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Assessment of antioxidant potential of herbal Greek yoghurt incorporated with Lemongrass (*Cymbopogon citratus*) extract

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Abstract

Herbal Greek yoghurt was prepared by adding concentrated lemongrass (*Cymbopogon citratus*) extract (CLE) at different levels (0.0, 1.0, 2.0, 3.0 and 4.0%). The herbal Greek yoghurt prepared with addition of CLE (3.0%) exhibited significantly ($p < 0.05$) higher scores for the sensory attributes *viz.* flavour (8.21 ± 0.10), colour and appearance (8.43 ± 0.11) and overall acceptability (8.38 ± 0.10) as compared to that of control, while the scores of body and texture (8.29 ± 0.06) and product acidity (7.38 ± 0.09) resembled to that of control. The optimized product had TS (39.17%), fat (4.21%), protein (8.19%), ash (0.72%), pH (4.85) and treatable acidity (1.07% LA). The CLE incorporated herbal Greek yoghurt had firmness (221.71 ± 18.34 g), consistency (5873.13 ± 153.47 G.S), cohesiveness (-193.87 ± 14.82 g) and index of viscosity (-667.81 ± 21.15 G.S). Further, the herbal Greek yoghurt had higher TPC (47.21 ± 0.03 μ M GAE/100 g) and antioxidant capacity *i.e.* ABTS (17.21 ± 0.04 μ M TE/100 g), DPPH (28.64 ± 0.03 μ M TE/100 g) and FRAP (23.15 ± 0.04 μ M TE/100 g).

Keywords: TPC, ABTS, DPPH, FRAP, herbal, Greek yoghurt, antioxidant, texture

1. Introduction

Greek yoghurt is a popular dairy product having characteristic flavour, refreshing taste and improved digestibility. Greek yoghurt differs from other yoghurts because it goes through a straining process to remove the whey. Strained Greek yoghurt is thicker, creamier yoghurt with a tart taste. The potential health benefits of Greek yoghurt include improved bone health, increased dietary protein, reduced appetite and hunger, boost in metabolism, improved gut health, good mental health (less stress, anxiety and depression), increased muscle mass, lower cardiovascular risks, reduced risk of type 2 diabetes, etc. (<https://www.healthline.com>, 2023) [1]. The Greek-style yoghurt (prepared by adding thickening agents to regular yoghurt) as well as low or no-fat Greek yoghurt may not share the same health benefits as traditional Greek yoghurt.

Lemongrass (*Cymbopogon citratus*) is a grass variety belonging to Gramineae family. It is a tropical grass native to western parts of India and Sri Lanka. It is believed to have a wide range of therapeutic effects, and has been used for centuries in South America and India (Costa *et al.*, 2015) [2]. Its leaves and roots possess pleasant lemon-like aroma and their extracts are used in several food products including beverages, frozen products etc. Lemongrass was usually known only for its aromatic properties. However, it also possesses numerous health benefits which make it an invaluable herb. The lemongrass extracts are reported to have the following health benefits: antioxidant properties, antibacterial and antifungal properties; detoxify the liver, pancreas, kidney, bladder and the digestive tract and boost the immune system. Lemongrass flavour just like citrus flavours combines well with acidic products. The freshly cut and dried leaves of lemongrass have been used traditionally for making fragrances, flavoring food, and treating a wide variety of ailments due to its numerous phytochemical properties (Ifesan and Olorunsola, 2018) [3]. Hence, in this study lemongrass flavour extracted from lemongrass leaves was used to produce a new variety of herbal Greek yoghurt having higher antioxidant potential.

2. Material and Methods

2.1 Milk

Fresh, chilled, raw cow milk of Kankrej breed was used in the study.

2.2 Lemongrass

Lemongrass (*Cymbopogon citratus*) grown in the Centre for Agro-Forestry, Forage Crops and Green Belt, S. D. Agricultural University, Sardarkrushinagar was used for the study.

2.3 Lactic cultures

Freeze dried yoghurt culture (Lyofast Y 350 A) consisting of specifically selected blend of lactic acid bacteria was obtained from Sacco System, Italy.

2.4 Skim milk powder

Spray dried skim milk powder (SMP) was procured from Banas dairy, Palanpur, Gujarat and was used for standardization of solid not fat (SNF) level.

2.5 Sugar

Crystalline sugar procured from the local market was used as

the sweetening material.

2.6 Preparation of concentrated lemongrass extract (CLE)

Concentrated lemongrass extract (CLE) was prepared by using dried lemongrass leaves powder through refluxing, filtration and centrifugation (10000 rpm/10 min) followed by concentration to 90% using rotary vacuum evaporator.

2.7 Preparation of herbal Greek yoghurt

Herbal Greek yoghurt was prepared by adding different levels of CLE i.e. T₁ (0%, control), T₂ (1.0%), T₃ (2.0%), T₄ (3.0%) and T₅ (4.0%) as per the flow diagram (Fig. 1). The product was optimized on the basis of sensory evaluation. The developed product was analyzed for physico-chemical analysis (total solids, fat, protein, ash, titrable acidity and pH) as well as for the total phenolic content (Kahkonen *et al.*, 1999) [4] and antioxidant potential by ABTS assay (Re *et al.*, 1999 [5]; Guo and Jauregi, 2018 [6]), DPPH assay (Brand-Williams *et al.*, 1995) [7] and FRAP assay (Benzie and Strain, 1996) [8]. The optimized product was also analyzed for textural properties (firmness, consistency, cohesiveness and index of viscosity) using Texture Analyzer.

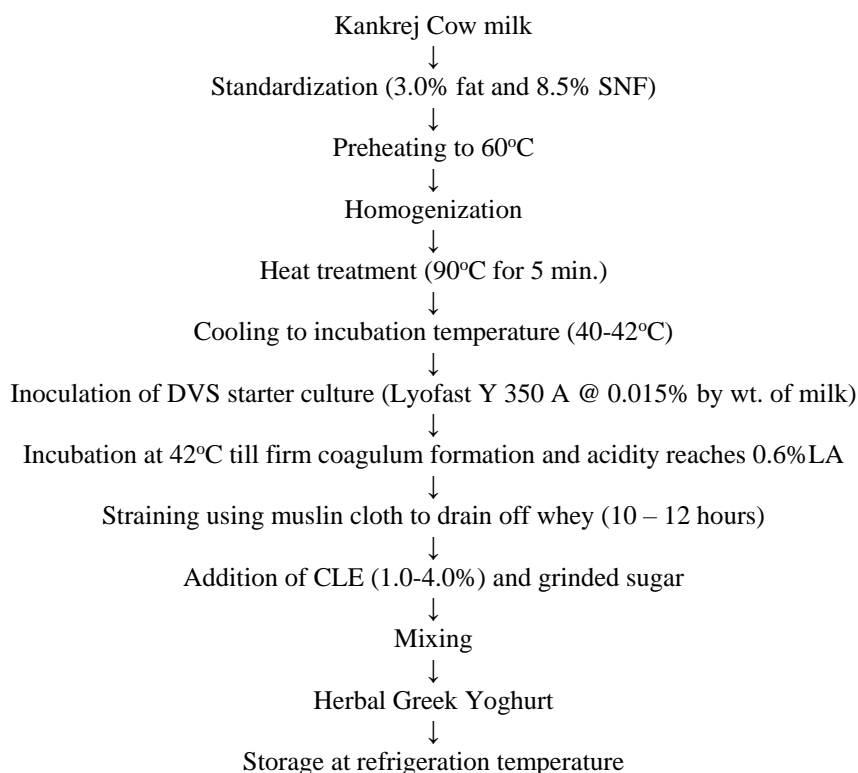


Fig 1: Flow diagram for preparation of herbal Greek yoghurt

2.8 Statistical analysis

Statistical analysis was carried out using completely randomized design (CRD) with 3 repetitions. The data are presented as means \pm standard error of mean (SEM) or means \pm standard deviation (STD). Analysis of variance (ANOVA) was used to determine the main effects of treatments (Gacula and Singh, 1984; Snedecor and Cochran, 1994) [9, 10].

3. Results and Discussion

3.1 Optimization of level of CLE in herbal Greek yoghurt

The sensory scores of herbal Greek yoghurt prepared with incorporation of CLE at different levels are presented in Table 1. The results delineated that addition of different levels of CLE in herbal Greek yoghurt had a marked influence on

flavour, colour and appearance and overall acceptability scores of the product. The herbal Greek yoghurt prepared with addition of CLE at different levels i.e. 0.0 (control), 1.0, 2.0, 3.0 and 4.0 per cent had flavour scores of 6.42 ± 0.13 , 6.76 ± 0.07 , 7.23 ± 0.12 , 8.21 ± 0.10 and 7.73 ± 0.09 , respectively, while the colour and appearance scores were 6.53 ± 0.11 , 6.94 ± 0.13 , 7.32 ± 0.09 , 8.43 ± 0.11 and 7.95 ± 0.08 , respectively, whereas the scores for overall acceptability were 6.63 ± 0.09 , 7.27 ± 0.08 , 7.70 ± 0.11 , 8.38 ± 0.10 and 8.03 ± 0.09 , respectively. It was observed that as the level of addition of CLE was increased from 1.0 to 3.0 per cent, the sensory scores for flavour, colour and appearance and overall acceptability increased significantly ($p < 0.05$). Further increase in the level of CLE to 4.0 per cent had significantly ($p < 0.05$) decreased

the scores of all sensory attributes which was attributed to exceptionally high intensity of flavour (limonene or citral), undesirable consistency and unusual colour and appearance of the product. The herbal Greek yoghurt prepared with addition of CLE (3.0%) exhibited significantly ($p < 0.05$) highest scores for the sensory attributes viz. flavour (8.21 ± 0.10), colour and

appearance (8.43 ± 0.11) and overall acceptability (8.38 ± 0.10), while the scores of body and texture (8.29 ± 0.06) and product acidity (7.38 ± 0.09) resembled to that of control. Therefore, 3.0 per cent of CLE addition was adjudged as the best level for incorporation in herbal Greek yoghurt.

Table 1: Optimization of levels of CLE in herbal Greek yoghurt

Sensory Attributes	Level of addition of CLE (%)					CD ($p < 0.05$)
	Control	1.0	2.0	3.0	4.0	
Flavour	6.42 ± 0.13^a	6.76 ± 0.07^b	7.23 ± 0.12^c	8.21 ± 0.10^e	7.73 ± 0.09^d	0.19
Body and texture	8.32 ± 0.09^b	8.30 ± 0.12^b	8.31 ± 0.09^b	8.29 ± 0.06^b	8.08 ± 0.11^a	0.18
Colour and appearance	6.53 ± 0.11^a	6.94 ± 0.13^b	7.32 ± 0.09^c	8.43 ± 0.11^e	7.95 ± 0.08^d	0.12
Product acidity	7.41 ± 0.14^b	7.42 ± 0.10^b	7.40 ± 0.07^b	7.38 ± 0.09^b	7.05 ± 0.13^a	0.19
Overall acceptability	6.63 ± 0.09^a	7.27 ± 0.08^b	7.70 ± 0.11^c	8.43 ± 0.10^e	8.03 ± 0.09^d	0.20

Means in each row with different superscripts (a, b, c, d, e) were significantly different (LSD test, $P < 0.05$) from each other. Data are presented as means \pm SEM (N=21).

3.2 Composition and physico-chemical characteristics of herbal Greek yoghurt

The control and CLE incorporated herbal Greek yoghurt samples were analyzed for compositional and physico-chemical characteristics. The average values of total solids (TS), fat, protein, ash, titratable acidity and pH are depicted in Table 2. The values of TS, fat, protein and ash for control product were 41.03 ± 0.15 , 4.34 ± 0.02 , 8.26 ± 0.07 and 0.77 ± 0.01 per cent, respectively, whereas for herbal Greek yoghurt

prepared with CLE were 39.17 ± 0.12 , 4.21 ± 0.03 , 8.19 ± 0.06 and 0.72 ± 0.01 per cent, respectively, indicating that control sample had highest proximate composition followed by CLE sample. Similarly, control and CLE added herbal Greek yoghurt had pH values of 4.82 ± 0.01 and 4.85 ± 0.01 and titratable acidity of 1.12 ± 0.002 and 1.07 ± 0.001 LA, respectively, which denoted the higher pH and lower titratable acidity of CLE incorporated herbal Greek yoghurt as compared to control sample.

Table 2: Composition and physico-chemical characteristics of control and CLE incorporated herbal Greek yoghurt

Parameters	Control herbal Greek yoghurt	CLE incorporated herbal Greek yoghurt
Proximate composition (%)		
Total solids	41.03 ± 0.15	39.17 ± 0.12
Fat	4.34 ± 0.02	4.21 ± 0.03
Protein*	8.26 ± 0.07	8.19 ± 0.06
Ash*	0.77 ± 0.01	0.72 ± 0.01
Physico-chemical characteristics		
pH	4.82 ± 0.01	4.85 ± 0.01
Titratable acidity (% lactic acid)	1.12 ± 0.002	1.07 ± 0.001
Values represent average of three trials i.e. Mean \pm STD (N=3), * (on dry basis) per cent by weight		

3.3 Antioxidant capacity and total phenolic content of herbal Greek yoghurt

The total phenolic content (TPC) as well as antioxidant activity by ABTS, DPPH and FRAP assays were measured for the control and CLE incorporated herbal Greek yoghurt and the results are depicted in Table 3. The highest TPC ($\mu\text{M GAE}/100 \text{ g}$) was recorded for herbal Greek yoghurt prepared with addition of CLE (47.21 ± 0.03) followed by control (22.48 ± 0.04). Similar trend was observed for antioxidant

capacity measured by ABTS, DPPH and FRAP assays which showed higher values for herbal Greek yoghurt prepared with CLE i.e. 17.21 ± 0.04 , 28.64 ± 0.03 and $23.15 \pm 0.04 \mu\text{M TE}/100 \text{ g}$, respectively, while lower antioxidant capacity was reported by control sample which possessed the values of 8.33 ± 0.02 , 12.36 ± 0.05 and $9.71 \pm 0.02 \mu\text{M TE}/100 \text{ g}$, respectively. The results indicated higher TPC and antioxidant potential of CLE incorporated herbal Greek yoghurt as compared to control.

Table 3: Antioxidant capacity and total phenolic content of control and CLE incorporated herbal Greek yoghurt

Product	Antioxidant capacity ($\mu\text{M TE}^*/100 \text{ g}$)			Total phenolic content ($\mu\text{M GAE}^{**}/100 \text{ g}$)
	ABTS	DPPH	FRAP	TPC
Control	8.33 ± 0.02	12.36 ± 0.05	9.71 ± 0.02	22.48 ± 0.04
CLE incorporated herbal Greek yoghurt	17.21 ± 0.04	28.64 ± 0.03	23.15 ± 0.04	47.21 ± 0.03
Data are presented as mean \pm STD (N=3), * - TE- Trolox Equivalent, ** - GAE- Gallic Acid Equivalent				

3.4 Texture profile analysis of herbal Greek yoghurt

The CLE (3.0%) incorporated herbal Greek yoghurt was analyzed for textural properties (firmness, consistency, cohesiveness and index of viscosity) using Texture Analyzer. The texture graph is illustrated in Fig. 2. The results

delineated that the CLE incorporated herbal Greek yoghurt had the values of firmness as $221.71 \pm 18.34 \text{ g}$, consistency as $5873.13 \pm 153.47 \text{ G.S}$, cohesiveness as $-193.87 \pm 14.82 \text{ g}$ and index of viscosity as $-667.81 \pm 21.15 \text{ G.S}$.

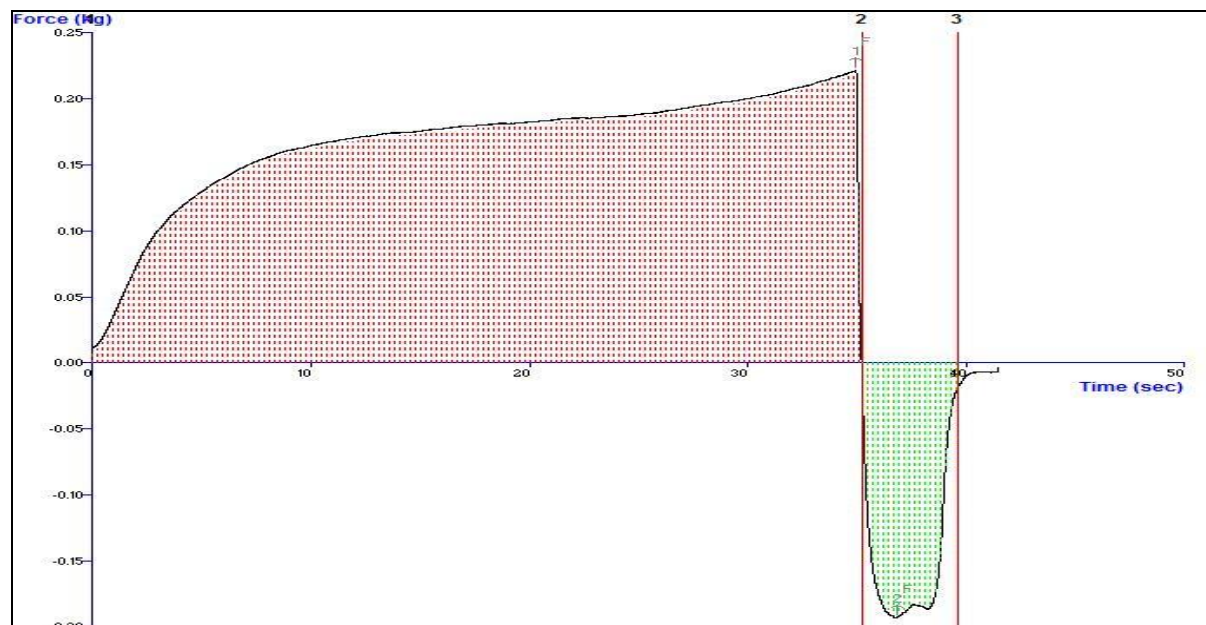


Fig 2: TAXT plus graph of herbal Greek yoghurt incorporated with CLE

4. Conclusion

The results of present investigation revealed that the herbal Greek yoghurt with enhanced antioxidant potential could be prepared by incorporating 3.0 per cent of CLE (concentrated lemongrass extract). The developed product had higher overall acceptability as compared to control. The TS, fat, protein and ash for herbal Greek yoghurt prepared with CLE was 39.17 ± 0.12 , 4.21 ± 0.03 , 8.19 ± 0.06 and 0.72 ± 0.01 per cent, respectively, while it had pH of 4.85 ± 0.01 and titratable acidity of $1.07 \pm 0.001\%$ LA. The CLE incorporated herbal Greek yoghurt had firmness (221.71 ± 18.34 g), consistency (5873.13 ± 153.47 G.S), cohesiveness (-193.87 ± 14.82 g) and index of viscosity (-667.81 ± 21.15 G.S). Further, the TPC and antioxidant potential of CLE incorporated herbal Greek yoghurt was higher as compared to control.

5. Acknowledgment

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6. Conflict of interest

Authors declare no conflict of interests.

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