



Development of Healthier Dessert Alternative: A Low-fat and Low-sugar Strained Yoghurt

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ABSTRACT

Background: Strained yoghurt, as a very delicious Indian dessert is traditionally made with full-fat yogurt, sugar and flavouring compounds. Packed with probiotic bacteria, calcium and protein, this fermented dairy treat offers numerous health benefits. Because of its high fat and high sugar content, it is refused by health-conscious individuals and the people with hypercholesterolemia and diabetes. In present research work, efforts were carried out to reduce the fat and sugar content in the strained yoghurt by substituting skim milk with double toned milk and sugar with stevia.

Methods: In present study, attempts were made to develop low-fat and low-sugar strained yoghurt with low-fat chakka, stevia and different levels of pink guava pulp (0-20%). Nutritional sensorial qualities of the developed yoghurt were assessed to confirm the formulation. Shelf-life study was conducted to assess its stability during storage under refrigerated condition.

Result: Sensory scores for taste, flavour, texture and overall acceptability of sample with stevia and 10% pulp were most encouraging after control. The reduced levels of non-reducing sugar and total sugar underline the acceptability of strained yoghurt containing stevia and pink guava pulp as low sugar product. The lower fat content in strained yoghurt samples is comparable with the range of FSSAI standards (3-4%) to label as a low-fat product that rightly justifies the use of ingredient formulation to make low-fat strained yoghurt. Low-fat and low-sugar strained yoghurt stored at 4±1°C in PP containers exhibited higher shelf-life (18 days) against PET containers (12 days).

Key words: Low-fat, Low-sugar, Pink guava pulp, Stevia, Strained yoghurt.

INTRODUCTION

Strained yoghurt, a traditional Indian dessert made from yogurt, is known for its rich flavour and cultural significance. Packed with probiotic bacteria, calcium and protein, this fermented dairy treat offers numerous health benefits. In India, there have been various attempts to enhance the nutritional and functional quality of strained yoghurt by integrating jaggery and pulp of different fruits and nuts (Sharma *et al.*, 2017; Sonwane and Sonkamble, 2020). Some of the reports stated the use of fruits in strained yoghurt like strawberry (Sonawane *et al.*, 2007), papaya (Nigam *et al.*, 2009), custard apple (Gavane *et al.*, 2010), apple (Kumar *et al.*, 2011), sapota (Shambharkar *et al.*, 2011; Sharma *et al.*, 2017) and jamun (Chavan *et al.*, 2019). Fermented yogurts like strained yoghurt are rich in probiotic bacteria, beneficial for gut health, digestion and immunity (Hadjimbei *et al.*, 2022).

Traditional strained yoghurt is high in fat (up to 10%), mainly due to its full-fat yogurt base (Bethapudi, 2017). Protein content is substantial, making it a nutritious dessert option. Lactic acid bacteria (LAB), convert lactose into lactic acid during fermentation (Bintsis, 2018). This process thickens the yogurt, lowers lactose content and enhances digestibility. Starter cultures containing specific LAB strains can influence the final texture, flavour and aroma of strained yoghurt. This traditional fermented milk product is rich in casein and contains a significant amount of sugar, making it a heavy meal that may be difficult to digest. Because of its high fat and high sugar content it is refused by health-

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conscious individuals and the people with hypercholesterolemia and diabetes. In present research work, efforts were carried out to reduce the fat and sugar content in the strained yoghurt by substituting skim milk with double toned milk and sugar with stevia. Toned milk provides significant decrease in the fat content of strained yoghurt while maintaining its nutrient profile. Stevia, a plant based natural sweetener, offers a sugar-free alternative that doesn't compromise on sweetness or inclusion of artificial additives. Stevia, a natural sweetener derived from stevia rebaudiana plant is a promising replacement to sugar in delicious desserts (Goyal *et al.*, 2010). Its glycosides provide a solution to address the problems related to lifestyle diseases like diabetes and obesity and are free from carcinogenic properties (Barriocanal *et al.*, 2008; Sharma *et al.*, 2009). The two main glycosides, i.e.

stevioside and rebaudioside in stevia makes it 200-300 times sweeter than sucrose (Vasuki *et al.*, 2020). Being a zero-calorie natural sweetener, stevia offers negligible effect on blood sugar levels. Hence, replacing sugar with stevia in strained yoghurt reduces its caloric content and glycaemic index, making it a suitable choice for diabetes and overweight individuals. (Lohner *et al.*, 2017). Stevia because of its neutral flavour easily blends with other ingredients in the formulation. Strained yoghurt can be enhanced with the addition of fruits, nuts, cardamom, saffron and other spices, resulting in improved colour and flavour. It is important to note that strained yoghurt should not contain any artificial flavour or colour (FSSAI, 2011).

Currently, the use of fruit pulp (mango, banana, sapota and strawberry) in strained yoghurt is gaining popularity to cater the demands of diverse population with respect to natural flavours and nutrition. Pink guava a (*Psidium guajava* L.) is one such fruit that is well-liked by the Indian population in terms of flavour and is also nutritionally rich. Phytochemicals like lycopene, carotenoids and flavonoids are present in pink guava (Edepalli *et al.*, 2022). It has 5.08% reducing sugars, 3.25% non-reducing sugars and 8.33% total sugars (Jawahar, 1999). This popular fruit is packed with antioxidants and other beneficial compounds, enhancing taste, appearance and nutritional value of strained yoghurt. The present study, focuses on valorisation of strained yoghurt, a fermented dessert by collaborating unique properties of stevia, toned milk and pink guava, highlighting their suitability for creating a more wholesome version of strained yoghurt.

MATERIALS AND METHODS

The present research work is undertaken at School of Food Technology, MIT ADT University Pune, during 2023-24.

Raw material

Double-toned milk, sugar and pink guava fruits were procured from the local market of Pune. Stevia syrup was procured from Kanha Biogenetics, Solan (MP).

Starter culture

Pure activated cultures of *Lactobacillus acidophilus*, *Lactobacillus delbrueckii* and *Streptococcus thermophilus* were preserved in MRS (de Man, Rogosa and Sharpe) broth at $4 \pm 1^\circ\text{C}$. The cultures were isolated from the broth, centrifuged and purified with sterilized distilled water. The mixture of *Lactobacillus acidophilus*, *Lactobacillus delbrueckii* and *Streptococcus thermophilus* were used @ 1% for inoculation.

Preparation of pink guava pulp

The pink guava fruits in their normal ripe state were used for the experiment. The fruits underwent a thorough wash with clean water and their peel layer was removed. The peeled fruits were cut into small pieces, processed in a grinder and filtered through muslin cloth to obtain fine pulp.

Preparation of strained yoghurt

To prepare strained yoghurt, double-toned milk (1.5% fat, 9% SNF) was heated over a burner at $72 \pm 1^\circ\text{C}$ for 15 s. Then it was cooled down at room temperature ($28 \pm 1^\circ\text{C}$). Inoculation was carried out by using 1% starter culture followed by incubation at 37°C for 24 h. The set curd was fragmented by agitation with a glass rod and it was hanged in muslin cloth (8 h) for removal of whey. After exclusion of whey, stevia syrup and pink guava pulp were added as per treatments (Table 1). The prepared strained yoghurt was packed and stored in PP and PET cups at refrigerated temperature ($4 \pm 1^\circ\text{C}$) for further evaluation and analysis.

Physico-chemical analysis of low-fat and low-sugar strained yoghurt

Total solids (AOAC, 1995), TSS (Refractometer), pH (pH meter), titratable acidity (lactic acid %), fat content (IS: Part

Table 1: Formulation of low-fat and low-sugar strained yoghurt.

Ingredients (%)	T ₀	T ₁	T ₂	T ₃	T ₄
Chakka	60	99.4	89.4	84.4	79.4
Sugar	40	NA	NA	NA	NA
Stevia	NA	0.6	0.6	0.6	0.6
Guava pulp	NA	NA	10	15	20

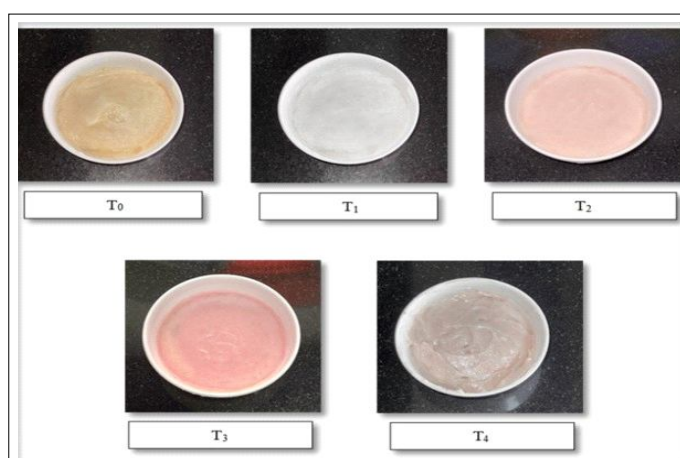


Fig 1: Low-fat strained yoghurt samples with sugar and stevia.

- I, 1980) reducing and non-reducing and total sugar content (Nelson-Somogyi) and fat content (Soxtron) of ingredients (chakka, pink guava pulp and stevia syrup) and strained yoghurt were estimated by standard methods.

Sensory analysis

A group of faculty members from the School of Food Technology formed a sensory evaluation panel to assess the quality of strained yoghurt samples (Fig 1). The samples were served to the panelists in a neutral environment, they were asked to evaluate all samples and rate them from 1 to 9 (hedonic rating), indicating their level of liking (dislike extremely to like extremely). The rating scale covered various aspects like colour, appearance, taste, flavour, texture and overall acceptability of the product. The ultimate score for each sensory property was determined by taking mean of the scores given by all the panelists.

Shelf-life assessment of formulated strained yoghurt

The low-fat (3.64%) and low-sugar (6.36%) strained yoghurt containing 0.6 % stevia and 10% guava pulp was selected based on highest sensory score and overall acceptability among all stevia-based samples and effect of packaging type (PP and PET) and storage period on total plate count, yeast and mould count and viable lactic acid bacteria count was assessed. The changes in acidity and pH were also noted during the storage.

RESULTS AND DISCUSSION

Physicochemical properties of ingredients and developed strained yoghurt

The physicochemical attributes are important to determine nutritive value, flavour and overall texture of strained yoghurt.

Physico-chemical properties of ingredients (Chakka, pink guava pulp and stevia) used in developing strained yoghurt are presented in Table 2. The data depicted in Table 3 outline the impact of incorporating guava pulp and stevia on the acidity, pH, TSS, total solids, fat and sugar content of strained yoghurt.

Acidity

The control sample containing sugar had the lowest acidity (0.99%), while the strained yoghurt made with stevia but no guava pulp had the highest acidity (1.27%). The acidity of strained yoghurt made with stevia and guava pulp was recorded as 1.21% (10% guava pulp), 1.18% (15% guava pulp) and 1.10% (20% guava pulp). The acidity is influenced by presence of lactic acid in the product (Melia *et al.*, 2021). Guava pulp had lower acidity (0.51%) as compared to chakka (0.84%) hence, increase in pink guava pulp level (0 to 20%) resulted in decreased acidity of strained yoghurt (1.27% to 1.10%). The higher acidity in strained yoghurt made with stevia but no guava pulp is due to the absence of guava pulp. These findings align with the results reported by Thakur *et al.* (2014), who observed a decrease in acidity with an increase in mango pulp content.

pH

The control sample with sugar had the highest pH level (4.23), while the strained yoghurt with stevia without guava pulp had the lowest pH level (3.79). The samples with both stevia and pink guava pulp (10, 15 and 20%) had 4.03, 4.13 and 4.16 pH, respectively. The increased pH (3.09 to 4.16) of stevia strained yoghurt could be due to decrease in acidity as the amount of fruit pulp increases. These findings align with the results reported by Shambharkar

Table 2: Physicochemical properties of ingredients.

Parameters	Chakka	Pink guava pulp	Stevia syrup
Acidity (%)	0.84±0.01	0.51±0.02	0.23±0.15
pH	4.47±0.03	3.45±0.05	5.96±0.24
TSS (°Bx)	5.66±1.15	10.33±0.58	ND
Total solids (%)	26.11±0.25	10.82±0.20	3.50 ± 0.01
Reducing sugar (%)	1.86±0.10	4.15±0.02	ND
Non-reducing sugar (%)	1.61±0.05	2.30±0.05	ND
Total Sugars (%)	3.48±0.11	6.45±0.06	ND
Fat (%)	3.01±0.13	0.74±0.04	ND

The values represent mean ± standard deviation of 3 replications. (ND=Not detected).

Table 3: Physicochemical properties of prepared strained yoghurt samples.

Treatment	Acidity (%)	pH	TSS (°Bx)	Total solids (%)	Reducing sugar (%)	Non reducing sugar (%)	Total sugar content (%)	Fat (%)
T ₀	0.99±0.01	4.23±0.06	37.00±1.00	78.46±0.64	3.84±0.07	33.92±0.25	37.77±0.19	3.53±0.105
T ₁	1.27±0.05	3.79±0.06	13.33±0.58	75.57±0.22	3.83±0.16	1.80±0.24	5.63±0.09	3.66±0.03
T ₂	1.21±0.05	4.03±0.21	13.66±0.58	74.83±0.46	4.55±0.11	1.81±0.16	6.36±0.07	3.64±0.026
T ₃	1.18±0.03	4.13±0.03	14.00±0.00	73.94±2.08	5.15±0.09	2.47±0.06	7.73±0.13	3.57±0.035
T ₄	1.10±0.02	4.16±0.06	14.33±0.58	72.64± 2.31	5.91±0.05	2.56±0.09	8.43±0.08	3.52±0.035
p-value	0.002	<0.01	<0.01	0.008	<0.01	<0.01	<0.01	0.04

The values represent mean ± standard deviation of 3 replications.

(2011), where increase in pH of strained yoghurt was observed with an increase in sapota pulp concentration.

TSS

TSS of strained yoghurt containing sugar stands at 37.00 °Bx, the highest among all the samples, due to the inclusion of sucrose. On the other hand, strained yoghurt with only stevia had the lowest TSS, measuring at 13.33 °Bx. The substantial TSS (37.00 °Bx) in strained yoghurt made with sugar is attributed to the presence of sucrose in the strained yoghurt mixture. Conversely, the reduced TSS in strained yoghurt with stevia (without guava- 13.33 °Bx, 10% guava pulp- 13.66 °Bx, 15% guava pulp- 14.00 °Bx and 20% guava pulp- 14.33 °Bx) can be attributed to the absence of sucrose in the formulation. Parallel findings were observed by Mane *et al.* (2019) when various artificial sweeteners were utilised as substitutes for sucrose.

Total solids

Strained yoghurt with sugar had the highest total solids content, with a percentage of 78.46%. Strained yoghurt with stevia without pulp follows behind with 75.57%, while strained yoghurt with stevia and 10% guava pulp and strained yoghurt with stevia and 15% guava pulp have percentages of 74.83% and 73.94%, respectively. The lowest percentage of total solids (72.64%) was found in strained yoghurt with stevia and 20% pulp. The reduced percentage of total solids in stevia and pink guava pulp as compared to chakka could be the reason for lower total solids content in strained yoghurt containing stevia and guava pulp.

Reducing sugar

The range of reducing sugar content varied from 3.84% to 5.91% in all strained yoghurt samples. The strained yoghurt with stevia without fruit pulp had the lowest reducing sugar content (3.84%) whereas, the strained yoghurt with stevia and 20 % pink guava pulp had the highest reducing sugar (5.91%). The findings (Table 3) revealed that with increase in proportion of pink guava pulp (10% to 20%), the reducing sugar content of strained yoghurt samples continued to rise (3.84% to 5.15%). This increase in reducing sugar content of strained yoghurt can be linked to higher fructose content found in fruits including guava (Ying *et al.*, 2020).

Non-reducing sugar

Non-reducing sugar content in strained yoghurt with sugar was the highest (33.92%). The lowest content of non-reducing sugar was found in strained yoghurt with stevia only (1.80%). The strained yoghurt sample with stevia and 10% pink guava pulp had the lowest non-reducing sugar (1.81%), among all the fruit pulp samples. Comparatively higher non-reducing sugar was observed in strained yoghurt with 15% guava pulp (2.47%) and 20% guava pulp (2.56%). The strained yoghurt containing stevia showed an increasing trend in the non-reducing sugar with increased percentage of guava pulp. However, the sugar percentage of all the treatments was significantly lower (1.80% to 2.56%) as compared to control (33.92%).

Total sugar

The strained yoghurt containing added sugar had the highest (37.77%) total sugar content. The lowest sugar content was found in strained yoghurt with stevia only (5.63%). The strained yoghurt sample with stevia and 10% pink guava pulp had the lowest sugar content (6.36%), among all the fruit pulp samples. Relatively higher total sugar content was observed in strained yoghurt with 15% guava pulp (7.73%) and 20 % guava pulp (8.43%). The strained yoghurt containing stevia showed an increasing trend in the total sugars with increased percentage of guava pulp. However, the total sugar percentage of all the stevia samples was significantly lower (5.63 to 8.43%) as compared to control (37.77%).

Fat content

The fat content (3.52 to 3.66%) in all the strained yoghurt samples was observed to be in the range of FSSAI standards to label a product as low-fat product (3-4%) that rightly justifies the use of ingredient formulation (double toned milk chakka, stevia, pink guava pulp) to make low-fat strained yoghurt. Strained yoghurt with sugar had a fat content of 3.53%, while strained yoghurt with stevia had slightly higher fat content (3.66%). Addition of guava pulp (10-20%) to strained yoghurt containing stevia in it, resulted in reduction in fat content (3.52-3.64%). Sameem *et al.* (2018) found similar trend in which the increased percentage of dragon fruit pulp caused a reduction in fat

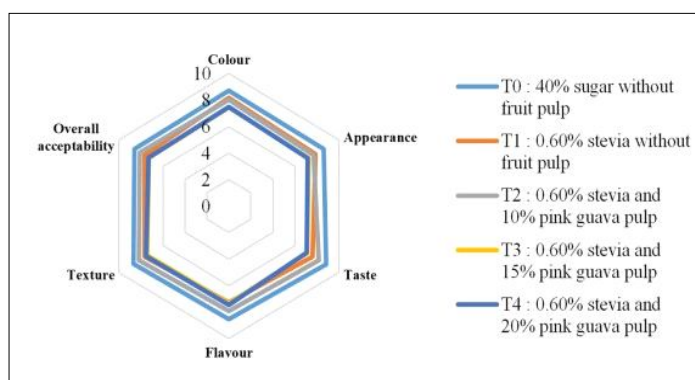


Fig 2: Sensory properties of low-fat and low-sugar strained yoghurt.

content of strained yoghurt. Kolape *et al.* (2010) also observed similar results.

Sensory profile of low-fat and low-sugar strained yoghurt

The results from the sensory evaluation of strained yoghurt samples are presented in Fig 2.

Colour

The control sample using sugar had the highest colour score (8.70). The colour score of strained yoghurt with stevia (8.18) and strained yoghurt with stevia and 10% pulp (8.00) reported higher acceptability (≥ 8) indicating the level of satisfaction experienced by the panellists in terms of the colour of these samples. The strained yoghurt with stevia without pulp, received the higher colour score (8.18) after control, *i.e.* strained yoghurt with sugar (8.70). This implies that the panellists found the colour of sample containing stevia be the most appealing among all the stevia strained yoghurt samples. Furthermore, strained yoghurt containing 10 % pulp recorded highest colour score (8.00) among guava pulp samples, that justifies its acceptability.

Appearance

The scores on appearance indicated that the visual appeal of strained yoghurt went on decreasing with rise in the quantity of pink guava pulp. Stevia strained yoghurt made

without pulp received the highest sensory score (7.86) for appearance after the control (8.61). This suggests that the panelists found the appearance of strained yoghurt with stevia without pulp to be the most appealing among all the strained yoghurt samples with stevia. Addition of pink guava pulp resulted in change of colour of the strained yoghurt thus the sensory scores of the treatments decreased as the level of pulp increased.

Taste

The average sensory rating of strained yoghurt sample with sugar was the highest (8.82) for taste. Remarkably, strained yoghurt with stevia and 10% pink guava pulp scored higher (8.16) after strained yoghurt with sugar (8.82), suggesting that adding pink guava pulp to the product improved its taste. Conversely, strained yoghurt which had 20 % pink guava pulp, obtained the lowest taste score (7.07). This indicates that 10 % pulp incorporation improved the taste of stevia strained yoghurt whereas further addition impaired it.

Flavour

The flavour score of strained yoghurt containing sugar was the highest (8.53). Among stevia samples, strained yoghurt containing 10% pulp had the highest flavour score (7.91) followed by 20% pulp sample (7.45). The lowermost score

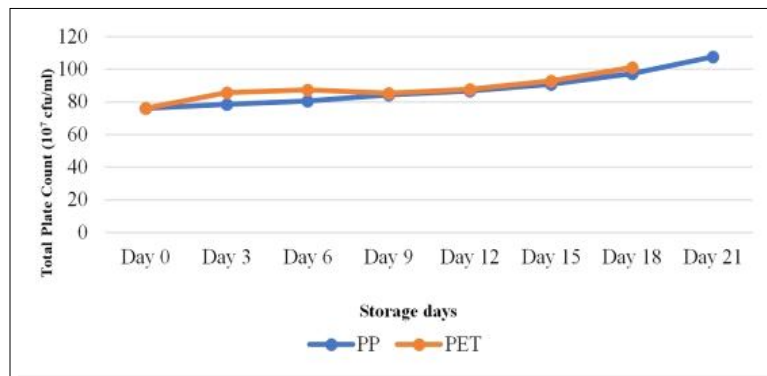


Fig 3: Effect of packaging material and storage days on total plate count of strained yoghurt.

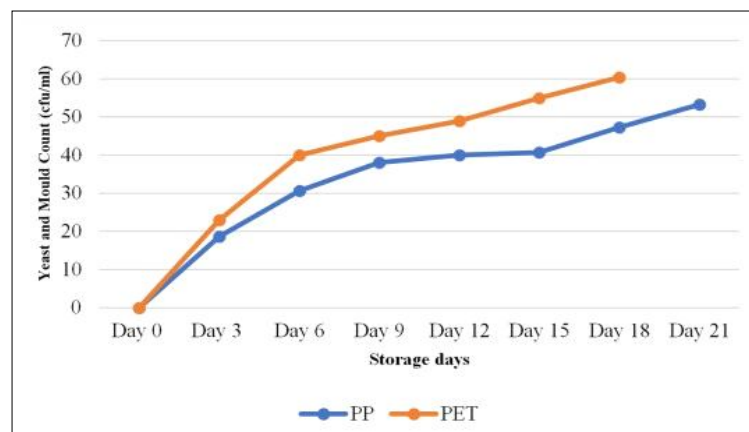


Fig 4: Impact of packaging material and storage days on yeast and mould count of strained yoghurt.

(7.28) for flavour was observed for strained yoghurt with stevia but without fruit pulp. The results revealed a pleasing effect of incorporating 10% pink guava pulp in stevia strained yoghurt.

Texture

The stevia strained yoghurt with 10% guava pulp received the highest score (8.19) for texture after strained yoghurt with sugar (8.70). On the other hand, strained yoghurt with 15% pink guava pulp received the lowest sensory score (7.43). It is a possibility that 10% fruit pulp in combination with 0.6% stevia and 89.4% chakka presented perfect balance in strained yoghurt formulation resulting in improved texture.

Overall acceptability

The strained yoghurt containing stevia and 10% guava pulp has recorded highest overall acceptability (8.09) after control (8.60). The strained yoghurt with stevia and 15% pink guava pulp had the lowest overall acceptability (7.28) followed by strained yoghurt with 20% guava pulp (7.30). The overall acceptability of strained yoghurt with stevia without fruit pulp was 7.66. Among all samples containing stevia in their formulation, the sample with 10% guava pulp

comes out on top with the highest overall acceptability (8.09).

Shelf-life estimation of developed strained yoghurt

The effect of storage and packaging on total plate count, yeast and mould, viable lactic acid bacteria and coliform count were assessed and presented graphically in Fig 3 to Fig 7.

Total plate count

The significant increase in total plate count of strained yoghurt was recorded throughout the storage tenure of 18 days (Fig 3). After 18 days, TPC of low-fat and low-sugar strained yoghurt was increased from 76.00×10^7 cfu/ml to 97.33×10^7 cfu/ml when stored in PP containers, whereas more increase in TPC was recorded in strained yoghurt stored in PET containers (101.00×10^7 cfu/ml). This could be because of the poor gas barrier properties of PET as compared to polypropylene (Packaging Gateway, 2004). Total plate count was found to be within acceptable limit (100×10^7 cfu/ml) for 18 days in strained yoghurt packed in PP container (97.33×10^7 cfu/ml) and 15 days in a PET container (93.00×10^7 cfu/ml). The similar results were reported by Kolape *et al.* (2010).

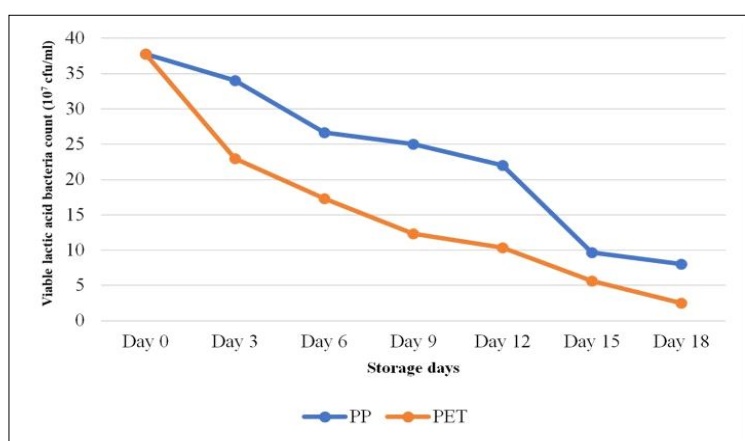


Fig 5: Impact of packaging material and storage days on viable lactic acid bacteria count of strained yoghurt.

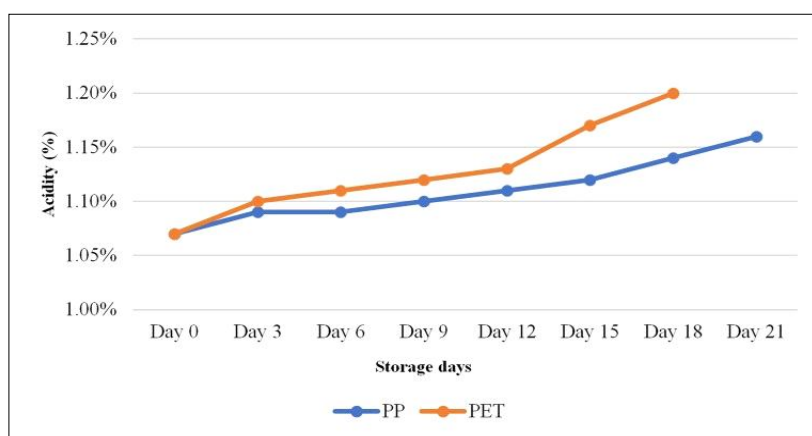


Fig 6: Impact of packaging material and storage days on acidity of strained yoghurt.

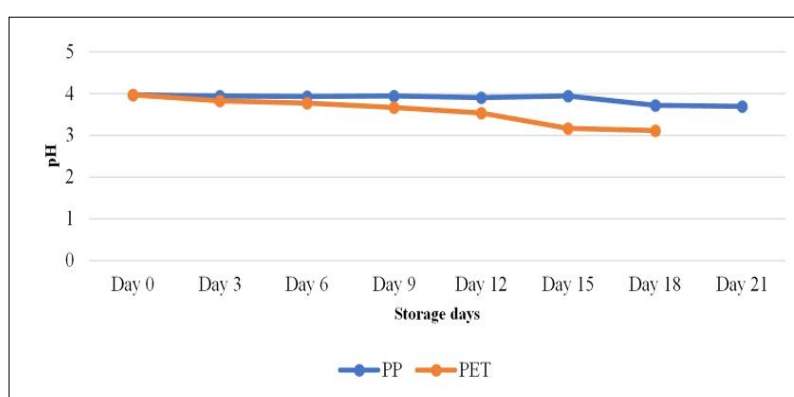


Fig 7: Impact of packaging material and storage days on pH of strained yoghurt.

Yeast and mould

The yeast and mould (YM) count recorded increasing trend from day 3 (PP- 18.67 cfu/ml and PET- 23.00 cfu/ml) in both the packaging materials (Fig 4). The substantial increase was observed for PET (60.33 cfu/ml) as compared to PP (47.33 cfu/ml) at day 18. The YM remained within the permissible limit laid down by the FSSAI (50 cfu/ml) in strained yoghurt packed in PP and PET up to 18 days (47.33 cfu/ml) and 12 days (49.00 cfu/ml), respectively. Poor moisture barrier properties of PET have played a critical role in the growth of yeast and moulds which resulted in spoilage after 9 days. The similar observations were reported by Rai *et al.* (2018) where yeast and mould did not exceed the maximum limit set by FSSAI till day 15.

Viable lactic acid bacteria (LAB)

Viable LAB count was decreased significantly from 37.80×10^7 cfu/ml to 8.00×10^7 cfu/ml in PP containers and to 2.53×10^7 cfu/ml in PET containers on 18th day of storage (Fig 5). It was found to be within the normal range (PP- 22.00×10^7 cfu/ml and PET- 10.33×10^7 cfu/ml) for 12 days as per FSSAI guidelines (viable count $> 10^8$ cfu/ml). The similar results are reported by Jadhav *et al.* (2019).

Coliforms

Coliforms were not traced in the strained yoghurt of samples packed in both PP as well as PET containers throughout the storage tenure.

Acidity

The significant increase in acidity (from 1.07% to 1.14% in PP containers and 1.20% in PET containers on 18th day) was recorded during entire storage period of strained yoghurt (Fig 6). The increased acidity of strained yoghurt throughout the storage could be attributed to fermentation of lactose sugar by probiotic micro-organisms present in strained yoghurt matrix causing increase in the percentage of lactic acid (Sivasankari *et al.*, 2017). Strained yoghurt packed in both PP and PET containers remained within acceptable limits of acidity ($< 1.4\%$) throughout the storage tenure as per FSSAI guidelines.

pH

The decrease in pH (from 3.97 to 3.72 in PP containers and 3.12 in PET containers) of strained yoghurt can be correlated with rise in acidity of strained yoghurt (Fig 7). The pH of strained yoghurt packed in PP containers remained in acceptable limit throughout the storage tenure (FSSAI limits- 3.50).

CONCLUSION

Consumers are increasingly conscious of their dietary intake and are looking for healthier options that do not compromise on taste. Strained yoghurt made with low fat chakka (89.40%), stevia (0.60%) and pink guava (10%) projected acceptable sensory properties (colour- 8.00, appearance- 7.70, taste- 8.16, flavour- 7.91, texture- 8.19, overall acceptability- 8.09) and lower level of sugars (non-reducing- 1.81%, total sugar-6.36%) and fat content (3.64%). This makes it an ideal choice for those who want to indulge in a sweet treat without feeling guilty about the calorie intake. Low-fat and low-sugar strained yoghurt stored at $4 \pm 1^\circ\text{C}$ in PP containers exhibited a shelf-life of 18 days against 12 days as in case of strained yoghurt stored in PET containers.

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Disclaimers

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Informed consent

NA

Conflict of interest

The authors declare that there are no conflicts of interest regarding the publication of this article. No funding or sponsorship influenced the design of the study, data collection, analysis, decision to publish, or preparation of the manuscript.

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