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Development of yoghurt fortified with beetroot powder, dates powder and stevia and its physicochemical characterization

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Abstract

The rising prevalence of diabetes, obesity and cardiovascular illness has intensified the public interest in functional foods that go beyond the basic nutrition. Low glycaemic index (GI) dairy products with natural, plant-based components have become an area of current interest. The present work is focused on the standardization of fortified yoghurt enriched with beetroot powder, stevia and dates powder. The ingredients are selected for their natural health benefits such as antioxidant properties, low calorie sweetener and colour enhancement. The formulation with 3% beetroot powder, 0.03% stevia and 2% dates powder exhibited excellent sensorial properties. The developed yoghurt recorded a slightly higher protein content (3.41%) compared to the control (3.12%). Total antioxidants and total phenolic content in functional yoghurt was found to be 23.71 g and 4.61 mg per 100 mL respectively against 8 g and 0 mg in control yoghurt. The dietary fibre in the fortified yoghurt was found to be 0.54% and had 3.41% protein and 0.99% minerals. The current research optimized the production of a diabetic-friendly traditional yoghurt.

Keywords: Antioxidant, diabetic-friendly, functional foods, stevia, beetroot powder, dates powder, low-calorie sweeteners, fortified yoghurt

1. Introduction

In recent years, there has been a growing consumer demand for functional foods that offer both health benefits and sensory appeal. Among these low glycaemic index (GI) foods have gain considerable attention for their role in managing blood glucose levels, for individuals with diabetes or those aiming for healthier diets. Yoghurt, a widely consumed dairy product, presents an ideal base for functional foods due to its probiotic content, nutritional value with high-quality proteins, vitamins, minerals and also deliver beneficial bacteria naturally present at consumption (Ghani *et al.*, 2026) ^[7]. Beetroot powder, derived from dehydrated and ground beetroots (*Beta vulgaris*) are rich in antioxidants, dietary nitrates, and betalains (Adjei *et al.*, 2024) ^[1]. Saman *et al.*, 2025 ^[12] reported that beetroot powder derived by drying and grinding beetroot, retains most of its bioactive compounds, polyphenols, flavonoids, and nitrates. These bioactive compounds contribute to the improved cardiovascular health, anti-inflammatory effects and is a vibrant natural colour. It also contributes to the fiber and micronutrient content of yoghurt.

Stevia, a natural sweetener extracted from the leaves of *stevia rebaudiana*, is well known for its intense sweetness up to 300 times than sucrose without contributing calories or raising blood glucose levels. The slight bitter aftertaste of stevia can be mitigated through blending with other natural sweeteners like dates powder. This helps to maintain a low glycaemic index, making it suitable for diabetic and calorie-conscious populations. Dates powder, made by drying and grinding dates (*Phoenix dactylifera*) provides a range of nutrients including minerals like potassium and iron and has antioxidants. It also lowers the glycaemic index of the product due to the healthy fiber. The main objective of the current study was to standardize the process of low glycaemic functional yoghurt fortified with beetroot powder, stevia and dates powder. The investigation was carried out at the department of Dairy Technology, College of Dairy Science and Technology, Idukki, Kerala.

2. Materials and Methods

The various raw materials used for the study and methods followed are elaborated in this chapter.

2.1. Raw materials/ chemicals

Pasteurized cow milk (3.0% fat and 8.5% solids-not-fat / SNF) was used for the preparation of yoghurt. Beetroot powder was prepared as follows: Fresh beetroot sourced from the local market was thoroughly washed, peeled, sliced to 3 mm thickness and steam-blanching for 3 minutes to preserve colour and functional compounds. The slices were then dried in hot air oven at 50-60 °C/ 8-10 hours and ground to a fine powder. The powder was sieved (mesh size 60) and stored in airtight containers. A highly purified (> 97%) stevia extract purchased from Now Foods, USA was used as non-calorific sweetener. Dates powder with no added sugar procured from the Southern Health Foods Pvt. Ltd, India was used in the study. All the above ingredients were stored in separate moisture-proof containers at room temperature till use. Yoghurt culture was a 1:1 combination of *Lactobacillus delbrueckii subsp. bulgaricus* and *Streptococcus salivarius subsp. thermophilus* purchased from the department of Dairy Microbiology, Verghese Kurien Institute of Dairy and Food Technology, Thrissur, Kerala. The chemicals used for the various analysis were of analytical grade procured from Sigma Aldrich Merck, India.



Fig 1: Preparation of beetroot powder

2.2 Preparation of control yoghurt

Control yoghurt was prepared with 8% added sugar as per the procedure described by Dias *et al.*, 2020 [5] as presented in Fig. 2. Milk was heated to 90 °C /10 minutes and cooled to 42 °C. It was added with 2% starter culture. Incubation was done at the same temperature for 4-6 hours and further stored at 4 °C till consumption.

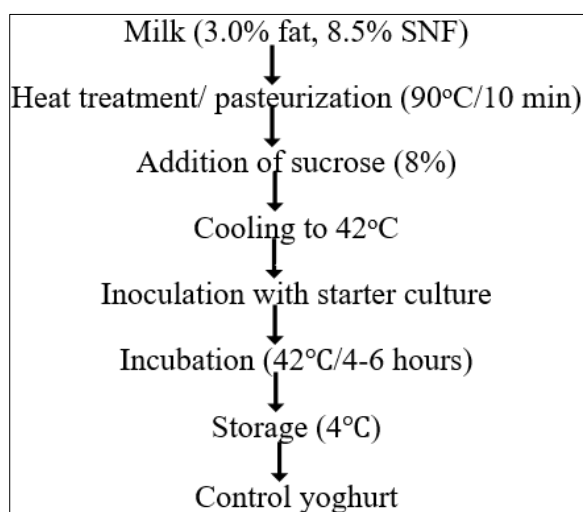


Fig 2: Preparation of control yoghurt

2.3 Preparation of fortified yoghurt

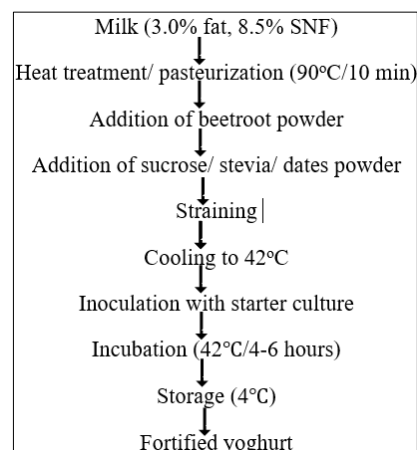


Fig 3: Preparation of fortified yoghurt

2.4 Optimization of the level of addition of beetroot powder

Beetroot powder was incorporated at varying concentrations of 1% (T₁), 3% (T₂) and 5% (T₃) of the total milk (w/w) (Table 1). The range was fixed based on preliminary trials. All other ingredients were kept constant at a fixed level in all the treatments, which were also selected based on preliminary study. Sensory evaluation was performed by six semi-trained judges using a 9-point hedonic scale as given in Table 2.

Table 1: Optimization of beetroot powder in yoghurt

Sample	Beetroot powder (%)	Sucrose (%)	Starter culture (%)
C	0	8	2
T ₁	1	8	2
T ₂	3	8	2
T ₃	5	8	2



Fig 4: Control and fortified yoghurts

2.5 Optimization of the level of addition of stevia to completely replace sucrose

Stevia powder was added to the optimized beetroot-fortified yoghurt, for partial/ complete replacement of sucrose. Full replacement was rejected in the preliminary study due to bitter after taste. The various treatments were designed by reducing the sucrose level to 25% (S₁), 50% (S₂) and 75% (S₃) of the original level (8%) by adding 0.01%, 0.02% and 0.03% respectively of stevia respectively for S₁, S₂ and S₃ (Table 2). Control was prepared with 8% added sucrose. The beetroot powder was added at the level optimized in 2.4, for all the samples.

Table 2: Level of addition of stevia powder to beetroot-fortified yoghurt

Sample	Addition of sweetener
C	Sucrose 8%
S ₁	Sucrose 6% + stevia 0.01%
S ₂	Sucrose 4% + stevia 0.02%
S ₃	Sucrose 2% + stevia 0.03%

2.6 Addition of dates powder to completely replace sucrose

An attempt was made to add dates powder for the complete replacement of sucrose in the beetroot-stevia-optimized functional yoghurt to reduce the glycaemic index to the maximum level possible.

2.7 Organoleptic and physicochemical analysis

The optimum product at each level of investigation was carried out by 9-point hedonic scale (Table 3) by six semi-trained judges.

Table 3: Score card for the organoleptic evaluation of yoghurt

Attributes	Score assigned				Scoring guide	
	Control	T ₁	T ₂	T ₃	Like extremely	9
Flavour					Like very much	8
Beetroot flavour					Like moderately	7
body and texture					Like slightly	6
Colour and appearance					Neither like nor dislike	5
Sweetness					Dislike slightly	4
Syneresis					Dislike moderately	3
Overall acceptability					Dislike very much	2
					Dislike extremely	1

Date: Signature:

The various physicochemical properties of the optimized yoghurt were evaluated by standard methods (AOAC, 2016) [3]. The moisture content was measured in accordance with AOAC Method 934.01, ash content with Method 942.05, fat content with Method 954.02, and protein content using the Kjeldahl method (Method 988.05).

2.8 Statistical analysis

All the experiments were conducted in three independent replications and the data were analyzed using SPSS 24 software package (IBM Inc., USA). One-way analysis of variance (ANOVA) was performed to study significant differences among the samples, followed by Tukey's multiple comparison test. A significance level of $\alpha = 0.05$ was used in all statistical evaluations (Snedecor and Cochran, 1994) [13]. All results are presented as mean $\pm$ standard error (SE) based on duplicate measurements.

3. Results and Discussion

3.1 Optimization of the level of addition of beetroot powder

The results obtained for the sensory evaluation of various samples are given in Table 4. T₂ exhibited highly significant ($p < 0.01$) acceptability rate with respect to the parameters body and texture, colour and appearance and overall acceptability. It also had highly acceptable consistency (syneresis). T₂ perceived similar flavour characteristics as that of the control/ traditional yoghurt. T₃ was least accepted among all the samples. Hence, T₂ with 3% of beetroot powder was selected for further study. This finding is in

accordance with early studies. The findings closely agree with the observance of Adjei *et al.* (2024) [1] reporting that addition of 2.03% of beetroot puree in yoghurt enhanced the consumer acceptability than the control.

Table 4: Optimization of the level of beetroot powder

Attributes	Treatments				Chi-square	p-value
	C	T ₁	T ₂	T ₃		
Flavour	7.83 $\pm$ 0.09 ^a	7.61 $\pm$ 0.14 ^{ab}	7.81 $\pm$ 0.14 ^a	7.11 $\pm$ 0.24 ^b	9.72*	0.02
Body and Texture	7.39 $\pm$ 0.20 ^{ab}	7.33 $\pm$ 0.19 ^{ab}	7.78 $\pm$ 0.15 ^a	6.72 $\pm$ 0.24 ^b	13.17**	0.004
Colour and appearance	7.44 $\pm$ 0.12 ^b	7.28 $\pm$ 0.11 ^b	8.06 $\pm$ 0.13 ^a	7.39 $\pm$ 0.16 ^b	16.41**	<0.001
Sweetness	7.39 $\pm$ 0.12 ^b	7.33 $\pm$ 0.14 ^b	8.00 $\pm$ 0.20 ^a	7.19 $\pm$ 0.21 ^b	8.81*	0.03
Syneresis	7.61 $\pm$ 0.23 ^{ab}	7.50 $\pm$ 0.26 ^{ab}	8.22 $\pm$ 0.15 ^a	7.00 $\pm$ 0.24 ^b	14.70**	0.002
Overall acceptability	7.50 $\pm$ 0.12 ^b	7.25 $\pm$ 0.09 ^b	8.20 $\pm$ 0.09 ^a	7.06 $\pm$ 0.13 ^b	30.04**	<0.001

All observations are mean value of three replicates with SE. * significant at $p < 0.05$ **significant at $p < 0.01$. a, b means different subscript vary significantly in a row. C-control yoghurt without addition of beetroot powder. T₁-yoghurt with 1% beetroot powder, T₂- yoghurt with 3% beetroot powder, T₃-yoghurt with 5% beetroot powder

3.2 Optimization of the level of addition of stevia to substitute sucrose

Stevia was added to the yoghurt optimized in 3.1 at varying concentrations as depicted in 2.5. 3% beetroot powder was added in all the samples. The various sensory parameters were studied as presented in Table 5. S₃ with 2% sucrose and 0.03% stevia showed highly significant ($p < 0.01$) acceptability in sweetness and overall acceptability and was selected as the best. There was no significant difference in syneresis among all the samples. The findings are in agreement with Hergesell *et al.* (2014) [8] in a study to evaluate the calorie reduction in stevia-fortified yoghurt. Ritu and Nandini (2016) [11] confirmed stevia's antihyperglycemic, antihypertensive, and antioxidant effects, while providing a safe sugar substitute in functional foods. Studies by Das and Maity (2026) [4] observed that blending stevia with fruit, vegetables or spice extracts mitigates bitterness and improves sensory attributes.

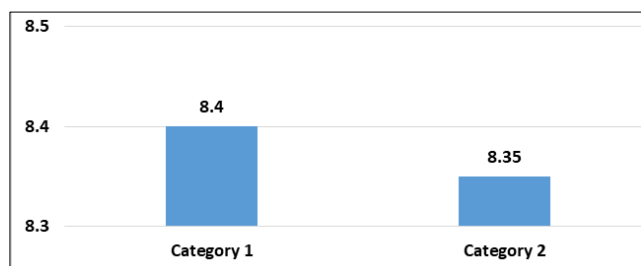
Table 5: Optimization of the level of stevia and sugar

Attributes	Treatments				Chi-square	p-value
	C	S ₁	S ₂	S ₃		
Flavour	8.00 $\pm$ 0.00 ^a	7.17 $\pm$ 0.19 ^b	7.50 $\pm$ 0.12 ^b	8.33 $\pm$ 0.11 ^a	32.05**	<0.001
Body and Texture	7.83 $\pm$ 0.09 ^{ab}	7.50 $\pm$ 0.15 ^b	7.78 $\pm$ 0.10 ^{ab}	8.11 $\pm$ 0.14 ^a	10.33*	0.016
Colour and appearance	7.94 $\pm$ 0.09 ^{ab}	7.44 $\pm$ 0.16 ^c	7.67 $\pm$ 0.12 ^{bc}	8.33 $\pm$ 0.11 ^a	20.76**	<0.001
Sweetness	7.83 $\pm$ 0.12 ^b	7.17 $\pm$ 0.15 ^c	7.56 $\pm$ 0.12 ^{bc}	8.33 $\pm$ 0.11 ^a	28.35**	<0.001
Syneresis	7.50 $\pm$ 0.27	7.11 $\pm$ 0.28	7.44 $\pm$ 0.27	7.89 $\pm$ 0.27	8.47 ^{ns}	0.053
Overall acceptability	7.77 $\pm$ 0.10 ^b	7.00 $\pm$ 0.16 ^c	7.50 $\pm$ 0.12 ^a	8.44 $\pm$ 0.12 ^a	34.76**	<0.001

All observations are mean value of three replicates with SE. * significant at $p < 0.05$ **significant at $p < 0.01$. a, b means different subscript vary significantly in a row. C-control yoghurt with 8% sucrose. S₁-yoghurt with 6% sucrose and 0.01% stevia, S₂- yoghurt with 4% sucrose and 0.02% stevia and S₃-yoghurt with 2% sucrose and 0.03% stevia.

3.3 Addition of dates powder to completely replace sucrose

Yoghurt fortified with 2% sucrose and 0.03% stevia was highly acceptable in 3.2 with respect to all the sensory properties. The 2% sucrose in S₃ was directly substituted with the same concentration of dates powder. The final product was highly acceptable. Similar results were reported by Jan *et al.* (2025) [9] in which a fortification up to 3% with dates fiber, improved texture, and maintained similar taste and acceptability to control yogurt.



Category 1 Functional yoghurt containing dates powder, category 2 Functional yoghurt without dates powder

Fig 5: Overall acceptability of yoghurt added with dates powder

3.4 Proximate composition of optimized beetroot-stevia-dates fortified yoghurt

The physicochemical properties of fortified yoghurt optimized in 3.3 was studied along with the control and the observations are given in Table 6.

Table 6: Physicochemical properties of optimized fortified yoghurt

Sl. No.	Parameters	Control	Fortified yoghurt
1	Protein (%)	3.12	3.41
2	Fat (%)	3.1	1.4
3	Carbohydrates (%)	11.7	13
4	Ash (%)	0.77	0.99
5	Moisture (%)	83.04	79.07
6	Total solids (%)	16.96	20.93
7	pH	4.5	4.7
8	Titrateable acidity (% lactic acid)	0.702	0.837
9	Fiber (%)	0	0.6
10	Dietary fiber (%)	0	0.54
11	Total antioxidants (%)	8	23.71
12	Total phenolic content (mg/100 mL)	0	4.61
13	Energy (kcal/ 100 g)	116	94.05

All observations are mean values of two independent replications

The developed yoghurt recorded a slightly higher protein content (3.41%) compared to the control (3.12%). This increase may be due to the combined protein contribution from beetroot and dates powder, as well as reduced moisture content, which concentrates the solids and thus the protein. The lower fat content in the fortified yoghurt (1.4%) compared to the control yoghurt (3.1%) could be attributed to the use of fat-free plant-based additives like beetroot and dates powder. An increase in carbohydrates (13%) and the ash content (0.99%) in fortified yoghurt could be explained by the inclusion of beetroot and dates powder. The increased titrateable acidity in the developed yoghurt (0.837% lactic acid) compared to that of control (0.702% lactic acid) suggests enhanced microbial activity due to availability of additional fermentable sugars from dates may also contribute to improved microbial safety and shelf life of the

product. Mekdade *et al.* (2025) [10] also agrees that addition of stevia glycosides in yoghurt does not influence the survival of the strains in yoghurt. The reduced energy value of the developed yoghurt (94.05 Kcal/100 g) compared to the control (116 Kcal/100 g) is largely due to a lower fat content and the use of stevia which is a non-calorific sweetener. The findings are in accordance with Ritu and Nandini (2016) [11]. The presence of dietary fibre (0.54%) not only improves the nutritional profile of the optimized product, but also contributes to its potential health promoting benefits such as improved gut motility and lowers postprandial glycaemic response. Al-Farsi and Lee (2008) [2] reported that dates possess a moderate glycaemic index and strong antioxidant activity, making them a promising ingredient for sweetening without compromising glycaemic control.

The fortified yoghurt exhibited higher antioxidant activity (23.71%) compared to the control yoghurt (8%). Incorporating small amount of beetroot powder (3 g) and dates powder (2 g) into yoghurt successfully enhanced antioxidant property. Beetroot raises yoghurt antioxidant potential because of betalains and phenolic acid and dates powder supplies flavonoids and carotenoids that further elevate antioxidant activity. The antioxidant activity is also influenced by the phenolic content in the product as suggested by Saman *et al.* 2025 [12].

4. Conclusion

This study was undertaken to develop yoghurt fortified with beetroot powder, dates powder, and stevia. These components were chosen for their nutritional benefits, antioxidant properties, and low glycemic index – making them ideal for consumers with diabetes or those seeking healthier alternatives to traditional yoghurt. It's positive sensory acceptance and nutritional density highlight its potential as a functional dairy product with promising applications in both health focused and general market. Future research should include *in vivo* testing to scientifically validate the low glycaemic potential of the product.

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