated probiotic yoghurt

	Synerisis (%)	Viscosity (cp) 25℃	Water activity at 27 ± 3℃	Colour		
				L*	a*	b*
Control	9.80	7.01	0.954	81.38	-0.90	8.75
Red banana pulp incorporated probiotic yoghurt	9.30	6.08	0.939	80.17	-0.85	8.68

Note: L - Lightness from black to white on a scale of zero to 100, a* - Negative a* corresponds with green, positive a* corresponds with red, b* - Negative b* corresponds with blue and positive b* corresponds with yellow*

The results obtained were in accordance with the study reported by Owolade et al. [12], the yoghurt was prepared using different varieties of banana at different levels of 10, 15 and 20% and were subjected to sensory analysis using seven point hedonic scale. The sample with 10% banana (paranta variety) had the score of 5.8 for taste which was higher compared to control which was 3.1, it also had highest overall acceptability of 6.1 among the samples while control had 4.1 out of 7. This study shows that addition of 10% banana had more acceptability than other levels.

On conformity with Shashikumar et al. [9], the yoghurt samples added with 5, 7.5, 10 and 12.5% of red banana pulp along with the control were subjected for sensory evaluation by 9-point hedonic scale. The sensory score awarded for control was 7.9 for appearance, 7.8 for body, texture and flavor and it scored 8.00 for overall acceptability whereas the 10% red banana pulp added sample was awarded 7.5 for appearance, 7.44 for body and texture, 7.50 for both flavor and overall acceptability. On comparing the average scores of all the samples, 10% red banana pulp incorporated sample was accepted by the panelists compared to other samples.

By considering sensory, milk set time, acidity and viability, the 10% red banana pulp added yoghurt was optimized in the present study.

3.3 Physico–chemical Characteristics of Optimized Red Banana Pulp Incorporated Probiotic Yoghurt

The physico chemical characteristics such as synerisis, viscosity, water activity and colour measurement were analyzed and are presented in Table 3. The synerisis of optimized red banana pulp incorporated probiotic yoghurt was 16.83% while for control yoghurt it was 27.71%. This showed that the addition of red banana pulp decreased the synerisis percentage. The lower percentage of synerisis may be due to the increase in the total solids content.

Similar results were found by Costa et al. [13], the decrease in synerisis in yoghurt added with 5% of green banana biomass (GBB) which was 14.26% whereas 16.66% for control, 17.34% for 3% GBB and 18.34% for 10% addition of GBB. The formation of firm clot which was capable of holding free water might have decreased the synerisis by drainage. On contrary the study reported by Pachekrepapol et al. [14], the stirred yoghurts blended with banana puree and fortified with calcium had increased the synerisis. This may be due to the weakening of casein network when fortified with calcium salt. They also found that fortification of 400mg of calcium lactate/100g resulted in the product with similar properties of non fortified yoghurt. The decrease in synerisis in the present study might be either due to increase in the total solids content or due to formation of firm clot which was capable of holding free water.

Viscosity of the product was 6.08 cP while the control had 7.01cP at 25℃, this indicates that the addition of red banana pulp decreased the viscosity of the red banana pulp incorporated probiotic yoghurt compared to control yoghurt. This might be due to, yoghurt is a gel made of casein micelles which are entrapped in water, viscosity decreases as the gel structure deteriorates, the addition of red banana pulp might have damaged the gel structure which decreased the viscosity of the product. A study reported by Aleman et al. [15] reported, the viscosity (firmness) can be improved by use of proteolytic strains (*S. thermophilus* and *L. bulgaricus*). The yoghurt which was incorporated with maitake mushroom showed lower viscosity than control yoghurt samples. The possible reason for lower viscosity may be due to the breakdown of gel network by the particles of maitake mushroom powder in yoghurt. This result was similar to the present study. Similar results were found by Izadi et al. [16] in the enriched yoghurt with phytosterol (2% yoghurt culture and 2% phytosterol) where the viscosity of the samples were measured using Brookfield viscometer with a spindle no. 4 at 3 rmp rotation speed, Results recorded after 50s of shearing in centipoises (cP). It was around 27,400 cP for enriched yoghurt and 31,200 cP for control yoghurt. Viscosity of enriched yogurts were lower than the control, it is because the gel matrix of casein micelles in yoghurt were entrapped in water, the addition of phytosterol emulsion may interrupt the gel structure of the enriched sample.

The water activity of the control sample was 0.954 and red banana pulp incorporated probiotic yoghurt was 0.939 which were almost similar, while the red banana pulp incorporated probiotic yoghurt had slightly lower than the control. This may be due to the incorporation of the red banana pulp which increased the water holding capacity by increasing the total solids content their by decrease in the water activity. The results obtained by Shah et al. [17] for water activity on yoghurts and probiotic bacteria were in line with the present study. The author prepared probiotic yoghurts using skim milk supplemented with 0, 4, 8, 12 or 16% sucrose. The water activity decreased, as the sugar level increased. A decrease in a_w inhibited acid production by both organisms (*S.thermophilus* and *L. bulgaricus*).

The prepared red banana incorporated probiotic yoghurt (Table 3) showed L* value of 80.17 where as control showed 81.38, the decrease in the lightness value in red banana pulp incorporated probiotic yoghurt may be due to addition of the pulp which is darker. Higher values of L* in dairy products were due to the ability of casein micelles and fat globules to scatter light. The a* value was -0.85 compared to control which was -0.90, the negative value for a* corresponds to green. b* value was 8.68 for red banana pulp incorporated probiotic yoghurt and control was 8.75, positive b* corresponds to yellow. In corroboration with Costa [13] who developed prebiotic yoghurt with green banana biomass (GBB) at 3 different levels of GBB 3, 5 and 10% in yoghurt and a control, studied the colour changes in the control and GBB yoghurt. The control sample showed L* of 92.40 whereas 91.71, 91.82 and 90.76 for 3, 5 and 10% GBB respectively. The absence of GBB in control had higher luminosity while the presence of GBB darkens the sample due to starch with granular structure that increases the amount of light that is absorbed and decreases the reflected light. As

the GBB concentration increases green colour was indicated (a*), it showed -2.08 for control, -1.57 (3%), -1.70 (5%) and -1.72 (10%), which is slightly similar to the present study. The b* value for control was 10.11, for 3% it was 10.43, for 5% it was 10.02 and for 10% it was 10.41 indicates the yellowness of the samples. In accordance with Aleman et al. [15] who studied and reported the physico – chemical, microbological and sensory characteristics of yoghurt by adding various ingredients (glutamine – 7mg/l, quercetin – 700mg/l, slippery elm bark - 210mg/l, marshmallow root – 1340mg/l, reducing sugar (NAG) – 210mg/l, licorice root – 210mg/l, maitake mushrooms – 42mg/l and zinc orotate – 70mg/l). The presence of reducing sugar reduces L*, this is due to maillard reactions of yoghurt proteins during pasteurization. Casein micelles and fat globules have the ability to scatter light and hence there would be higher L* values for dairy products. a* values of mushroom added samples are higher than control samples, whereas quercetin added samples had lowest values. This may be due to the brown pigments in mushrooms that promoted higher redness colour in yoghurt. Quercetin is a yellow pigment and is responsible for high b* values. b* may also increase due to increase in synerisis values. Addition of powder to milk, destabilizes casein micelles during pasteurization that affect b* values.

4. CONCLUSION

Fermentation helps in improving the bioavailability of nutrients present in the milk. Yoghurt, a fermented milk product can be prepared using different varieties of fruits available as a value addition. A similar venture has been taken up in this study, where Kamalapur's red banana (GI tag no. 133 – 2009) was used as the added component for value addition with the advantages of probiotic culture. The red banana pulp incorporated probiotic yoghurt has benefits of both red banana and also the probiotic culture (*L. acidophilus*) used in yoghurt. Instead of only offering fruit or plain yoghurt, the red banana pulp infused yoghurt, with its complementary sour and sweet flavours, draws in customers by presenting the fruit in an enticing way.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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