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Preparation and Nutritional Evaluation of Soursop Juice as Partial Replacement for Dairy Milk in Yoghurt Production

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ABSTRACT: Nowadays, virtually all major food stores offer a wide selection of plant-based milks made from almonds, oats, cashews, macadamia nuts, coconut and our old friend, the soy-bean. These forms of milk are typically lower in calories than dairy milk, and they do not contain saturated fat. Consequently, the objective of this paper is to investigate the preparation and nutritional evaluation of soursop juice milk as partial replacement for dairy milk in yoghurt production using appropriate standard methods. Data obtained shows that yoghurt enriched with soursop juice received a colour score of 7.57, which was slightly higher than that of plain cow milk yoghurt, indicating a positive contribution to colour acceptability. Aroma and taste ratings for soursop-supplemented yoghurt were above 7, placing them in the "I like it" category, suggesting favourable sensory attributes. Furthermore, it achieved an overall acceptability score of 7.00, indicating strong consumer preference and potential market appeal. The addition of soursop juice provided additional nutritional value, including increased dietary fibre and ash content of 1.98 and 2.00 respectively. This enrichment may offer enhanced health benefits compared to plain cow milk yoghurt. The presence of dietary fibre from soursop juice improved the stability of the yoghurt, reducing whey separation and enhancing texture. This suggests that the addition of soursop juice contributes to a more stable and desirable product. Soursop juice enhances the sensory attributes, nutritional profile, and stability of yoghurt compared to plain cow milk yoghurt. These improvements suggest that yoghurt with soursop juice may offer a competitive edge in the market, appealing to consumers seeking both better taste and nutritional benefits.

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Yoghurt is a widely consumed dairy product produced by the fermentation of milk using a starter culture comprised of lactic acid bacteria, specifically *Lactobacillus delbrueckii subsp. bulgaricus* and *Streptococcus thermophilus*. This fermentation process leads to the production of lactic acid. Since yoghurt is recognized as a significant source of probiotics, it can be categorized as a functional food. Functional foods are identified as contemporary food products formulated to contain substances or probiotics that may offer health-promoting or disease-preventing benefits. These substances or probiotics are

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included at concentrations that are safe and adequate with the end result of achieving the intended health benefits. Additional ingredients may encompass nutrients, dietary fibre, phyto-chemicals, and other bioactive substances or probiotics (Norman Temple, 2022)

As a functional food, yoghurt have positive effects on immune, cardiovascular or metabolic health (El-Abbadi *et al.,* 2014; Gijsbers *et al.,* 2016; Facioni *et al.,* 2020). The bacteria used to make yoghurt are known as yoghurt cultures and the fermentation of sugars in the milk by these bacteria produces lactic acid which acts on milk protein to give yoghurt its texture and characteristic pleasant sour taste (US Food and Drug Administration 2016). A good strain of starter culture not only influences the flavour and aroma, it can also speed up the process, reduce the production costs of yoghurt, and improve the nutritional benefits of the yoghurt (Abou-Dawood *et al.,* 2013)

Fruits are an important and necessary part of the human balanced diet which are considered as dietary supplements due to their crucial role in promoting physical health. In addition to their health benefits, fruits are rich in various organic, inorganic, and bioactive compounds, also rich in moisture, carbohydrates (Ndife *et al.,* 2014; Zahid A. & Khedkar R., 2022). Herbal-based remedies have been used since ancient times, and in recent years, scientists have renewed emphasis in studying the biological activities of plants due to the importance of plant-derived active compounds in agriculture and medicine (Kumari *et al.,* 2021; Moghadamtousi *et al.,* 2015).

Soursop has gained significant popularity because of its rich nutritional profile (Chang *et al.,* 2018; Menezes *et al.,* 2019). *Annona muricata*, commonly known as soursop or custard apple, belongs to the Annonaceae family. Species in this genus share common traits, including root growth, wood structure, xylem, flowering, fertilization, fruit development, and seed type (Tiencheu *et al.,* 2021). The soursop tree sprouts in warm climates across Europe, Africa, United States of America, and India. The fruit germinated is vibrant green, spiky, round, and known for its sweet, sour, creamy, and delicious taste (Gyesi *et al.*, 2019). It is essential to understand the high post-harvest respiration rate of soursop, as well as its maturation process and appropriate maturity indicators before the crop can be cultivated. The fruit has a short shelf life, which makes it prone to senescence, and it is not suitable for further processing (Chang *et al.,* 2018). However, soursop is gaining attention due to its bioactive compounds with nutraceutical properties. The pulp is an excellent source of fibre and contains various compounds that may offer health benefits when consumed in moderation. For instance, the polyphenols in soursop are natural antioxidants that help protect cells from damage caused by free radicals (González *et al.,* 2017). Over 200 bioactive compounds, mainly alkaloids, phenols, and acetogenins, have been identified in the plant (Gyesi *et al.,* 2019). Soursop phytochemicals have long been used in herbal medicine to treat parasitic and bacterial infections, fever, hyperglycemia, hypertension, inflammation, anxiety, and cancer which is due to its antibacterial, anti-protozoan, anti-inflammatory, anti-oxidant, and anti-tumor properties. Research has shown that soursop extract exhibits these several properties - antibacterial, anti-protozoan, anti-inflammatory, etc., in various scientific studies (Gyesi *et al.,* 2019). Therefore, the objective of this paper is to investigate the preparation and nutritional evaluation of soursop juice as partial replacement for dairy milk in yoghurt production.

MATERIALS AND METHODS

Sample Collection and Preparation: The study was conducted in Edo South L.G.A of Edo States, Nigeria. To conduct this research, a range of consumable and non-consumable materials were used. The consumable ones include: soursop fruit, powdered cow's milk, starter culture, and water; whereas the non-consumables include: blender, table spoon, beaker, refrigerator and incubator. 10 pieces of matured and fresh soursop fruit, Peak powdered milk, and 1L of Tito unsweetened dairy yoghurt were bought from Oba Market, Benin City. Since the moisture content present in the soursop fruits is relatively high, the fruits were purchased the same day the production took place. The powdered milk was stored at room temperature until used while the dairy yoghurt was stored under refrigerated temperature. All reagents used for chemical analysis were of analytical grade.

Preparation of Soursop Juice: Matured and fresh soursop fruits were washed with clean water, hand-peeled, cut, and de-seeded (removal of the seeds). One hundred (100g) grams of the pulp was blended with 1000ml of distil water using an electric blender severally. The pulp was filtered using muslin cloth to obtain soursop juice.

Preparation of Yoghurt: 100 g of full cream powdered milk (Peak, WAMCO Co, Holland) was diluted in 1litre of distilled water each and labelled sample A and B. 200ml of soursop purée was measured using a volumetric flask into a sample bottle and labelled B. The liquid cow milk (A) and the composite cowmilk and soursop yoghurt (Sample B) were separately pasteurized (85°C) for 15 minutes, homogenized and cooled at 44°C. The samples were inoculated with

0.44% yoghurt culture (50%:50% mixture of *Lactobacillus bulgaricus* and *Streptococcus thermophillus)* at 44°C. The two samples were inoculated in a thermostatic bath at 44°C for 7hours, and allowed to cool by refrigerating. This process resulted in two yoghurt samples A and B. The two samples were taken to the laboratory for analytical tests.

Physicochemical Analysis

Determination of pH: The pH of cow milk yoghurt flavoured with soursop juice in different proportions was determined using the method described by AOAC (2022). The pH E201 meter was calibrated by rinsing the electrode with de-ionized water. Afterwards, the electrode was wiped dry before using it for analysis by inserting the electrode in the sample and left for 2-4 minutes until a stable value was noticed on the digital display of the pH meter.

Determination of Total Titratable Acidity: The total titratable acidity (TTA) of cow milk yoghurt flavoured with soursop juice in different proportions was determined using AOAC (2022) method. Exactly 2.5 ml of the sample was measured into a conical flask and diluted with 7.5ml of distilled water. Three (3) drops of phenolphthalein indicator was added to the sample and the diluted yoghurt sample was titrated against 0.1N sodium hydroxide (NaOH) until a pink end point was observed. The titre value at the end point was noted. The TTA was calculated as percentage (%) using the acid factor of lactic acid for each soursop flavoured yoghurt sample (0.009).

$$\%TTA = \frac{\mathrm{ML(NaOH)\ x\ N(NaOH)\ x\ 0.09\ x\ 100}}{\mathrm{Volume\ of\ Sample}} \quad (1)$$

Where; TTA=Total Titratable Acidity; ML=Volume; N=Normality of NaOH; 0.09= Equivalence Factor.

Proximate Analysis: This test was carried out to determine the major constituents of sample yoghurt and to verify if the sample yoghurt are within its specified parameters. This analysis partition food into six (6) different components: crude protein, crude fibre, moisture, ash content, crude fat and carbohydrates. Proximate constituents were determined in triplicates using Standard methods of the Association of Official Analytical Chemists (A.O.A.C., 2022).

Sensory Evaluation: The method described by Olugbuyiro and Oseh (2011) was adopted. Two labelled samples of soursop supplemented yoghurt and plain cow milk yoghurt were presented to ten sensory panellists to evaluate the samples on a 9-point Hedonistic scale based on their personal opinion on each sensory attribute of the supplemented and non-supplemented yoghurt. In the sensory evaluation form, there is provision for additional comments which is optional. Potable water inside a transparent glass cup was provided for the sensory panellists to rinse their mouth before evaluating each sample.

Statistical Analysis: All the determinations were done in triplicates and a mean value was calculated in each case. Analysis of variance (ANOVA) was performed and separation of the means was by Duncan's Multiple Range Test, significant difference was accepted at $p<0.05$ using SPSS version 21.0.

RESULTS AND DISCUSSION

The research combines empirical nutritional data with economic analysis to provide a comprehensive overview of the health benefits and market potential of soursop. It examines the effects of incorporating soursop juice into yoghurt and compares its properties with those of plain cow milk yoghurt. The addition of soursop juice was evaluated for its impact on sensory attributes, nutritional content, and product stability. Yoghurt enriched with soursop juice received a colour score of 7.57, which was slightly higher than that of plain cow milk yoghurt, indicating a positive contribution to colour acceptability. Aroma and taste ratings for soursop-supplemented yoghurt were above 7, placing them in the "I like it" category, suggesting favourable sensory attributes. Furthermore, it achieved an overall acceptability score of 7.00, indicating strong consumer preference and potential market appeal. The addition of soursop juice provided additional nutritional value, including increased dietary fibre and ash content of 1.98 and 2.00 respectively.

Physiochemical Analysis: Physiochemical composition of the two yoghurt samples are shown in Table 1. Sample A has low pH value of 3.18 and a low TTA value of 0.28%, while sample B has an increased pH and TTA value of 4.13 and 0.77% respectively.

Table 1: physicochemical properties of prepared yoghurt

Samples (%)	pH	TTA	TSS
Sample A	3.18 ± 1.00	0.28 ± 0.40	19.10±5.74
Sample B	4.13 ± 0.05	0.77 ± 0.01	16.50 ± 0.60

Values are means ± standard deviations of triplicate determinations. Values in the same row sharing the same letters are significantly different (p<0.05 level); the superscript alphabets "a-c" separates the means obtained from ANOVA using Duncan's Multiple Range Test.
Sample A – 100% Cow Milk: 0% Soursop Juice
Sample B – 80% Cow Milk: 20% Soursop Juice

Total Titratable Acidity (TTA) and pH are key indicators of yoghurt quality. A study by Virgen-Ceceña *et al.* (2019) noted the pH of soursop yoghurt as 4.08, and when compared to cow milk yoghurt, significant differences in acidity were found. Cow milk yoghurt had a TTA of 0.28% and a pH of 3.17, indicating higher acidity. In contrast, soursop-supplemented yoghurt had a higher pH of 4.13, suggesting lower acidity due to the buffering effect of soursop purée. According to Codex (2018), plain yoghurt should have 0.50% lactic acid and a pH under 4.5, aligning with these findings. The addition of soursop impacted the acidity and pH, with potential improvements in taste and texture while maintaining acceptable acidity levels (KO Amanze & Amanze, 2024; Arab *et al.*, 2022).

Proximate Analysis: The proximate composition of the sample yoghurt is shown in Table 2. Sample B has high carbohydrate and protein content – 10.51% and 3.72%, while sample A has a relatively low carbohydrate and protein content – 7.73% and 3.66% respectively. The ash content was significantly higher in sample B (1.98%) than in sample A (0.64%).

Table 2: proximate composition of prepared yoghurt

Samples (%)	Carbohydrates	Protein	Fat	Ash	Crude Fibre	Moisture Content
Sample A	7.73±0.56[a]	3.66±0.10[a]	5.15±0.10[c]	0.64±1.50[a]	0.22 ± 1.00[c]	83.69±0.02[c]
Sample B	10.51 ± 0.24[a]	3.72 ± 0.03[b]	7.14 ± 0.24[a]	1.98 ± 0.05[b]	2.00±0.18[b]	90.11 ± 0.65[c]

Values are means ± standard deviations of triplicate determinations. Values in the same row sharing the same letters are significantly different (p<0.05 level); the superscript alphabets "a-c" separates the means obtained from ANOVA using Duncan's Multiple Range Test. Sample A – 100% Cow Milk: 0% Soursop Juice; Sample B – 80% Cow Milk: 20% Soursop Juice

According to Codex (2018), yoghurt supplemented with soursop purée has a higher crude fibre content compared to cow milk yoghurt. This was also observed in this study whereby yoghurt supplemented with soursop juice and the cow milk yoghurt has a crude fibre of 2.00 and 0.22 respectively. This suggests that the soursop-enriched yoghurt may act more effectively as a probiotic, aiding in the maintenance of a balanced gut micro-biota and supporting overall digestive health. Additionally, the increased fibre content may impact the absorption of certain minerals. The carbohydrate level in soursop-supplemented yoghurt is 10.51 while that of cow milk yoghurt is 7.73. This indicates that; higher carbohydrates mean more energy and calories, which can benefit consumers needing extra energy, enhanced flavour from soursop making the yoghurt more appealing. Additionally, the carbohydrates, especially dietary fibre, support digestive health by aiding regular bowel movements and gut function. The higher carbohydrate content can also affect the yoghurt's glycemic index, which is important for managing blood sugar levels. The yoghurt supplemented with soursop juice has a higher ash content, this signifies that there is the presence of high concentration of minerals and inorganic substances in the yoghurt.

Sensory Properties: The sensory properties of the yoghurt samples are shown in Table 3. The sensory evaluation scores for colour, appearance, taste, aroma, mouth-feel, and overall acceptability ranges from 5.80 – 7.57, all above the mean score of 5 for the 9-points hedonistic scale used. The two samples were accepted by the consumers, Sample B was significantly preferred to Sample A in terms of colour, taste, aroma, appearance, mouth-feel, and overall acceptability.

Table 3: sensory properties of prepared yoghurt

Samples (%)	Colour	Appearance	Aroma	Taste	Mouth-feel	Overall Acceptability
Sample A	7.30±0.01[b]	7.00±1.05[b]	5.80±1.23[a]	7.37±0.01[a]	7.37±0.01[a]	6.43±0.01[a]
Sample B	7.57±1.06c	7.70±1.16[b]	6.30±0.82	8.90±0.57	7.50±0.85c	7.00±1.05[b]

Values are means ± standard deviations of triplicate determinations. Values in the same row sharing the same letters are significantly different (p<0.05 level); the superscript alphabets "a-c" separates the means obtained from ANOVA using Duncan's Multiple Range Test. Sample A – 100% Cow Milk: 0% Soursop Juice; Sample B – 80% Cow Milk: 20% Soursop Juice

The sensory qualities of yoghurt can be enhanced by incorporating fruit products (Çam *et al.*, 2013; Lutchmedial *et al.*, 2004). Yoghurt with added soursop purée received a colour score of 7.57, slightly higher than plain cow milk yoghurt, indicating that soursop purée positively influenced the colour appeal of the yoghurt (Çam *et al.*, 2013; Lutchmedial *et al.*, 2004). Judges rated the aroma and taste of the soursop-supplemented yoghurt above 7, which falls within the "I like it" range. The addition of soursop purée also improved the stability of the yoghurt, likely due to its dietary fibre content (Rodríguez *et al.*, 2006). Overall, the soursop-supplemented yoghurt had a good acceptability rating of 7.8, suggesting it could perform well in the market.

Conclusion: Yoghurt enriched with soursop juice offers several advantages over plain yoghurt, including improved colour, aroma, and taste. The soursop-supplemented yoghurt scored higher in sensory evaluations, particularly in colour and flavour. Its dietary fibre content supports digestive health and may influence the yoghurt's glycemic index. Additionally, soursop juice enhances the yoghurt's stability by reducing whey separation and improving texture. Overall, this yoghurt is both a functional food and an energy-boosting beverage, with high consumer acceptability and potential for market success.

DECLARATIONS

Declaration of Conflict of Interest: The authors declare no conflict of interest.

Data Availability Statement: Data are available upon request from the first author in person of Akemien, N.N.

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