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Optimization of palm jaggery for the preparation of dietetic yoghurt

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Abstract
An investigation was carried out to find out the feasibility of incorporating palm jaggery to replace cane sugar and to study the physico-chemical, microbiological and organoleptic qualities of dietetic yoghurt, and turmeric powder was added as a colouring agent to mask the colour of palm jaggery in the final dietetic yoghurt. No variation was found in the curd setting time of control and treatment samples. The pH value of control and treatments was uniformly maintained at 4.5. The fat and total solids content of the control and treatments exhibited no significant difference among them. The textural properties like firmness and consistency of control and treatments exhibited a significant difference ($P< 0.01$). As the cane sugar replacement level increased, the firmness and consistency scores of the treatments also increased. The coliform and yeast and mould count of control and treatments exhibited no significant difference among them. On sensory analysis, the appearance score of control and treatments exhibited no significant difference, but the body & texture and flavour score exhibited a significant difference ($P< 0.01$) among them. The total sensory scores of control and treatments exhibited a significant difference ($P< 0.01$). The replacement of cane sugar with palm jaggery along with turmeric powder as a colouring agent did not affect the acceptability as reported by the sensory panel. Hence, it can be concluded that the yoghurt samples can be prepared by replacing cane sugar with palm jaggery up to 100 per cent level without affecting the physicochemical, microbiological and sensory properties.

Keywords: Yoghurt, palm jaggery and turmeric powder

1. Introduction
Yoghurt is a fermented milk product obtained from the milk by the lactic acid fermentation of *Streptococcus salivarius subsp. thermophiles* and *Lactobacillus delbrueckii subsp. bulgaricus* (FAO/WHO, 1977) [1]. Regular consumption of yoghurt improves human gut health. Moreover, yoghurt supplies good quality proteins, also an excellent source of calcium, phosphorus, potassium and contains significant quantities of general vitamins. Yoghurt could be used for feeding, owing to its higher Ca/Na ratio (Tamime and Deeth, 1980) [2]. Raw cane sugar (or brown sugar) normally contains 94 to 98.5 per cent sucrose and 1.5 to 6 per cent non-sucrose components (Koltuniewicz, 2010) [3]. Probably, the cane sugar aggravates blood sugar in people with diabetes mellitus and has no nutritional value. Hence, instead of cane sugar, palm jaggery was used to enhance the sugar content in the yoghurt.
Palm jaggery is made from the extract of palm trees in the southern part of India. Because of its cooling effects on the human body, it is of high value. Nutritional composition of palm jiggery is protein - 0.35 per cent, fat (ether extraction) - 0.17 per cent, minerals - 0.74 per cent, carbohydrates - 90.60 per cent, calcium -0.06 per cent, phosphorus - 0.06 per cent, iron - 2.5 (mg/gm), nicotinic acid - 5.24 (mg/100 gm), vitamin B1 -24.0 (mg/100 gm), Riboflavin - 432.0 (mg/100 gm) and Vitamin C - 11.0 (mg/100 gm).
Palm jaggery is highly-priced due to its medicinal properties. It usually contains 65 to 85 per cent sucrose and 5 to 15 per cent reducing sugars and is consumed directly or used for the preparation of sweet confectionary items (Vengaiah *et al*., 2013) [4]. Further, palm jaggery is used in the ayurvedic and traditional medicines in India, as it has a role to reduce the chance of lung cancer. The palm jaggery has an intense, earthy taste or is reminiscent of chocolates in its taste. Due to these properties, palm jaggery can be effectively used to replace cane sugar.
The addition of palm jaggery in the yoghurt preparation leads to a colour change in the final product. To mask the typical palm jaggery colour in the yoghurt, two drops of turmeric powder solution has been added during yoghurt preparation. Moreover, the inclusion of turmeric power in the yoghurt will also enhance the appeal beyond its therapeutic benefits.

Longvah *et al*. (2017) [5] reported that the turmeric powder (*Curcuma domestica*) contains 10.58 per cent moisture, 7.66 per cent protein, 6.13 per cent ash, 5.03 per cent total fat and 49.22 per cent carbohydrates. Therefore, by considering the valuable aspects of palm jaggery and turmeric powder, the present study is envisaged to prepare yoghurt with the above said ingredients and to evaluate its physicochemical and sensory properties.

2. Materials and Methods

The experiments were carried out by utilizing the facilities at the Department of Livestock product technology (Dairy Science), Veterinary College and Research Institute, Namakkal. Fresh-pooled cow milk was purchased from Livestock Farm Complex, Veterinary College and Research Institute, Namakkal. Spray-dried skim milk powder (Aavin Dairy, Erode) was used to adjust the solids-not-fat content in yoghurt. Ampoules of freeze-dried culture of *Streptococcus thermophilus* and *Lactobacillus bulgaricus* were obtained from National Dairy Research Institute, Karnal, Haryana. Cane Sugar, purchased from the local market, was used in the experiment. Palm jaggery was purchased directly from the local palm jaggery manufacturers at Namakkal.

Different treatments of dietetic yoghurt were designed as follows

Table 1: Treatments Details

Treatments	Details
Control	Plain yoghurt without replacement of cane sugar
T1	Yoghurt with 25% replacement of cane sugar
T2	Yoghurt with 50% replacement of cane sugar
T3	Yoghurt with 75% replacement of cane sugar
T4	Yoghurt with 100% replacement of cane sugar

2.1 Preparation of palm jaggery incorporated yoghurt

Yoghurt mixes were prepared by incorporating cow milk, skim milk powder, cane sugar, and the palm jaggery was used to replace the cane sugar at 25, 50, 75 and 100 per cent levels. The turmeric powder was used as a colour for yoghurt. The turmeric colour solution was prepared by mixing four-grams of powder in 100 ml distilled water and two drops of turmeric solution has been added to the 100 gram of yoghurt mixes and mixed well before incubation. Yoghurt was prepared as per the method described by Malarkannan and Geevarghese (1996) [6].

Table 2: Ingredients for 100 gram of yoghurt mixes

Ingredients (in grams)	Control	T_1 (25%)	T_2 (50%)	T_3 (75%)	T_4 (100%)
Cow milk	88.26	88.26	88.26	88.26	88.26
Skim milk powder	5.74	5.74	5.74	5.74	5.74
Sugar	6	4.5	3	1.5	0
Palm jaggery	0	1.5	3	4.5	6
Total	100.00	100.00	100.00	100.00	100.00

2.2 Process flow chart for the preparation of dietetic yoghurt

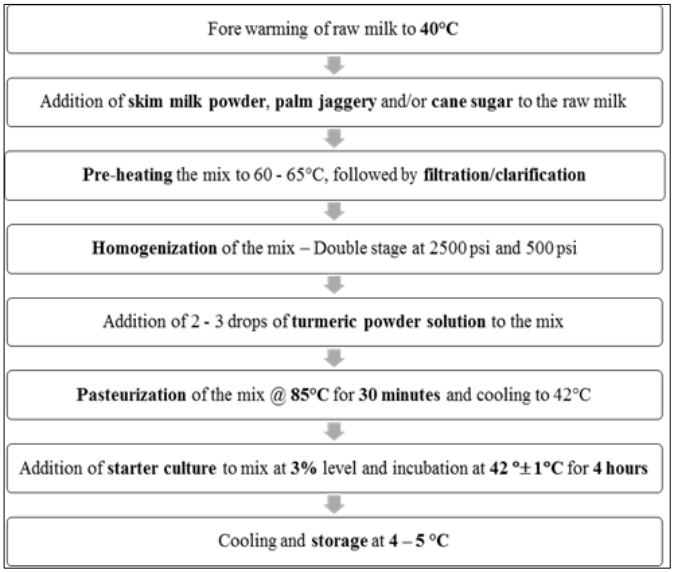

Chart 1: Preparation of dietetic yoghurt

2.3 Physico chemical analysis of yoghurt

pH was estimated using digital pH meter. Total solids content was determined according to AOAC (1990), 15th edition. Fat was estimated as per the procedure described in IS:SP:18 (Part XI) – 1981.

2.4 Texture analysis of yoghurt

The Firmness and Consistency of palm jiggery enriched yoghurt were characterized using the Instron Texture Analyser (Model: TA. XT Plus, Stable Microsystems) and Texture Expert Software. A Back Extrusion Cell (A/BE) with 35mm disc and extension bar using 5kg load cell was used to measure the firmness and consistency of the developed dietetic yoghurt. Six measurements for each sample were recorded using a 5 mm diameter and 150 mm long stainless steel probe adapter attached to a 5kg load cell. The penetration depth at the geometrical centre of the samples contained in a standard size back extrusion container (50mm diameter) was 30 mm and the penetration speed was set at 1.0 mm/s. The firmness of the samples was determined as the peak compression force during penetration. The maximum negative force is taken as the indication of consistency/resistance to flow off the disc during back extrusion. All determinations were carried out at 15 °C.

2.5 Organoleptic evaluation

Yoghurt samples were evaluated for appearance, flavour, body and texture and total sensory by a panel using a 9-point Hedonic scale (Dubey *et al.*, 2011) [7]. All the samples were appropriately coded before subjected for sensory evaluation.

2.6 Statistical analysis:
The data obtained in all the experiments were analysed statistically by applying two-way ANOVA by approved statistical methods of SPSS (version 20.0).

3. Results and Discussion
The results pertaining to the physico-chemical and microbiological properties of control and treatment yoghurt samples are presented in Table 3.

3.1 Physico chemical analysis of yoghurt
There seems to be no variation in the curd setting time due to the substitution of palm jaggery in the place of cane sugar. The present results of the control and treatments are at par with the values reported by Malarkannan and Geevarghese (1996) [6] and Ghadge*et al.* (2008) [8]. The pH value of control and treatments exhibited no significant difference and was within the limits prescribed by FSSAI (2012) [9]. The fat and total solids content of the control and treatments exhibited no significant difference among them and were within the FSSAI (2012) [9] prescribed limits of 3.0 and 13.5 per cent respectively.

Table 3: Physico-chemical, microbiological properties of yoghurt samples

Parameters	Control	T1	T2	T3	T4
Setting time (hours)	3.50±0.02	4.13±0.01	4.14±0.01	4.18±0.01	4.20±0.01
pH	4.53±0.01	4.55±0.00	4.56±0.00	4.57±0.00	4.58±0.00
Fat (%)	3.00±0.14	3.02±0.16	3.08±0.11	3.01±0.13	3.05±0.12
Total solids (%)	23.88±0.02	23.87±0.15	23.86±0.22	23.89±0.24	23.87±0.22
Firmness (g)	108.59^{b}±1.56	141.18^{a}±3.44	151.98^{a}±3.40	156.11^{a}±2.82	159.46^{a}±2.29
Consistency (g-sec)	2023.73^{e} ±20.29	2204.39^{d}±54.24	2596.93^{c}±56.29	2908.24^{b} ±29.85	3112.90^{a} ±43.32
Coliform count (cfu/ml)	2.75±0.25	3.50±0.29	2.50±0.50	3.00±0.41	3.25±0.63
Yeast and mould count (cfu/ml)	10.25±0.48	10.25±0.63	10.75±0.63	12.00±0.71	12.00±0.91

Means bearing superscript within the treatments differ significantly ($p< 0.01$)

3.2 Textural and microbial analysis of yoghurt
The firmness of control and treatments exhibited a significant difference ($P< 0.01$) among them, and exhibited an increasing trend towards 100 per cent replacement of cane sugar with palm jaggery. The consistency of control and treatments exhibited a significant difference ($P< 0.01$) among them. As the cane sugar replacement level increases, the consistency scores of the treatments also increases and the results are congruent with the findings of Yilmaz-Ersan and Topcuoglu (2021) [10].

The coliform and yeast and mould count (cfu/ml) of control and treatments exhibited no significant difference among them and were within the FSSAI (2012) [9] prescribed limits of 10 and 100 per gram (maximum) respectively.

3.3 Sensory evaluation of yoghurt
The samples of yoghurt were subjected to sensory evaluation by a panel of six judges using the score card adopted by Pearce and Heap (1974) [11] and the results are presented in Table 4.

Table 4: Sensory properties of yoghurt samples

Parameters	Control	T1	T2	T3	T4
Appearance score	8.33±0.01	8.32±0.02	8.30±0.02	8.31±0.02	8.30±0.02
Body and Texture score	8.67^{a}±0.01	8.64^{b}±0.01	8.62^{b}±0.01	8.61^{bc}±0.02	8.58^{c}±0.02
Flavour score	8.89^{a}±0.01	8.89 ^{a}±0.01	8.87^{b}±0.01	8.87^{b}±0.01	8.86^{b}±0.01
Total score	8.63^{a}±0.01	8.67^{b}±0.01	8.60^{c}±0.02	8.60^{c}±0.02	8.58^{d}±0.02

Means bearing superscript within the treatments differ significantly ($p< 0.01$)

The appearance scores of control and treatments exhibited no significant difference among them. But, the body and texture and flavour scores of control and treatments exhibited a significant difference ($P< 0.01$) among them. Similarly, the total scores of control and treatments exhibited a significant difference ($P< 0.01$) among them. The replacement of cane sugar with palm jaggery along with turmeric solution as a colouring agent did not affect the acceptability as reported by the sensory panel based on the score card evaluation.

The appearance, body and texture, flavour and total scores exhibited in the present study are in accordance with the reports of Malarkannan and Geevarghese (1998) [6] for yoghurt prepared with condensed coconut water and also in resemblance with Ghadge *et al.* (2008) [8] for apple pulp incorporated yoghurt.

4. Conclusion
Hence, it can be concluded that the yoghurt samples can be prepared by replacing cane sugar with palm jaggery up to 100 per cent without affecting the sensory properties. Moreover, there is no marked variation has been noticed in the physico-chemical and microbiological analysis. The replacement of cane sugar with palm jaggery in yoghurt with turmeric solution as a colouring agent did not affect the acceptability as reported by the sensory panel based on the score card evaluation and thereby, the consumers can harvest the benefits of consuming palm jaggery and catch up on a new yoghurt variety.

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