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Nutritional and Sensory Evaluation of Functional Probiotic Soft Cheese

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Abstract

Due to the health concerns associated with the consumption of synthetic additives in dairy products, there is an increasing demand by consumers for dairy products with functional foods for promotion of health. The study was designed to evaluate the nutritional and sensory qualities of probiotic cheese made from reconstituted powdered milk and grated carrot at various levels of 0 (T1), 10 (T2), 20 (T3), 30 (T4) and 40 g/L (T5) stored at 4ºC and analysed at 0, 7, 14 and 21 days of storage. The experimental design was the completely randomized design in a 5×4 factorial arrangement. Results revealed significant (p<0.05) increase in carbohydrate and decrease in moisture with increased carrot inclusion. However, no significant (p>0.05) difference was observed in the fat content while the protein value was significantly (p<0.05) lower (17.16 %) in T1. Storage effect showed that at 21 days, all proximate constituents significantly (p<0.05) decreased except moisture content. Free fatty acids (13.02 %) and peroxide values (26.19 mEqO2/kg) were highest in 40 g carrot cheese while the thiobarbiuturic acid (0.01 µgMA/g) and Total titratable acidity (4.21 g/L) were significantly least. Storage effect revealed a decrease in free fatty acids (12.77-12.42 %), thiobarbiuturic acid (5.19-2.59 µgMA/g), peroxide values (19.84-15.10 mEqO2/kg), and total titratable acidity (0.02- 0.01 g/L) with increase in storage time. The antioxidant value was at its peak in T4 (30 g grated carrot) at 24 hr of storage. Cheese infused with 10 g grated carrot was significantly (p<0.05) preferred (3.12) and the overall acceptability (3.23) was highest at 21 days of storage. In conclusion, this study showed that the addition of 10 g grated carrot to probiotic soft cheese enhanced the carbohydrate quality and improved the acceptability of the product and this could confer significant health benefits to the consumers.

Key words: Carrot, soft cheese, probiotic, storage, sensory, nutritional

Évaluation nutritionnelle et sensorielle du fromage fonctionnel probiotique

Résumé

En raison des préoccupations sanitaires liées à la consommation d'additifs synthétiques dans les produits laitiers, la demande des consommateurs pour des produits laitiers fonctionnels destinés à la promotion de la santé augmente. L'étude a été conçue pour évaluer les qualités nutritionnelles et sensorielles du fromage probiotique fabriqué à partir de lait en poudre reconstitué et de carottes râpées à divers niveaux de 0 (T1), 10 (T2), 20 (T3), 30 (T4) et 40 g/L (T5) stocké à 4ºC et analysé à 0, 7, 14 et 21 jours de stockage. Le plan expérimental était un design complètement randomisé dans une disposition factorielle 5×4. Les résultats ont révélé une augmentation significative (p<0,05) des glucides et une diminution de l'humidité avec l'augmentation de l'inclusion de carottes. Cependant, aucune différence significative (p>0,05) n'a été observée dans la teneur en matières grasses, tandis que la valeur protéique était significativement (p<0,05) plus faible (17,16 %) dans T1. L'effet du stockage a montré qu'à 21 jours, tous les constituants proximaux ont diminué de manière significative (p<0,05), sauf la teneur en humidité. Les acides gras libres (13,02 %) et les valeurs de peroxyde (26,19 mEqO2/kg) étaient les plus élevés dans le fromage à 40 g de carottes, tandis que l'acide thiobarbiturique (0,01 µgMA/g) et l'acidité titrable totale (4,21 g/L) étaient significativement les plus faibles. L'effet du stockage a révélé une diminution des acides gras libres (12,77-12,42 %), de l'acide thiobarbiturique (5,19-2,59 µgMA/g), des valeurs de peroxyde (19,84-15,10 *mEqO2/kg) et de l'acidité titrable totale (0,02-0,01 g/L) avec l'augmentation du temps de stockage. La valeur antioxydante était à son apogée dans T4 (30 g de carottes râpées) après 24 heures de stockage. Le fromage infusé de 10 g de carottes râpées a été significativement (p<0,05) préféré (3,12) et l'acceptabilité globale (3,23) était la plus élevée après 21 jours de stockage. En conclusion, cette étude a montré que l'ajout de 10 g de carottes râpées au fromage probiotique mou améliore la qualité des glucides et l'acceptabilité du produit, ce qui pourrait conférer des avantages importants pour la santé des consommateurs.*

Mots-clés : Carotte, fromage mou, probiotique, stockage, sensoriel, nutritionnel

Introduction

In recent times, there is an increasing demand for healthy functional food products free from synthetic substances due to their health concerns (Indiarto *et al*., 2023., Ibhaze *et al*., 2024). The consumption of cheeses supplemented with probiotics has been associated with several benefits to human health, such as improving lactose intolerance, immune system functions, intestinal health and inhibition of pathogens (Karimi *et al.*, 2012). Also, Vinderola *et al.* (2002) opined that the supplementation of dairy products with probiotics are able to produce natural antimicrobial substances that inhibit undesirable microorganisms in the digestive system of humans. Probiotic cheese is a nutritional and versatile dairy product that can be made by coagulation of whole milk, skimmed milk, or cream milk (Bodyfelt *et. al.*, 2018). Probiotic cheese is rich in protein, fat, minerals such as calcium, iron, phosphorus, vitamins and essential amino acids and therefore an important food in the diet of both young and old people (Oladipupo and Jadesimi, 2019). The use of probiotic bacteria can enhance flavor, texture in cheese. The inclusion of food containing phytochemicals in our daily diet may reduce birth defects, cancer, cardiovascular, and neurodegenerative diseases (Blancquaert *et al.*, 2010; Liu, 2013).

Carrot (*Daucus carota* L.) is a nutritious seasonal root vegetable (Kamel *et al*.,2023) that can be grown throughout the year by irrigation. Carrots are known as a multinutritional food source and are rich in natural bioactive compounds such as phenolics, carotenoids, polyacetylenes, and ascorbic acid (Ahmad *et al.*, 2019). Essentially carrot is a rich source of beta-carotene a precursor of Vitamin A, which is essential for good eyesight, robust immune system and healthy skin. Carrots are believed to possess various health benefits due to their nutritional composition and antioxidant capacity, including the potential to prevent cardiovascular disease and certain types of cancer (Geetha *et al.*, 2021). As a result, carrots can be used as a functional ingredient in any product to increase the biological and nutritional values (Er-gun, 2018). The thrust of this study was to examine the effect of grated carrot on the nutritional and sensory qualities of probiotic-carrot soft cheese stored and sampled weekly over 21 days.

Materials and methods

Instant full cream powdered milk, freeze dried mix-starter culture (*Lactobacillus bulgaricus* and *Streptococcus thermophilus*) and sucrose were purchased from a confectionery store. The *Calotropis procera* leaves was obtained from the institution's premises. The carrot was purchased from veggies stall.

Production of grated carrot

Carrot was scrapped with the use of knife to remove all forms of dirt, washed with clean water, diced and then grated and thereafter steam -blanched for 3 min to inactivate pectinase and peroxidase, and elevate the bioavailability of beta-carotene by thermal treatment (Ghosh *et al*., 2019).

Probiotic carrot cheese production

A 1500 g of full cream powdered milk was weighed into 5 L of water and mixed thoroughly using a mixer. Mixture was then pasteurised at 45˚C. A 100 g of salt was added and mixed thoroughly and thereafter divided into 5 aliquots (1L each) and 5 mL of coagulant (*Calotropis procera* juice) was added to each aliquot and thereafter infused with 10, 20, 30 and 40 g grated carrot respectively and stirred until a curd was formed. The first portion without carrot was used as the control. Each aliquot mixture was allowed to cool to 42^0C and then inoculated with 3 g freeze dried mix of *Lactobacillus bulgaricus* and *Streptococcus thermophiles.* The inoculated mixture was then transferred to the incubator for fermentation at 43^0C for 14 hrs. Thereafter, the cheese was drained off the whey using a cheese cloth. Product was refrigerated and analysed for parameters under investigation at specified days of 0, 7, 14 and 21 days.

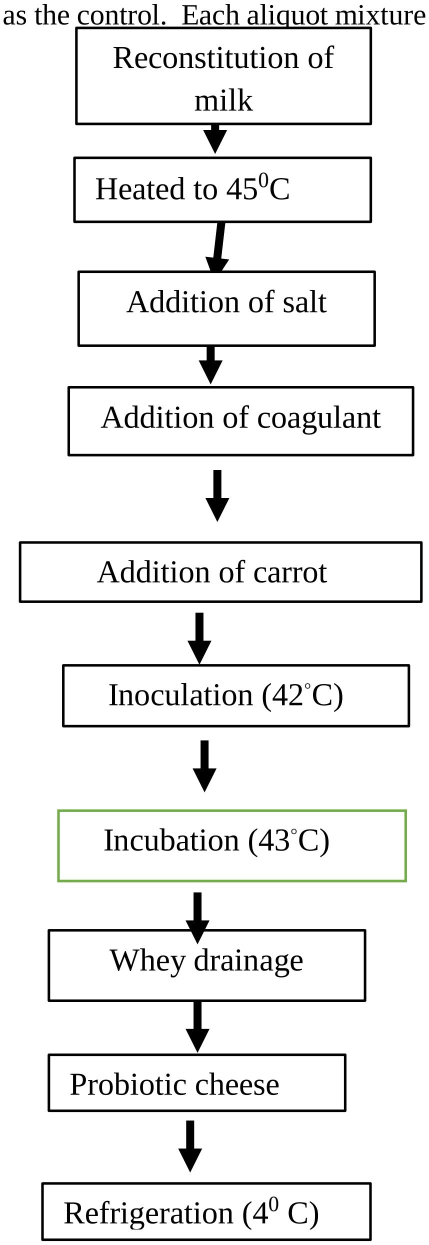

Figure 1: Flowchart for Production of Functional Probiotic soft cheese

Laboratory Analyses

Determination of (DPPH) free radical scavenging ability was determined according to the method of Gyamfi *et al.*, 2012) method, Peroxide Value (AOAC, 2012), thiobarbituric acid (Rossell, 1994), total titratable acidity (AOAC, 2012). The free fatty acid of the cheese samples was determined as described by Kokotou, (2020). Proximate analysis was determined according to the method of AOAC (2012).

Sensory evaluation

The organoleptic properties of the cheese were evaluated by a 15-member panelist drawn from students and staff of the Department of Animal Production and Health, Federal University of Technology, Akure. They evaluated the cheese samples for colour, texture, mouth feel, flavour, taste and overall acceptability in a five-point hedonic scale. Samples were removed from the refrigerator about 30 mins before evaluation and kept at room temperature. Approximately 100g of cheese was presented to each panel member. Enough water was provided to the panelists to rinse their mouths between samples. The panelists were requested to rank the samples in order of their preference.

Experimental design and statistical analysis

The experimental design was the completely randomized design in a 5x4 factorial arrangement. Data were subjected to analysis f variance (ANOVA) using SPSS 25.0 software (SPSS, 2017) means were separated using New Duncan's Multiple Range Test (NDMRT).

Results

The proximate composition of probiotic- carrot cheese presented in Table 1 revealed significant ($p < 0.05$) differences except fat. Moisture, ash, fat, protein and carbohydrate contents ranged from 26.03 - 31.83, 2.08-3.12, 18.12-18.76, 17.16-18.93 and 29.13-35.29 %, respectively. T1 (control) had the highest moisture, ash and fat contents and the least protein and carbohydrate concentrations and T5 had the highest carbohydrate content. Storage effect showed significant ($P<0.05$) differences in all the parameters examined. At 21 days of storage, moisture content was at its peak (37.49 %) while the ash (2.20 %), fat (17.04 %), protein (18.17 %) and carbohydrate (25.17 %) contents were least. Treatment effect on the cheese chemical composition (Table 2) showed that total titratable acidity (TTA) ranged from 0.01- 0.02 g/L. Sample T5 had lower thiobarbituric acid **(**TBA) value (4.21 mgMDA/g) and utmost value of 5.01 mgMDA/g in T1. Free fatty acids (FFA) ranged from 12.25- 13.02 % while the peroxide value (PV) varied from 11.24- 26.19 mEqO2/kg with T5 having the optimum value. Storage effect revealed significant differences ($P<0.05$) across the treatments as a steady decline was observed in the FFA (12.77 -12.42 %), TBA (5.19-2.59 μgMA/g), TTA (0.02-0.01 g/L) to the 21st day. Highest antioxidant was observed in T4 (49.13 %) at day 24hrs of storage and the least scavenging ability (24.19 %) was observed in T3 at 21 days of storage (Figure 1). Presented in Table 3 is the organoleptic evaluation of the probiotic- carrot cheese. Treatment effect showed that the overall acceptability was utmost (3.12) in T2 probiotic- carrot cheese and least (2.61) in T5 probiotic- carrot cheese. However, the storage effect revealed that overall acceptability was topmost at 21 days of storage with a value of 3.23 while the least (2.51) was obtained at 24 hrs of storage.

Table 1. **Proximate composition of Functional probiotic soft cheese**

	Moisture	Ash	Fat	Protein	Carbohydrate
Treatment Effect					
T1 (Control)	31.83^{a}	3.12^{a}	18. 76	17.16^{b}	29.13^{e}
T2 (10 g)	30.15^{a}	2.08^{d}	18. 62	18.93^{a}	30.22^{d}
T3 (20 g)	28.15^{b}	2.66^{b}	18. 42	18.36^{a}	32.41^{c}
T4 (30 g)	28.02^{b}	2.32^{c}	18. 36	18.12^{a}	33.18^{b}
T5 (40 g)	26.03^{b}	2.66^{b}	18.12	17.90b	35.29^{a}
SEM	0.00	0.00	0.12	0.00	0.00
P value	0.00	0.00	0.00	0.00	0.00
Storage Effect					
Day 1	28.14^{b}	2.48^{c}	17.23^{c}	18.43^{c}	38.72^{a}
Day 7	22.59^{d}	2.98^{a}	17.68^{a}	18.76^{a}	36.85^{b}
Day 14	27.13^{c}	2.63^{b}	17.47^{b}	18.61^{b}	34.22^{c}
Day 21	37.49^{a}	2.20^{d}	17.04^{d}	18.17^{d}	25.17^{d}
SEM	0.01	0.01	0.01	0.01	0.01
P value	0.00	0.00	0.00	0.00	0.00

T1: (Control) 0g of carrot, T2: 10g of carrot, T3: 20g of carrot, T4: 30g of carrot, T5: 40g of carrot

. **Table 2: Chemical Properties of functional probiotic soft cheese**

Treatment Effect	PV (mEqO2/kg)	TTA(g/L)	TBA(μgMA/g)	FFA (%)
T1 (Control)	12.19^{d}	0.01^{b}	5.01^{a}	12.25 ^{c}
T2 (10 g)	21.42^{b}	0.01^{b}	4.28^{c}	12. 32^{d}
T3 (20 g)	22.24^{e}	0.02^{a}	4.23^{b}	12.46^{c}
T4 (30 g)	24.04^{c}	0.02^{a}	4.25^{d}	12.75^{b}
T5 (40 g)	26.19^{a}	0.01^{b}	4.21^{e}	13.02^{a}
SEM	0.34	0.00	0.00	0.01
P Value	0.00	0.00	0.00	0.00
Storage Effect				
Day 1	19.84^{a}	0.02^{a}	5.19^{a}	12.77^{a}
Day 7	17. 04^{c}	0.01^{b}	5.11^{b}	12.52^{b}
Day 14	15.19^{c}	0.01^{b}	4.84^{c}	12.53^{b}
Day 21	15.10^{c}	0.01^{b}	2.59^{a}	12.42^{c}
SEM	0.30	0.00	0.00	0.00
P Value	0.00	0.00	0.00	0.00

PV = Peroxide Value; TTA=Titratable Acidity; TBA=Thiobarbituric Acid; FFA= Free Fatty Acid. T1: (Control) 0g of carrot, T2: 10 g of carrot, T3: 20 g of carrot, T4: 30 g of carrot, T5: 40 g of carrot

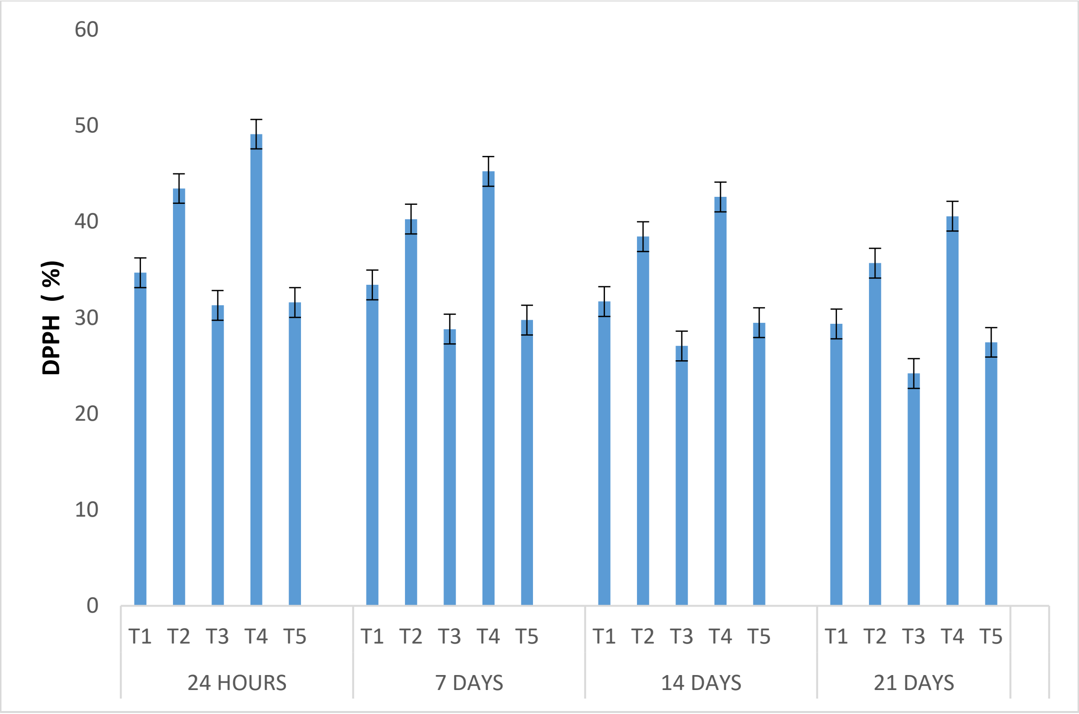

Fig 2: Antioxidant properties of functional probiotic soft cheese
T1: (Control) 0 g of carrot, T2: 10 g of carrot, T3: 20 g of carrot, T4: 30 g of carrot, T5: 40 g of carrot

Table 3: Organoleptic properties of functional probiotic soft cheese

Treatment Effect	Colour	Texture	Taste	Flavour	Mouth feel	Overall acceptability
T1	2.48a	2.73^d	3.23^a	2.95^c	3.20^a	2.97^b
T2	2.32^b	3.43^a	3.17^c	3.22^a	3.13^b	3.12^a
T3	1.99^c	3.14^c	3.25^b	3.09^a	2.88^c	2.83^c
T4	1.65^d	3.22^b	3.07^d	2.91^c	2.80^c	2.80^c
T5	1.92^c	3.27^b	3.05^d	3.23^a	2.77^d	2.61^d
SEM	0.19	0.17	0.20	0.17	0.21	0.26
P-Value	0.01	0.03	0.03	0.03	0.03	0.03
Storage Effect						
Day 1	2.32^a	2.77^b	3.22^a	2.53^b	2.69^b	2.51^b
Day 7	2.12^a	2.82^b	3.14^a	2.79^b	3.03^a	2.81^b
Day 14	1.92^b	3.49^a	3.11^b	3.57^a	3.15^a	2.96^b
Day 21	1.83^b	3.54^a	3.09^b	3.63^a	3.23^a	3.23^a
SEM	0.13	0.12	0.14	0.12	0.15	0.18
P-Value	0.00	0.00	0.00	0.00	0.00	0.00

^{a,b,c,d}: means with the same row different subscripts are significantly different ($p<0.05$)
T1: (Control) 0 g of carrot, T2: 10 g of carrot, T3: 20 g of carrot, T4: 30 g of carrot, T5: 40 g of carrot

Discussion

Proximate Composition of functional Probiotic Soft Cheese

The decrease in moisture content with increased inclusion of grated carrot could be that the carrot absorbed water from the cheese matrix as it contains cellulose, pectin and starch that can absorb water. This therefore indicated that the cheese with low moisture would have higher dry matter content and could stay better. However, the increased moisture content during storage could be due to the high water holding capacity of carrot. This result is in agreement with the findings of Kamel *et al*. (2023) who reported that cheeses treated with carrot powder had higher moisture contents during storage and Khalifa and Wahdan (2015) in soft white cheese treated with cranberry fruit extract. The relatively high fat content obtained in this study could be due to the full cream milk powder used. This suggest the potential of the product to improve absorption of fat- soluble vitamins (ADEK) as well as flavour and texture for consumers' satiety and satisfaction. Although, the fat content obtained in this study was lower than the range of 25.5 - 25.75 % in probiotic cheeses with different starters reported by Yerlikaya and Ozer (2014). The variation could be due to the inclusion of carrot in this study. The highest ash content in the control over the carrot –cheese could be due to the dilution effect of carrot. Carrot added bulk to the cheese thereby diluting the mineral concentration. Also, the ability of carrot to absorb water which lowered the moisture content can also lead to a reduction in the ash concentration. The decline in protein during storage could be due to proteolysis by enzymes or microbial actions by their consumption of proteins as nutrient thereby depleting the quatum of protein in the cheese. The higher carbohydrate concentration observed in carrot fortified cheese compared to the cheese without carrot could be attributed to the carrot inclusion. This therefore suggests that carrot fortified cheese could serve as a good source of energy for the consumer. However, the microbes present in the cheese could be implicated in the depletion of carbohydrate as storage progressed as they would have used the carbohydrate as source of energy for their activities and proliferation.

Chemical Properties of functional Probiotic Soft Cheese

The peroxide value is crucial in assessing the oxidative stability of food products as it reveals the degree of lipid oxidation and potential rancidity. The higher peroxide values (PV) in carrot cheese could be due to the action of the beta-carotene, a pro-oxidant present in carrot in breaking down fatty acids. Elevation of PV during storage indicates deterioration of nutritional and sensory qualities of dairy products (Siddique and Park, 2019). However, carrots contain antioxidants which can counteract oxidation thereby reducing peroxide value during storage as observed in this study. The total titratable acidity (TTA) that indicates the amount of acid in a food (Ibhaze *et al.*, 2024) was relatively low in all the samples and throughout the storage period. The probiotics could be implicated as they would have used up the lactose in the product thereby causing a reduction in the lactose concentration which reduced its conversion to lactic acid leading to low acid concentration. The TTA provides insights into cheese's flavour and shelf stability (Islam *et al*., 2021) and the overall quality of the product. Free fatty acids (FFA) in dairy products are produced due to breakdown of milk fat by either enzymatic reactions (lipolysis, esterification), chemical reactions (autoxidation and hydrolysis), microbial fermentation (bacterial lipolysis, yeast and mold fermentation). The increase in FFA in carrot cheese as storage progressed is in line with the report of Delgado *et al*. (2009) and Nouira *et al.* **(**2011**).** An inverse relationship was observed between the FFA and the TBA (Table 2). Thiobarbituric Acid (TBA) values are indicative of lipid oxidation and can influence the overall quality and taste of the cheese (Ioannidou *et al*., 2022).

Antioxidants of Functional Probiotic Soft Cheese

Antioxidant compounds deactivate free radicals which can cause cells damage thereby playing a significant role as a health-protecting factor (Ibhaze *et al*., 2022). The relatively high antioxidant concentrations (Fig 1) observed in this study implies higher free radical scavenging ability which would result in enhanced nutrition, improved shelf life and stability, immune system support as well as reduced off –flavour of the product. Values obtained in this study were higher than the range 7.45 - 34.9 % reported by John *et al.* (2017). The radical scavenging abilities of the cheese could be beneficial in the management of type 2 diabetes as free radicals are involved in the development and complications of diabetes in a number of ways; the white blood cell production of reactive oxygen species mediates the autoimmune destruction of the beta cells in the islets of Langerhans in the pancreas, abnormalities in transition metal metabolism are postulated to result in the establishment of diabetes and diabetes associated hyperglycaemia causes intracellular oxidative stress, which contributes to vascular dysfunction (Ademosun and Oboh, 2015).

Organoleptic properties of Functional probiotic Soft cheese

Colour, flavour, mouth feel, consistency, taste are important factors in determining the overall acceptability of any food by the consumer. The Table 3 showed that the infusion of carrot enhanced the cheese flavour due to the naturally occurring terpenoids in carrot which are responsible for carrot flavor. Cheese with the least inclusion of grated carrot (10 g) was most accepted. The least overall acceptability of cheese with the highest carrot inclusion (40 g) could be attributed to the quantity of carrot infused in the cheese which affected the mouth feel (rough), colour and taste. This observation may not be far-fetched from the preference of consumers for smooth mouth feel dairy product. However, a corresponding increase in the overall acceptability with increase in the storage period was observed. This could be attributed to the presence of probiotic cultures in the cheese which had a fermentative effect resulting in a fresh mild acidic flavour desirable by consumers. This observation was similar to the findings of Hamdy *et al.* (2020) in low fat feta cheese and Kamel *et al.* (2023) in carrot powder probiotic cheese.

Conclusion

Based on the findings of this study, it can be concluded that using carrot as a functional component in probiotic soft cheese enhanced the nutritional and sensory qualities of the cheese. Probiotic cheese made from reconstituted powdered milk and infused with 10 g grated carrot was best acceptable and most preferred at 21 days of storage. However, further study is recommended to extend the period of storage.

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