Dairy-based Drinking Yoghurt Enriched with Monkey Orange Fruit: Product Development and Consumer Acceptability in South Africa

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Abstract

There has been a growing interest in developing innovative dairy products that combine nutrition, flavour, and health benefits. One such product involves Strychnos spinosa, commonly known as monkey orange, an indigenous fruit that grows predominantly along the coast of KwaZulu-Natal in the Republic of South Africa. Despite its impressive nutritional benefits, the monkey orange fruit remains underutilised. This study assessed the acceptability and willingness to purchase a monkey orange-enriched drinking yoghurt. The study was conducted in two phases: product development and consumer acceptability testing. A total of 60 participants were conveniently selected to evaluate the product. Each participant rated the dairy-based monkey orange enriched drinking yoghurt using two standardised scorecards: a 9-point hedonic scale to measure sensory attributes and a food action rating scale to assess consumption preferences. The findings revealed notably positive results. On the food action rating scale, over 50% of respondents were willing to consume the product occasionally. While the results suggest that commercialising this indigenous dairy-based fruit-enriched drinking yoghurt is promising, further research is essential to address critical aspects such as optimising production and developing effective market introduction strategies to ensure long-term success.

Keywords: Monkey orange, Strychnos spinosa, consumer acceptability, indigenous fruit, value-added

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Introduction

Indigenous wild crops have historically played a significant role across Africa; they serve as essential sources of food for humans and animals while providing medicinal benefits. Furthermore, these crops are particularly valued for their exceptional drought tolerance and superior nutritional profiles compared to conventional fruits. These indigenous wild crops usually grow in rural areas; hence, they are utilised mostly by the rural communities as well as foragers. However, there is a paucity of literature to provide substantial information on these indigenous crops. Due to indigenous plants not being at the forefront of research and commercialisation, they have remained underutilised (Omotayo & Aremu, 2021). Similarly, despite the nutritional benefits of indigenous fruits, they remain underutilised and under-consumed, implying that the nutritional (macro and micronutrient) benefits are not maximised by vulnerable groups (Rayne et al., 2022). Minerals and vitamins are vital elements that the human body requires for the proper functioning of the system. Thus, incorporating Indigenous fruits into daily diets has been recommended for optimum well-being. Given their significant nutritional value, the consumption of these fruits should become a societal norm to improve overall health and well-being. Studies have shown that monkey orange has numerous health benefits due to its high concentration of essential minerals and phytochemicals (Omotayo & Aremu, 2021). The fruit contains bioactive compounds, including phenolics, flavonoids, and ascorbic acid, contributing to the antioxidant properties (Lubisi et al., 2025). Although the monkey orange antioxidant content reduces as the fruit ripens, it is noted for its high vitamin C content, which helps boost immunity and is beneficial in fighting oxidative stress and chronic disease. Beyond the nutritional value, monkey orange has been investigated for potential pharmaceutical applications, with the bioactive compounds exhibiting antimicrobial and anti-inflammatory properties (Thothela et al., 2025). Research also suggests that the fruit, bark, and leaf extracts are notable for their therapeutic properties to treat bacterial infections, malaria, and gastrointestinal disorders (Thothela et al., 2025). This underlines the importance of the health-benefiting components associated with monkey orange. The fruit can be consumed raw, and in certain regions of Africa, value-added products such as powders, juices, and jams have been developed from monkey orange (Rayne et al., 2022; Ngadze et al., 2019). Fermented foods and beverages have been one of the leading functional foods. Functional foods are considered to have certain scientifically proven beneficial components to improve the health of the human body (Mudgil & Barak, 2019). Milk-based fermented beverages are one of the socially accepted functional food products due to their nutritional content, especially for gut health regulation amongst other health benefits (Hasegawa & Bolling, 2023; Mudgil & Barak, 2019). The functionality of these beverages is due to the presence or fortification of certain bioactive or functional components (Mudgil & Barak, 2019; Zhao et al., 2021). Probiotic yoghurt is valued for its high nutritional value because it contains calcium, zinc, and Vitamin B (Sarkar, 2019). There has been limited research on innovative food products, like dairy-based beverages enriched with monkey orange. This creates an opportunity for advancing food product innovation, especially in terms of food processing techniques and enhancing consumer acceptance.

Exploring the potential of functional foods could create new opportunities for incorporating underutilised ingredients such as the monkey orange into daily diets, thereby promoting both dietary diversity and food innovation. This study seeks to address the knowledge gap regarding the potential of Indigenous food crops, particularly monkey orange, as commercially viable and nutritionally valuable food sources; however, this fruit remains underutilised due to limited research and its commercialisation. This study seeks to address this gap by exploring the broader applications of monkey orange and its potential role in improving dietary diversity and addressing micronutrient deficiencies. To enhance the consumption of monkey orange fruit among young adults and improve dietary diversity through an innovative food product, a dairy-based monkey orange-enriched drinking yoghurt was developed, and consumer acceptability was assessed.

Literature review

Monkey orange (*Strychnos spinosa*) is a Southern African Indigenous, naturally occurring fruit that grows mostly in the wild, with little or no maintenance. The *Strychnos spinosa* is a fruit-bearing species that belongs to the Loganiaceae family (Omotayo and Aremu, 2021). The tree grows in warmer climatic regions, and it is adaptive to temperature, and can withstand tropical heat, making it climate resistant as well as adaptive. In South Africa, the monkey orange fruit grows mainly in four provinces: KwaZulu-Natal, Limpopo, Mpumalanga and the Eastern Cape. The fruit thrives in these warmer climates, specifically in Zululand. The recent interest in utilising this indigenous fruit is owing to its outstanding nutritional composition and climate resilience. Monkey orange fruit contains various minerals and vitamins and has a unique flavour profile. The fruit contains phytochemicals essential for wellbeing, such as flavonoids and phenolic acids, with health-promoting properties, including antioxidants, anti-ageing and anti-inflammation benefits (Omotayo & Aremu, 2021; Mashau & Tshishonge, 2024). According to Zmora et al., (2017), the nutritional status of an individual directly affects the immune cell metabolism and function. Therefore, the phytochemicals, including flavonoids and polyphenols that are available in the monkey orange fruit, have been identified to modulate the immune system, leading to improved health outcomes (Kimondo, 2022; Yahfoufi et al., 2018). Furthermore, the antioxidant properties have been investigated to play an important role in reducing oxidative stress (Omotayo and Aremu, 2021). Therefore, the nutritional content of the Monkey orange fruit can contribute towards improving the nutritional status and thus enhancing the immune system of vulnerable groups experiencing nutrient deficiencies. Local edible wild fruits, like monkey orange fruit, can increase food security and help alleviate micronutrient deficiencies (Omotayo & Aremu, 2021). In addition to the nutritional benefits, the fruit also has diverse health-promoting benefits, including the management of non-communicable diseases and sexually transmitted infections among different ethnic groups in Africa (Aremu et al., 2022). Indigenous wild crops in Africa, including monkey orange, remain significantly under-researched, and there are limited scientific studies on the potential benefits. The fruit is versatile as it can be consumed unprocessed as a snack or processed into products such as juice and jams and even used as an ingredient in desserts and puddings (Rayne et al., 2022; Ngadze et al., 2019). However, the seeds must be avoided as they are known to be toxic to humans (Ngadze et al., 2019). The exterior shell of the fruit is green when unripe and turns various shades of yellow as it ripens. Typically, the fruit is harvested while still unripe and buried under sand to expedite the ripening process. This method, which can take several months, is preferred as it helps prevent postharvest losses (Mbhele et al., 2022; Mashau & Tshishonge, 2024).

The process of value addition and food processing directly affects the utilisation and shelf life of underutilised crops. Substitution of existing ingredients or the addition of new ingredients can improve the overall acceptability (Ngadze, 2028). This not only enhances the nutritional value and marketability of the crops but also contributes to food security and economic development. Some rural households already use and process the fruit by making juices or adding it to porridge (Ngadze et al., 2019). The pulp can be frozen or dried to extend shelf life (Avakoudjo et al., 2019). This shows the versatility of the fruit and the potential for innovative product development. The formulation of a dairy-based drinking yoghurt, incorporating monkey orange fruit, is expected to yield a distinctive product that meets consumer demands. Yoghurt is one of the most popular fermented milk products that is socially acceptable and commonly consumed across all age groups. It uses “good” bacteria, namely Streptococcus thermophiles, Bifidobacterium and Lactobacillus acidophilus, which were used in the production of the prebiotic yoghurt for this study (Hadjimbei et al., 2022). Yoghurt provides essential minerals and vitamins that aid in ensuring proper bodily functions. Probiotic yoghurt contains live microorganisms intended to maintain or improve the “good” bacteria in the digestive tract and throughout the body. It is also valued for its high nutritional value because it contains calcium, zinc, and Vitamin B (Sarkar, 2019; Hadjimei et al., 2022). Gut health has also been a topic of note in recent years as various health issues have emerged, and the root cause has been pointed towards poor gut health (Mudgil & Barak, 2019). Fermented cost-sustainable protein functional foods have been tasked with solving this issue, especially among young people (Tachie et al., 2024). Fermented drinks like probiotic yoghurt have already established a place for themselves in the market, adding value to them by using underutilised crops that are nutrient-rich to make the product stand out in the market for improved food and nutrition security. Evolving with the food trends is the incorporation of dairy products with indigenous crops since they are known for being nutrient-dense and climate-resistant (Omotayo et al., 2020). The nutritional value of the fruit when paired with another equally nutritious food item, in this case, probiotic yoghurt, can result in additional health benefits and improved nutritional value. Therefore, incorporating the fruit into a dairy-based beverage will enhance the nutritional properties, resulting in a functional food product.

Although diverse fruits, including monkey orange, are nutritious, a significant barrier to the consumption and knowledge of indigenous fruits is identified as a challenge to their limited accessibility. These fruits are not widely available in mainstream markets, which contributes to their relative obscurity despite their low maintenance, high yield, and affordability (Omotayo & Aremu, 2021; Ngadze et al., 2019). Many indigenous wild fruits and vegetables have long been stigmatised and perceived as "poor man's food" (Qwabe & Pittaway, 2023), leading young adults to disregard these foods to avoid these negative associations. Introducing these fruits in value-added products may be more appealing and acceptable to the youth, thereby overcoming the stigma and encouraging broader acceptance and consumption (Omotayo & Aremu, 2021). This study aligns with a growing trend in South Africa, where research and the integration of indigenous fruits into popular food products have gained momentum. Since the youth have been conditioned with high sugar, fat, and sodium foods, the product developed needs to meet those expectations to have a place in the market (Agulanna, 2020). The dairy-based drinking beverage enriched with Monkey orange fruit developed in this study seeks to improve consumer acceptability and willingness of young adults to consume the fruit in an innovative way that also follows current trends. The outcomes of this study will assess the product's acceptability and its potential for commercialisation. Recent studies utilising Indigenous fruits are reported in Table 1. Similar challenges and opportunities exist in the current study, which is further explored in the discussion section of this article.

Table 1: Food products made with indigenous fruits

Study title	Reference	Indigenous Fruit	Food product	Key findings
Effect of using dried white sapote fruit (*Casimiroa edulis*) on the quality characteristics of bio-low-fat goat milk yoghurt drink	Elkot et al., 2023	White sapote fruit (*Casimiroa edulis*)	Bio-low-fat goat milk yoghurt drink	The rheological properties of the resulting bio-yoghurt drinks were greatly improved by the total solids of the yoghurt that were added to the mixture.
Formulation of functional beverage from a blend of baobab (adansonia-digitata), pineapple (comosus ananas) and black-plum (syzygium cumini) fruits	Adedokun, 2023	Baobab (adansonia-digitata)	Functional beverage	Baobab-pineapple-black plum juice blends showed the presence of micronutrients and phytochemicals that establish their potential to improve health when consumed. Juice blends of baobab, pineapple, and black-plum fruits synergistically increased the antioxidant potential and mineral contents.
The potential health benefits and food applications of jamun (Syzygium cumini L.), an indigenous fruit of India	Ayenampundi et al., 2022	Jamun (Syzygium cumini L.	Value-added products (beverages, jam, cake, etc.)	Jamun fruit has potential health benefits such as anti-cancer, anti-inflammatory, anti-obesity, cardio protection, etc., due to the presence of steroids, alkaloids, phenols and flavonoids.
Fermented fruits and legumes in Africa: production factors and health benefits	Ashaolu, 2024	Various fruits and legumes	Beverages	Fruit- and legume-based African food products potentiate affordable options for tackling both African and global hunger and malnutrition issues.
Development of Value-added Ready-to-serve beverage Based on *Garcinia penduculata*: A Super Fruit	Islam et al., 2024	*Garcinia penduculata*	Value-added Ready-to-serve beverage	This indigenous nutraceutical fruit can be utilised fully to produce value-added products and their commercialisation, thereby making it available throughout the season, which shall further help in the sustainable economic status of the local growers. Future studies may attempt commercialisation of the developed product, which could be a better alternative to synthetic soft drinks because of the nutritional quality and functional properties.

Methodology

The University of Zululand, located on the KwaDlangezwa campus in a rural area, primarily enrols students from surrounding regions within KwaZulu-Natal, South Africa. As a result, most of the students are Zulu speaking, which means they are likely to be familiar with the indigenous wild fruit featured in this study. This demographic context is relevant, as it offers insight into the potential cultural awareness and acceptance of the fruit among the student population, influencing the sampling technique used in this research. This study was granted ethical clearance from the University of Zululand Research Ethics Committee (UZREC171110 030). This study employs an experimental design with a quantitative approach. The selection of participants was based on convenience sampling, with a total of 60 students, both male and female, from the youth demographic. Convenience sampling was chosen to allow for young adults interested in the study and available to participate in the sensory evaluation, thus avoiding additional time or cost implications (Golzar et al., 2022). The Monkey orange fruit used in the study was locally sourced from the King Cetshwayo district. The selection of the fruit follows recent trends in the country's interest in utilising this fruit and adding value to food products (Ngadze et al., 2018). Three trials were conducted with 10 sensory panellists who had completed sensory evaluation training during their undergraduate qualification. The final assessment of the product was completed by 60 untrained consumer participants. Ingredients were locally sourced from local supermarkets and fruit vendors in Zululand. The milk was heated in a double boiler, soaked gelatine was added, and the mixture was heated to 90°C. Once the desired temperature was reached, the mixture was removed from the heat and allowed to cool to 45°C. The starter culture was then stirred in, and the mixture was poured into a sterilised jar and sealed. The top of the jar was sterilised using boiling water, and the mixture was incubated overnight in a water bath placed in a warm environment. Fermentation occurred throughout 8 to 12 hours. Following fermentation, the yoghurt was refrigerated to allow further cooling. After six hours, the yoghurt had set, and it was stirred with a wooden spoon, with an essence added to mask any undesirable odours. Yoghurt has been investigated as a basis for the formulation of many types of dairy desserts and other convenient food products (Wajs et al., 2023, Moatsou, 2024). Besides, substances such as stabilisers, colourants, sweeteners and flavourings, natural additives from plants such a fruit, vegetables, cereals, nuts, seeds, plant/herbal extracts, byproducts, and waste from various fruits can also be added (Bankole et al., 2023) . Thus, the yoghurt was mixed with monkey orange sauce to formulate the value-added yoghurt, which was served chilled. Figure 1 below shows the process followed to prepare the yoghurt.

Reception of fresh milk (Full cream milk)
↓
Homogenization (heat)
↓
Add soaked gelatine (heat to 90°C)
↓
Cooling to 45-35°C
↓
Inoculation with ABT-5 starter culture
↓
Sterilization of container top
↓
Incubation (8-12 hours)
↓
Fermentation
↓
Cooling (6 hours)
↓
Stirring and adding essence
↓
Mix in cooled Monkey Orange sauce
↓
Serve chilled

Figure 1: Flow chart of yoghurt production

The monkey orange fruit was fully ripe at the time of purchase and was processed in-house (Figure 2). The fruit was first cracked open, after which a metal sieve was used to extract both the pulp and juice. This process also assisted in the removal of the seeds. Following extraction, the pulp and juice were further processed and prepared into a monkey orange sauce using the ingredients for the formulation, as depicted in Table 2.

Table 2: Quantities and ingredients used to make the dairy-based beverage

Quantity	Yoghurt Ingredients	Quantity	Monkey Orange Sauce
2 litres	Full cream milk	75g	Butter
20g	Gelatine powder	225g	Granulated cane sugar
4g	ABT-5 yoghurt culture	375ml	Fresh cream
10g	Vanilla extract	45ml	Pineapple juice
		150g	Monkey orange juice and pulp
		5g	Vanilla extract
		10g	Full cream milk powder
		10g	Corn starch

The sensory acceptability of the drinking yoghurt was evaluated through product formulation in a controlled classroom setting with 60 consumer participants. The products were served immediately from the fridge, ensuring they were chilled, which is the intended temperature at which yoghurt is consumed. The evaluation took place in a classroom equipped with privacy screens to ensure objective results from the participants. A 30ml sample of the yoghurt was poured into a plastic cup, each coded with a random three-digit number, and presented on a white tray alongside water, a plain cracker (for palate cleansing), a teaspoon, a pen, an eraser, and a scorecard for recording results (Figure 3). Instructions were provided to the participants, detailing the product, potential allergens, and the tasting procedure. Participants assessed the product using a nine-point hedonic rating scale, evaluating the appearance, aroma, taste, and mouthfeel of the sample. In addition, the Food Action Rating Scale (FACT) was used to gauge participants' willingness and intent to purchase the drinking yoghurt. The entire process lasted less than five minutes.

Figure 2: Ripe monkey orange fruit (Omotayo & Aremu, 2021).

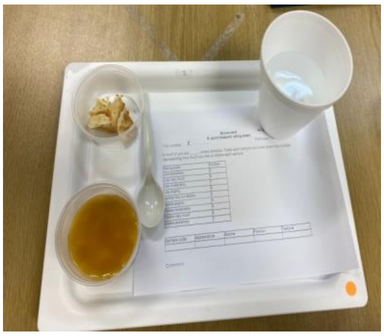

Figure 3: Sensory evaluation tray setup

Data was captured on an MS Excel spreadsheet and presented as graphs, tables, averages and percentages. A one-way ANOVA test was performed to determine if there were statistically significant variations in the sensory qualities (appearance, smell, taste, texture, and overall acceptability) of the drinking yoghurt, as evaluated by 60 participants using a 9-point hedonic scale.

Results and discussion

Information was captured using a nine-point hedonic scale to measure the likeability of the product, and a Food Action Rating Scale (FACT) was used and examined through percentage distribution to gauge the consumers' willingness to purchase the product. This section provides results and discussions on these two scales. The demographic profile (Table 1) showed an equal distribution of both genders, which shows equal interest in innovative products. Most participants (65%) were between the ages of 18 and 22, which aligns with the university population distribution and target group.

Table 3: Demographics of the participants

Variable	Attributes	Frequencies	Percentages (%)
Gender	Male	30	50
	Female	30	50
	Prefer not to disclose	0	0
Age category selected	18-22 years	39	65
	23-27 years	19	31
	28-32 years	1	2
	33-36 years	0	0
	>36 years	1	2

The evaluation of monkey orange yoghurt was performed using a 9-point hedonic scale, wherein participants assessed the products based on appearance, aroma, flavour, texture and overall acceptability. The average score and standard deviations for each attribute are presented in Table 4.

Table 4: Average scores and standard deviations for each sensory attribute

Sensory attributes	Mean±SD
Appearance	7.9±0.8
Aroma	7.2±1.0
Taste	7.8±0.9
Mouth feel	7.5±0.7
Overall acceptability	7.6±0.8

Results in Table 4 indicate that the p-value is < 0.05, hence there is a significant difference in at least one sensory quality. This indicates that participants evaluated certain attributes more favourably or unfavourably in comparison to others. The product's appearance obtained the highest grade of 7.9 ± 0.8, indicating that the product was visually appealing to the consumers. The taste (7.8 ± 0.9) and mouthfeel (7.5 ± 0.7) received favourable reviews, signifying acceptable taste and texture of the monkey orange value-added yoghurt. However, the aroma (7.2 ± 1.0) obtained the lowest rating, indicating that the aroma of monkey orange may require enhancement or masking. The overall acceptability score of 7.6 ± 0.8 indicates a high level of consumer approval and significant potential for its commercialisation. Results for the Food action rating scale are shown in Figure 5.

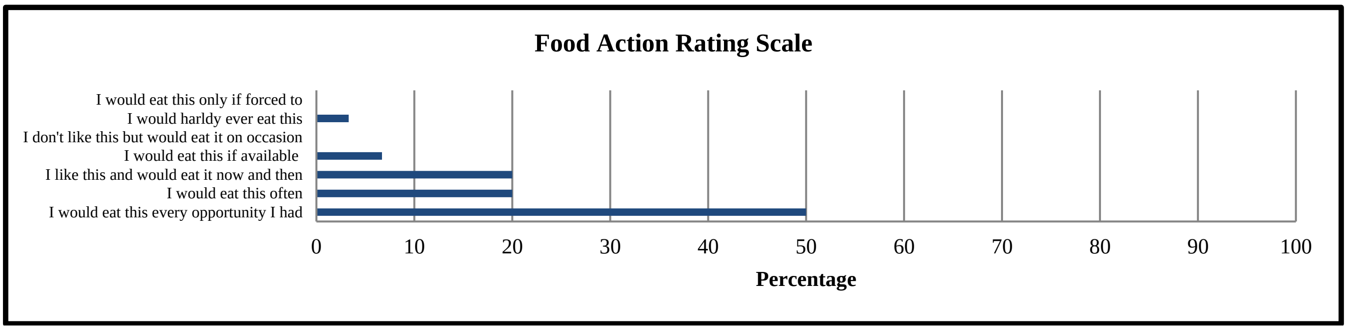

Figure 5: Results depicting willingness to purchase monkey orange value-added yoghurt from participants

Consumer acceptability results

Innovative products are developed to meet a specific need, but consumer acceptance of these products must be assessed. In this study, the results from the 9-point hedonic rating scale were presented as averages. The nine-point hedonic rating scale was utilised to conduct an affective test, measuring product acceptance based on personal reactions and preferences (Palmer et al., 2023). The scale measured the individual attributes of the product: appearance, aroma, taste, and mouth feel, and received positive mean scores (Figure 4). This shows that the individual attributes of the product are acceptable as well as the overall product across the age and gender demographics selected for this study. This is promising results as it shows that the product is well-liked by the intended target market. The sensory properties of the yoghurt in terms of appearance, aroma and mouthfeel were similar to those commercialised, which could indicate why it was viewed as being acceptable by participants. However, the taste of monkey orange is unique and not like any products available in stores. This positive feedback from the food action rating scale may be due to participants being familiar with fruit, thus increasing the chance of likeability of the product (Pitaway, 2023; Ngadze et al., 2019). The results indicate that the drinking yoghurt is well formulated and does not differ from drinking yoghurts in the market, thus it could potentially be commercialised. To appeal to a wider spectrum of consumers, the yoghurt formulation did not include sugar. In contrast, sugar was used to enhance the flavour of the fruit in the monkey orange sauce. The unique flavour of the product was attributed to the flavour profile. The fruit has a sweet-sour pulp but can vary from very sweet, sweet and sour (Omotayo & Aremu, 2021; Mbhele et al., 2022). The sugar in the sauce was used to balance the natural sourness of the fruit, whilst the vanilla extract was used to improve the aroma of the product. The sweetness of the fruit is highly dependent on the stage of ripeness as well as harvest time (Ngadze et al., 2019). The monkey orange fruits used in this production were fully ripe and were evident based on the outward appearance, a bright yellow colour on the skin, a pleasant smell and fruit size. Even though other ingredients were added to the monkey orange sauce, the flavour profile of the fruit was dominant.

One study that further supports the idea of sensory acceptability evaluated beverages made with cow milk and soy. The researchers found that the outcomes were best when the two were blended (Šertović et al., 2019). Similarly to this research study, the findings showed that probiotic fruit-based dairy beverages play a significant role in consumer acceptance by enhancing sensory attributes, including taste, aroma, appearance, and mouthfeel. Therefore, the monkey orange-based drinking yoghurt exceeds consumer expectations for sensory quality, consistent with studies showing that sensory properties significantly influence the acceptability of innovative food products. Furthermore, the unique flavour profile of the monkey orange fruit highlights the importance of flavour optimisation in novel products, and this is supported by other studies that suggest the sensory uniqueness of indigenous fruits has been leveraged to create marketable products. Indigenous fruits such as the baobab and the marula fruit have been utilised in African countries, especially in rural areas. One such study emphasised the significance of balancing unique flavours with consumer preferences for sweetness and texture. The study investigated plant and dairy-based yoghurts and revealed that dairy-based yoghurts were more sensorially acceptable as compared to plant-based yoghurts, particularly for the texture attribute (Gupta et al., 2022). Thus, both this research study and the study on plant and dairy-based yoghurt highlight the importance of texture attributes in consumer acceptability. The texture of yoghurt in the current study was improved by using fresh cream, which has a higher fat content than milk, thus contributing to improved mouthfeel. Whilst sensory properties play an important role, knowledge of fruit is equally important. Rural communities, especially in African countries, are familiar with indigenous fruits, which contribute to the acceptability of the products, similar to this research study. This is supported by findings that cultural familiarity and traditional knowledge about local fruits can positively influence consumer attitudes toward innovative food products (Mojikon et al., 2022). Thus, both studies show similarities in the use of indigenous plants for high consumer acceptance of products due to familiarity with the crops. This study, therefore, underscores the potential for commercialising indigenous fruit-based dairy beverages by ensuring that sensory attributes meet consumer expectations while leveraging the unique qualities of local fruits. Overall, the consumer acceptability results of the monkey orange yoghurt show that consumers have taken a liking to the product, especially in terms of taste and appearance, which suggests potential for commercialisation.

Potential for commercialisation

The Food Action Rating Scale, often referred to as a "FACT Scale", was used to determine the attitudes and willingness to purchase the monkey orange drinking yoghurt. Figure 6 depicts that more than 70% of the consumers responded positively and showed interest in purchasing the product. On the other end, 10% of the respondents showed uncertainty, saying they would "eat it if available" and "hardly ever". This is understandable since the fruit has a complex flavour profile, which some consumers may not be accustomed to. The participants' familiarity with the fruit contributed to their greater acceptance of its incorporation into the product. In this case, the youth were more receptive to the inclusion of the fruit because it was blended with a popular food item, yoghurt. Diversifying one's diet need not be complicated; through the modification of household favourites, daily nutritional requirements can be effectively met (Omotayo & Aremu, 2020). Introducing underutilised food crops into consumers' diets requires gradual acceptance, as these foods can be consumed in various forms, including dried, juiced, fermented, or as value-added products such as jam (Ngadze et al., 2019; Omotayo & Aremu, 2021). The youth can indulge in this fruit as an alternative to high-sugar foods that they have grown accustomed to (Kesa et al., 2023). The fruit has a unique flavour composition, which can make it more appealing to the youth, but taste is subjective to one's palate. Through the process of Westernisation, which involves the consumption of non-indigenous and local foods, as well as the influence of trends, the youth have expanded their palates. They are more adventurous and willing to try new foods and combinations. Drinking yoghurt could serve as an effective introduction to indigenous fruits, offering a way to familiarise young people with these foods despite the negative connotations and stigmas often associated with them (Kesa et al., 2023; Sarfo et al., 2022). The sensory and consumer acceptability results illustrate a promising potential for the commercialisation of the monkey orange drinkable yoghurt. The utilisation of the indigenous monkey orange fruit and the positioning of the drinkable yoghurt as a convenient health snack can offer an innovative range of nutritious and healthy products to health-conscious consumers. Health-conscious consumers, as well as younger consumers, are relatively more likely to try novel products, thus making them a significant target market for this product. Therefore, the marketing strategies for the monkey orange fruit drinkable yoghurt should focus on the sensory properties, nutritional benefits, and easy-to-eat convenience. Despite the potential positioning of the product in the market, there may be several barriers to the commercialisation of the product. One of the barriers would include the cost of production, seasonality, and perishability of the fruit, thus influencing the pricing of the product. The harvesting and ripening of the fruits occur in a specific season, which poses a barrier to ensuring a consistent supply and production of the monkey orange fruit-based products. However, this could be addressed by harvesting monkey orange when in season, then processing it for use as needed.

Product market positioning

Positioning the drinkable monkey orange yoghurt as a premium product would require significant focus on the product's unique sensory attributes and nutritional profile. Such products are mostly known to be targeted to health-conscious consumers who looking for functional foods that are high in probiotics, vitamins, and minerals. This is supported by Spiro & Wood (2021) that consumers are continuously looking for nutritious and healthy snacks as alternatives to high sugar and calorie content products. Therefore, the product can be introduced into the market as a functional food that possesses health benefits, including enhanced digestion and immunity, which are a major drive in the global dairy market. On the other hand, the monkey orange drinkable yoghurt can be positioned as a mass-market product by zooming into affordability, convenience, and accessibility. The product can thus be offered in resealable plastic bottles, which would appeal to consumers who are seeking an easy-to-eat or on-the-go meal for time convenience. Furthermore, marketing strategies should focus on the health benefits of the product but also address familiarity concerns by facilitating consumer education campaigns.

Functional foods

Functional foods are foods that contain ingredients that provide health benefits beyond the food's basic nutritional composition (Temple, 2022). Probiotic yoghurt is a source of various minerals and vitamins as well as protein but is primarily recommended to improve gut health. Scientific evidence indicates that the consumption of probiotic microorganisms helps in maintaining a favourable microbial profile and has resulted in several therapeutic benefits in the human body (Worku et al., 2020; Ashoula, 2024). By using a product that is globally known in the market, yoghurt, and incorporating it with an indigenous fruit. This enriched product has the potential to address micronutrient deficiencies and to promote overall health. Functional dairy beverages have gained significant popularity in recent years, particularly among younger consumers, due to their perceived health benefits and alignment with contemporary food trends (Hadjimbei et al., 2022; Ashoula, 2024). These beverages, such as probiotic-rich yoghurt drinks, are enriched with bioactive ingredients that promote health beyond basic nutrition. One of the key advantages of functional dairy beverages is their positive impact on gut health (Dahiya & Nigam, 2022; Mudgil & Barak, 2019). Probiotics, often present in these drinks, are live microorganisms that confer health benefits when consumed in adequate amounts, particularly by improving the balance of the gut microbiota (Hadjimbei et al., 2022). This has become an area of growing interest as research increasingly links a healthy gut microbiome to enhanced immune function, mental well-being, and overall metabolic health. The youth are increasingly aware of the importance of gut health and are seeking functional foods and beverages that support digestive wellness, aligning with the broader wellness trend that emphasises holistic health (Khatun & Bhattacharya, 2024). Moreover, these consumers are drawn to functional dairy drinks because they are perceived as convenient, nutritious, and easily incorporated into a busy lifestyle. In response to these trends, dairy brands are fortifying their products with additional functional ingredients such as fibre, omega-3s, and vitamins, which are further linked to supporting the gut-brain axis and overall vitality (Dahiya & Nigam, 2022). As the demand for functional beverages continues to rise, it reflects a broader shift towards mindful, health-conscious consumption among younger generations, highlighting the growing intersection of food trends, functional health, and youth culture (Khatun & Bhattacharya, 2024).

Nutritional profile of the monkey orange fruit

Along with the product's high level of consumer acceptability, its nutritional profile lends credence to its potential as a functional food. Monkey orange fruit has been notably found to have high value use in rural communities, thus highlighting its importance as a food source and medicinal plant (Ngadze et al., 2018). Research also highlights the monkey orange fruit to be more nutritionally dense in vitamins, minerals, and bioactive compounds, which can then enhance the food and nutrition security status of the population (Chamane, 2022). Arguments from researchers thus make the fruit relevant to address the specific nutritional needs of the population, particularly those with special dietary needs. Furthermore, the utilisation of the monkey orange fruit in the development of food products can offer a softer, safer, and more convenient food option containing numerous nutritional benefits. Further supporting the nutritional value, Shai et al. (2020) state that the Mapula people frequently consume monkey orange fruit, suggesting a significant function for this fruit in satisfying nutritional needs. The *Strychnos* species has been recognised for its potential to enhance food and nutrition security, and the traditional processing methods have been modified to enhance its nutritional profile (Ngadze et al., 2017). Li et al. (2020) further state that the species contributes positively to diet diversity, which is important in combating malnutrition and its associated complications. Research reveals that the fruit is known to possess phytochemicals, which are active compounds that prevent ageing, inflammation, and other types of cancer (Ngadze et al., 2016). Notably, according to Ngemakwe et al. (2017), the monkey orange fruit contains numerous essential nutrients, including copper, thiamine, and nicotinic acid, which are found to be 20% higher as compared to the daily requirements. Considering the arguments made by researchers, the monkey orange fruit can thus be a suitable option for developing yoghurt to improve nutrient intake. According to research, the monkey orange fruit is rich in other vital nutrients, including vitamin C, zinc, and iron, which are important for enhancing the immune system and metabolic processes (Hassan et al., 2014). In this regard, the presence of these vitamins and minerals may contribute to the overall health of the population. for instance, vitamin C may provide significant antioxidant benefits to these individuals. In addition, the zinc and iron content enhance its nutritional value, making it a valuable ingredient in developing food for health-conscious individuals. Moreover, the fruit is likely to be high in phytochemicals associated with anti-inflammatory and antioxidant effects (Aremu et al., 2022). The nutritional composition of Money orange is depicted in Table 5 below.

Table 5: Nutritional content of the monkey orange (Ngadze et al., 2016).

Nutrient	Nutrient content per 100g
Energy (KJ)	1681KJ
Carbohydrates (mg)	28.7g
Protein	9.0g
Fats	15.8g
Fibre	9.2g
Fe	3.3mg
P	60.3mg
Ca	73.1mg
Mg	81.2mg
Zn	0.5mg
Na	23.3mg
K	1342.4mg
Cu	0.62mg
Vitamin C	88mg

Overall, the sensory evaluation revealed that consumers had a favourable impression of the product based on their scoring of the product's appearance, flavour, and texture. Monkey orange fruit has considerable nutritional properties, such as probiotics for digestive health, critical vitamins, minerals, and antioxidant-rich phytochemicals, which highlight its potential health advantages. Consequently, there are significant chances for market penetration and effective commercialisation because the product satisfies consumer taste preferences while also aligning well with current health trends.

Conclusion

Monkey orange is a fruit with promising nutritional and medicinal potential, which can be explored for value-added products such as the drinking yoghurt developed in this study. The current study aimed to assess the possibility of incorporating monkey orange sauce into yoghurt. The study's findings were positive, offering promising insights into the potential for commercialisation of the monkey orange-based yoghurt. The positive responses from students may encourage them to explore and incorporate more indigenous and underutilised crops into their diets. Innovative products, such as the one developed in this study, often serve as an introduction to consuming and learning more about Indigenous crops and their nutritional benefits. With the right strategies, these products can be adopted by the mainstream market, catering to the target consumer and promoting broader acceptance of Indigenous foods by fostering awareness and encouraging the incorporation of monkey orange fruit through a popular product, such as drinking yoghurt. Our study helps promote locally available, sustainable foods, improves nutrition, and contributes to diversifying diets, preserving culture, and increasing the consumption of underutilised fruits, especially among young people.

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