Current Nutrition & Food Science, 2021, 17, 764-772

RESEARCH ARTICLE

Evaluation of Consumer Sensory Acceptability and Shelf Life of Orange-fleshed Sweet Potato-enriched Mozzarella Cheese

Nixon Kebeya[1], John M. Nduko[1,]* and Patrick S. Muliro[1]

[1]Department of Dairy, Food Science and Technology, Egerton University, Egerton, Kenya

ARTICLE HISTORY

Received: October 19, 2020
Revised: January 28, 2021
Accepted: February 02, 2021

DOI:
10.2174/1573401317999210422093112

Abstract: ***Background***: Consumer interest in convenience foods is a new trend worldwide that is expected to increase due to busy lifestyles. Studies have shown that sweet potato has unique nutrients, which if incorporated into cheese, can make it a functional food. Food product development process requires that before a product is commercialized, it is subjected to consumer acceptability and shelf-life tests.

Objective: The objective of this study was to determine the sensory acceptability and shelf life of mozzarella cheese that was enriched with orange-fleshed sweet potato to improve fiber content.

Methods: Mozzarella cheese was prepared with orange-fleshed sweet potato powder at 0% up to 5.5% at intervals of 0.5% and a seven-point hedonic scale was used to evaluate product acceptability based on colour, aroma, acidity, texture, and fibrousness. Cluster analysis and principal component analysis were carried out using Minitab® software. For shelf life, total coliform count, *E. coli*, and yeasts and moulds counts were used.

Results: Hedonic scores for all sensory attributes except color were not significantly ($p>0.05$) different between control and treatments. Cluster analysis grouped the sensory attributes into 3 clusters (1-color; 2-aroma, texture and fibrousness; 3-taste and acidity). All the sensory attributes loaded positively on component 1, while taste, acidity, and fibrousness loaded negatively on component 2 of principal component analysis. Fresh cheese had no coliforms, *E. coli*, yeasts and molds. The yeasts and molds were used to predict shelf life and their numbers were directly proportional with the cheese storage period. The control samples had the longest predicted shelf life of 42 days and the shelf life decreased with increase in orange-fleshed sweet potato incorporation with a treatment of 5.5% orange-fleshed sweet potato having 29 days.

Conclusion: Orange-fleshed sweet potato (OFSP)-enriched mozzarella cheese had similar sensory acceptability as the control without OFSP. It should therefore be promoted as a functional food with a possibility of using food grade anti-mold agents for extended shelf life.

Keywords: Mozzarella cheese, sensory analysis, orange-fleshed sweet potato, shelf life, functional food, dietary fibre.

1. INTRODUCTION

Mozzarella is a type of cheese that is the most consumed worldwide due to its continued use in fast food preparations. The growth in the cheese sector is mostly due to convenience packaging, increased use of cheese in the foodservice sector, and growth in specialty cheeses [1]. Mozzarella cheese has gained utilization in convenient foods such as pizza, pasta products, and burgers [2]. Mozzarella is rich in proteins and fats but low in dietary fiber. Through product enrichment and fortification, some highly valued foods such as pizza can be improved nutritionally with elements such as fiber. Traditional value-added dairy products are an integral part of global diets [1]. Given the modern and busy lifestyles accelerated by urbanization and mass and social media among the working class, nutritional value of foods has become a key component in making food choices [3]. Food impacts on health, growth and development. Owing to the increased awareness of the linkage between diet and health, there is increased interest in consumers about the nutritional and therapeutic aspects of the food they eat; hence increased demand for low fat and dietary fiber-fortified dairy products [3, 4]. Fiber-rich and low-fat foods are known to play a role in better health [5].

Trends within consumers have also shown an avoidance of high calorie foods [4]. High fat intake is associated with an increased risk for obesity and some types of cancer. Saturated fat intake is associated with high blood cholesterol and coronary heart disease [6]. Milk and derived dairy products are devoid of dietary fiber [7]. Inclusion of dietary fiber will make dairy products to be of special interest and

*Address correspondence to this author at the Department of Dairy, Food Science and Technology, Egerton University, Egerton, Kenya;
Tel: +254 728 851 448; E-mail: jnduko@egerton.ac.ke

2212-3881/21 $65.00+.00

several efforts to provide good health options to the consumers have been led by governments [8]. Enriching mozzarella cheese with functional components such as dietary fiber is a strategy expected to moderate the calories and fat content in cheese.

Fiber is added to dairy products because of its water-holding capacity and its ability to increase the production yield, improve textural properties and structure, and reduce caloric content by acting as a bulking agent [9]. Some of the ingredients that have been incorporated in dairy products to increase fiber content include inulin [10], citrus (orange and lemon) fiber [11], date fiber [12], and gum Arabic [13]. The results from these studies indicate that dietary fiber could be used to improve the functional properties of dairy products, including mozzarella cheese, which is desirable by many consumers. Some of the ingredients are expensive and little effort has been made to process cheese with potato flour as a locally available source of fiber and fat replacer.

Orange-fleshed sweet potatoes (OFSP) are an excellent source of fiber especially insoluble dietary fibre (1.35%-2.64%) [14], minerals, β-carotene, and vitamin C [15]. Sweet potatoes have potential of reducing blood cholesterol especially LDL (low density lipoproteins) [16] and can also serve as a functional ingredient in cheese to improve physical and structural properties, and sensory characteristics [17]. However, there is very little information on the effect of enriching mozzarella cheese with OFSP on acceptability and shelf life. This information would be useful for dietary interventions on fast foods whose consumption is steadily rising. The aim of this study was therefore to investigate the consumer acceptability and shelf life of OFSP-enriched mozzarella cheese.

2. MATERIALS AND METHODS

2.1. Study Site

The study was conducted at the Guildford Dairy Institute, Egerton University, Kenya. Cow milk was obtained from the Tatton Dairy Unit at Egerton University, while OFSP was sourced from Kenya Agricultural and Livestock Research Organization (KALRO), Njoro, Kenya. The cheese starter culture containing a mixture of *Streptococcus salivarius* ssp. *thermophilus* (formerly *Streptococcus thermophilus)* and *Lactobacillus delbrueckii* ssp. *bulgaricus* (formerly *Lactobacillus bulgaricus)* was used. Both the starter culture and Rennet were sourced from Promaco Ltd., Nairobi, Kenya.

2.2. Procedure of Sample Preparation

2.2.1. Procedure of OFSP Preparation

Locally available orange-fleshed sweet potatoes (KENSPOT 4) were sourced from KALRO Njoro, Kenya. These were selected, washed with clean water, peeled, and sliced into small pieces using the universal kitchen machine. The pieces were quickly blanched in water held at 60°C for one minute and oven dried at 60°C for 36 hours until the moisture level was 12 ± 1%. The pieces were then ground into flour using a laboratory miller and sieved to attain the finest sizes (about 200 μm). These were then placed in an amber colored container before use in the making of the mozzarella cheese.

2.2.2. Procedure for Preparation of Mozzarella Cheese

Cheeses (from 20 L bovine milk for each replication) were prepared in triplicates for each treatment according to the method described by Jeewanthi *et al*. [18]. Briefly, pasteurized (72°C/15s) bovine milk was heated to 30°C and inoculated with cheese starter culture (2%). Acidity development was monitored for 30-45 minutes while continuously stirring. After adding rennet (0.003%), the milk was ripened for 45 min as per the manufacturer's instructions. The resulting curd was cut with a cheese wire knife into 1 cm cubes. The curds were cooked to 38°C by slowly increasing temperature at the rate of 1°C rise per 5 min with agitation. Whey was drained and curds were cheddared at 38°C and flipped every 15 min until the pH dropped to 5.4-5.5 (Titratable acidity 0.4-0.5%). The curds were milled and formed into a ball which was put into 75-85°C hot water (curd to water of 1:1) and kept stretching manually using a kitchen stick until curds were exposed to enough heat. The obtained cheese was weighed immediately before storage using a digital weighing balance. The weight of the cheese sample was recorded, and the yield of the cheeses determined (was approximately 11%). Salting was done at 2.0 % with addition of OFSP powder at 0% up to 5.5% at intervals of 0.5% into the cheese. Salt and OFSP addition was followed by vigorous kneading and molding for 10 min using a kitchen stick for complete mixing. Finally, all samples were packaged aerobically in plastic films and stored at 4°C.

2.2.3. Procedure for Sensory Evaluation

Each experimental cheese sample was coded and provided to evaluators. The evaluation was conducted independently, and the evaluators had to rinse their mouths with warm water and take a break for about 20 s between testing. The evaluation of consumer preference for all cheese samples was conducted on the same day the cheese was manufactured. Consumer preference test for variables such as color, aroma, texture, acidity, fibrousness and overall acceptance was done. The sensory analysis was performed by a panel of 25 semi-trained panel. The testing and scoring was based on a 7-point hedonic scale, (7-like extremely, 6-like very much 5-Like, 4-neither like nor dislike, 3-dislike 2-Dislike very much and 1-dislike extremely [19].

2.2.4. Microbial Load Determination

Microbial loads for total coliform count, yeasts and moulds, and faecal coliforms were determined according to standard methods. Twenty-five (25) grams of the cheese samples were homogenized in 225 ml sodium citrate solution (2%), serially diluted and inoculated on plates in replicates. Total coliform counts (TCC) were enumerated by pour plating on MacConkey agar and incubating at 37°C for 24 h. Yeasts and molds were determined on Potato Dextrose Agar (PDA) supplemented with 0.01% chloramphenicol and incubating at 25°C for 5-7 days [20]. Fecal coliform counts were enumerated on EMB agar and incubated at 37°C for 24 hours. Cheese samples were serially diluted up to 10^5 before being pour plated onto appropriate media.

2.2.5. Procedure for Shelf Life Testing

Shelf life can be tested by either real-time or by accelerated methods. In this study, real-time technique was used. Shelf life was determined by monitoring the yeasts and molds counts of samples stored at 4°C for 21 days at intervals of 7 days. Shelf life was determined according to the method by Labuza [21], and Calligaris *et al*. [22]. The other variables such as packaging and environmental conditions were kept constant. Yeast and mold counts obtained for each day of analysis were plotted against time. The regression model obtained was fitted to the reaction kinetics model of zero-order and the shelf life extrapolated.

Formula for expressing the reaction order is given below (Eqs. 1-3):

$$\frac{d[YM]}{dt} = k[YM]^n \quad (1)$$

Where: K is the rate constant of reaction, n is order of the reaction (a curve fitting parameter),

$$[YM] = [YM]_{0+kt} \quad (2)$$

$$S.L: = \frac{[YM]-[YM]_O}{k} \quad (3)$$

YM is the maximum yeasts and moulds count as a factor of measuring quality (100 cfu/g). YM_0= Initial yeasts and moulds count.

S.L: is the predicted shelf life in days.

2.3. Data Analysis

A completely randomized design (CRD) was used in this study. Where, there were 12 treatments which are the levels of OFSP flour incorporation at 0, 0.5, up to 5.5% on weight basis. The 0% treatment was the control and the treatments were replicated 3 times. Response variables were initial microbial load, sensory parameters and shelf life. Microbial data was first transformed to $\log_{10}$ before analysis. Analysis of variance, regression analysis, cluster analysis, principal component analysis and post-hoc analysis using Tukey's HSD (Honestly significant difference) were carried out using Minitab® software version 18 at 95% confidence level. Data were reported as mean ± standard error.

3. RESULTS

3.1. Consumer Acceptability

3.1.1. Sensory Evaluation

Consumer panel rating of the sensory attributes of mozzarella-style cheeses enriched with OFSP is shown in Table **1**. There were no significant ($p > 0.05$) differences of mean hedonic scores of sensory attributes across the treatments except for color. Color was significantly ($p < 0.05$) affected by the level of OFSP incorporation into the mozzarella cheese where the control was rated the highest with score of 6.40, while incorporation level of 5.5% rated the lowest with score of 4.72. Mozzarella-style cheese with OFSP incorporation level of 0.5% was rated the highest on aroma (5.60), texture (5.76), fibrousness (5.36), and overall acceptability (5.72), while mozzarella-style cheese with 3.0% OFSP was rated the highest (5.68) on taste.

3.1.2. Cluster Analysis of Sensory Properties

Cluster analysis of the sensory attributes of mozzarella cheese enriched with OFSP as scored by the panelists is shown in Fig. (**1**). The contribution of the sensory attributes towards the overall acceptability of the cheese products was found to cluster into three groups: cluster one had only colour, cluster two had aroma, texture and fibrousness, while cluster three had taste and acidity.

3.1.3. Principal Component Analysis

Loading matrix of the sensory attributes of mozzarella-style cheeses on principal components is shown in Table **2**. All the sensory attributes loaded positively on principal component one (53.2%) while only taste, acidity, and fibrousness loaded negatively on component two (12.1%). The pictorial output on how sensory attributes were loading on the principal component analysis is shown in Fig. (**2**). The two principal components accounted for approximately 65.3% of sensory attributes important in cheese where color and texture were the major sensory attributes contributing to the overall acceptability of the cheese, while fibrousness and acidity were the least attributes contributing to the acceptability of mozzarella cheese.

3.2. Shelf Life of Cheeses

3.2.1. Initial Microbial Load

The initial microbial counts of the mozzarella cheeses were evaluated on the day of manufacture (day zero-0) and the total coliforms counts and *E. coli* were not found in the samples. This then formed the basis for using the yeasts and molds as the target spoilage microorganism in this study.

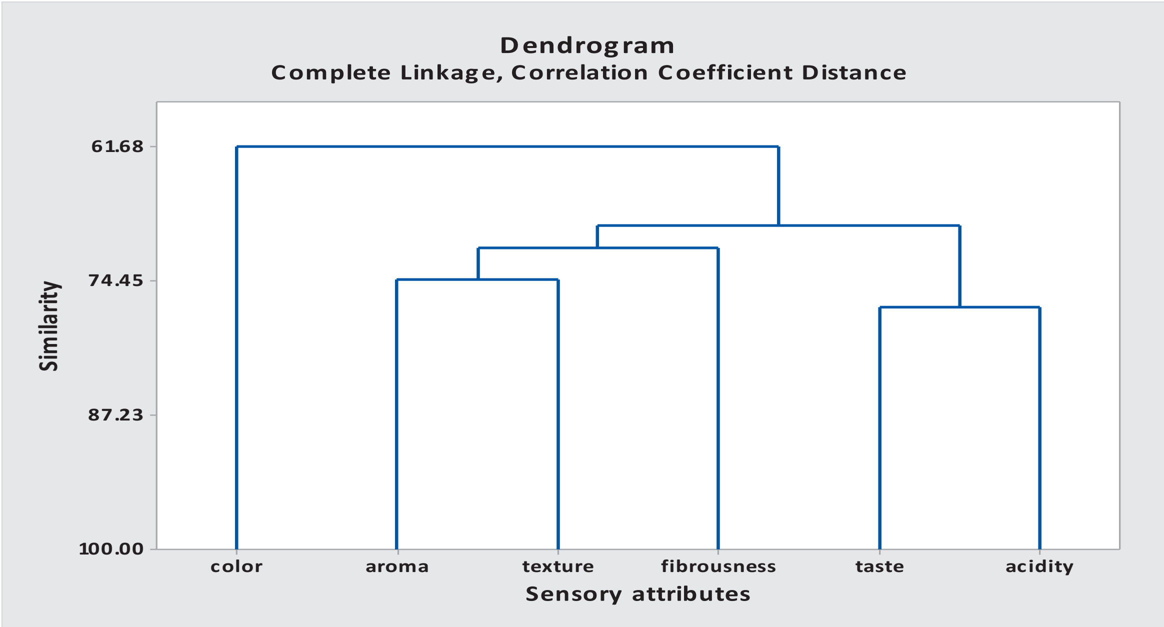


Fig. (1). Dendrogram showing the correlation coefficient distances among the study variables. (*A higher resolution / colour version of this figure is available in the electronic copy of the article*).

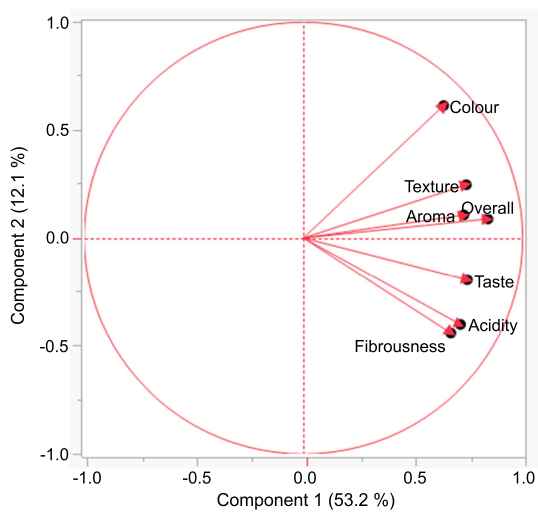


Fig. (2). Principal component analysis showing the loading of sensory attributes of mozzarella-style cheeses. (*A higher resolution / colour version of this figure is available in the electronic copy of the article*).

3.2.2. Effect of Storage Time on Yeasts and Molds Growth

The effect of OFSP incorporation in mozzarella cheese on yeasts and molds growth during storage is presented in Fig. (**3**). Molds were detected on day 7 of cheese storage for most of the treatments. The molds continued to multiply till day 21. However, the control and the treatments with OFSP up to 1.5% had significantly lower ($p<0.05$) mold counts at days 14 and 21 compared with the treatments with over 2% OFSP incorporation. The treatment having 5.5% OFSP had the highest mold count while the control had the least counts on day 21.

3.2.3. Predicted Shelf Life of the Mozzarella-style Cheeses

Counts obtained for each day of analysis of the mozzarella cheeses enriched with OFSP were plotted against time and gave a first order reaction as shown in Fig. (**4**). The coefficient of determination was well above 0.95. The regression model obtained was fitted to reactions kinetics model of zero-order and the shelf life extrapolated. The effect of OFSP substitution level in mozzarella cheese on predicted shelf life in days at 4±1°C using regression model is shown in Table **3**. It was predicted that the control had the longest shelf life of 41.5 days, while mozzarella-style cheese with 5.5% OFSP had the shortest shelf life of 29.1 days.

Table 1. Hedonic scores of sensory attributes for the mozzarella-style cheeses with different levels of OFSP.

OFSP (%)	Colour	Aroma	Texture	Taste	Acidity	Fibrousness	Overall
0.0	6.40±0.15[a]	5.08±0.28[a]	5.48±0.30[a]	5.40±0.24[a]	5.12±0.28[a]	5.08±0.24[a]	5.56±0.22[a]
0.5	6.04±0.19[ab]	5.60±0.19[a]	5.76±0.19[a]	5.44±0.28[a]	5.08±0.24[a]	5.36±0.19[a]	5.72±0.17[a]
1.0	5.64±0.23[b]	5.52±0.23[a]	5.28±0.22[a]	5.56±0.25[a]	5.64±0.23[a]	5.04±0.18[a]	5.44±0.18[a]
1.5	4.80±0.25[c]	4.96±0.25[a]	5.44±0.19[a]	5.28±0.27[a]	5.40±0.19[a]	5.20±0.22[a]	5.08±0.20[a]
2.0	4.76±0.27[c]	5.28±0.30[a]	5.12±0.23[a]	5.44±0.23[a]	5.20±0.28[a]	4.92±0.27[a]	5.08±0.26[a]
2.5	4.40±0.23[d]	4.80±0.27[a]	4.76±0.25[a]	5.32±0.20[a]	4.88±0.25[a]	5.00±0.27[a]	4.96±0.22[a]
3.0	5.64±0.22[bc]	5.40±0.16[a]	5.36±0.24[a]	5.68±0.24[a]	5.48±0.19[a]	5.28±0.23[a]	5.60±0.22[a]
3.5	5.12±0.28[c]	5.40±0.21[a]	5.24±0.18[a]	5.32±0.19[a]	5.04±0.23[a]	5.24±0.18[a]	5.16±0.24[a]
4.0	5.40±0.20[c]	5.32±0.19[a]	5.12±0.18[a]	5.24±0.18[a]	5.00±0.25[a]	5.32±0.22[a]	5.48±0.20[a]
4.5	4.92±0.30[c]	5.16±0.21[a]	5.20±0.26[a]	5.12±0.25[a]	5.28±0.26[a]	4.84±0.23[a]	4.96±0.24[a]
5.0	5.00±0.24[c]	5.32±0.22[a]	5.12±0.24[a]	5.24±0.19[a]	5.16±0.24[a]	5.08±0.23[a]	4.92±0.24[a]
5.5	4.72±0.30[cd]	5.12±0.27[a]	4.96±0.25[a]	5.32±0.22[a]	5.44±0.22[a]	4.92±0.21[a]	4.96±0.27[a]

Key: The values are means standard deviations of triplicate measurements. Letters with different superscript along the column are statistically different at $p<0.05$.

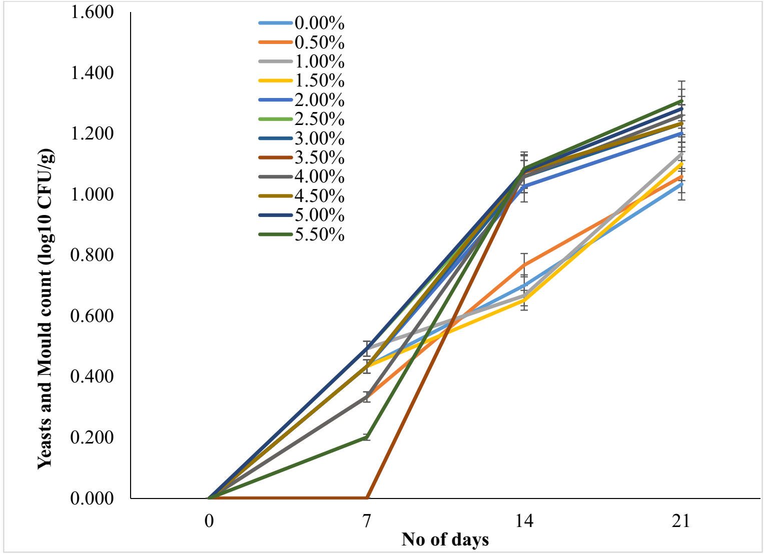
Table 2. Table showing cluster analysis for sensory attributes of mozzarella cheese enriched with OFSP.

Sensory Attribute	Principal Component 1	Principal Component 2
Colour	0.63919	0.61370
Aroma	0.73113	0.10725
Texture	0.74231	0.24697
Taste	0.74709	-0.19405
Acidity	0.71560	-0.40128
Fibrousness	0.67184	-0.44135
Overall	0.84103	0.08874

4. DISCUSSION

The overall consumer acceptability of the mozzarella cheeses with orange-fleshed sweet potato (OFSP) was not significantly different among the treatments and had similar score as the control. The overall acceptability of a food product reflects the total sum of the sensory attributes [23]. In this study, hedonic scores for most of the sensory attributes including aroma, texture, taste, acidity, and fibrousness of the OFSP treatments were not significantly different compared with the control (no OFSP incorporation). The similarity of hedonic scores for the sensory attributes for the control and treatments was reflected in the overall acceptability scores, where treatment scores were similar to those of the controls. However, with increase in OFSP incorporation, the cheese visual appearance (color) changed gradually towards yellow probably due to the carotenoids in the OFSP [24].

Cluster analysis is a statistical method used to benchmark consumer liking. It enables both the identification and definition of the key drivers of preference and eventually, sensory specification [25]. In this study, cluster analysis offered a basis for the interpretation of PCA plot and identification of sensory attributes that were related. The sensory attributes grouped into three clusters. The first cluster had only color, indicating that color individually contributed significantly to the acceptability of the cheese products and it laid the foundation for clusters. Similarly, the position of color on the PCA plot indicated a significant contribution to the overall acceptability of the cheeses. Orange-fleshed sweet potato is rich in pro-vitamin A (beta-carotene) [24] that gives a yellow/orange color that could affect consumer acceptability. Therefore, the variations observed in the study treatments are attributed to color intensity that depend on the amount of OFSP incorporated into the product. This is in tandem with other studies where it is documented that visual appearance massively influences



Key: CFU= colony forming unit per gram.

Fig. (3). Effect of OFSP substitution in mozzarella on yeasts and moulds growth during storage. (*A higher resolution / colour version of this figure is available in the electronic copy of the article*).

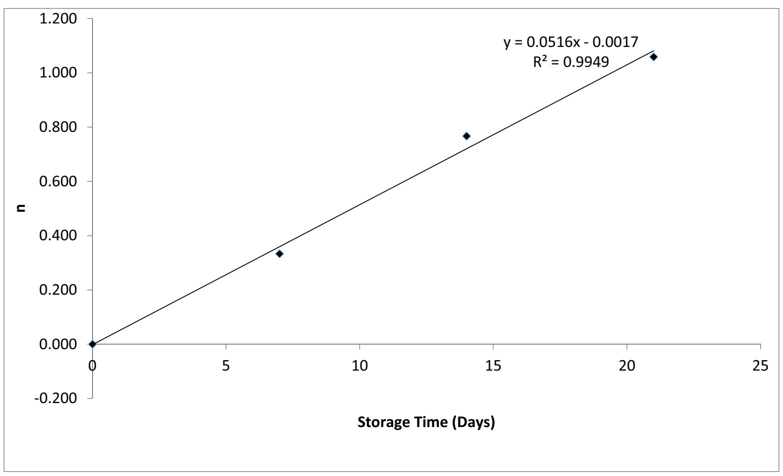


Fig. (4). Regression curve showing linear growth model for yeasts and moulds. (*A higher resolution / colour version of this figure is available in the electronic copy of the article*).

consumer acceptability of food [26]. In cluster two, there were aroma, texture and fibrousness. The position of texture on the PCA plot indicated that it had a significant contribution to the overall acceptability of the cheeses, although ANOVA of the hedonic scores did not detect significant variation between the treatments and the control. Texture is a hard-to-measure attribute, which is a sensory and functional manifestation of the structural, mechanical and surface properties of foods [27, 28]. Texture is determined by the fingers, tongue, incisors and molars when the cheese is chewed by the panelists and the added quantities of OFSP may not be high enough to alter textural characteristics to be detected. However, OFSP is high in starch compared to the cheese matrix, hence it could affect the cheese gelling matrix (texture) and thus affect overall acceptability of the products. This is similar to an observation by Bi *et al*. [29], who found that addition of inulin to mozzarella cheese affected the molecular interactions and spatial arrangements of the proteins and fat globules, hence affecting texture. The fibrous texture (fibrousness) loaded negatively on component two of PCA plot and thus incorporation of the OFSP had a negative effect on the overall acceptability of the cheeses.

The flavor parameters of taste and aroma in the cheeses could not be differentiated by the panelists. Taste and aroma clustered differently in cluster analysis, which was consistent with their positions on the PCA plot. The contribution of the flavor parameters to the overall acceptability of the cheeses was minimal. Flavor is the sensory impression of food determined mainly by the chemical senses of taste and smell

Table 3. Table showing predicted shelf life as extrapolated by the regression model.

OFSP Level	Regression Model	R^2	Shelf Life (Days)
0.0	Y=0.0481X+0.037	0.9908	41.5
0.5	Y=0.0516X-0.007	0.9949	39.0
1.0	Y=0.051X+0.037	0.9740	39.0
1.5	Y=0.0503X+0.019	0.9840	39.8
2.0	Y=0.0599X+0.036	0.9633	33.4
2.5	Y=0.0609X+0.056	0.9618	32.8
3.0	Y=0.0618X+0.033	0.9615	32.3
3.5	Y=0.0682X-0.139	0.8482	29.3
4.0	Y=0.064X-0.013	0.9562	31.1
4.5	Y=0.062X+0.035	0.9559	32.3
5.0	Y=0.0633X+0.048	0.9687	31.6
5.5	Y=0.0687X-0.073	0.9272	29.1

[30]. Smell is the main determinant of a food item's flavor, whereas the taste of food is limited to sweet, sour, bitter, salty, and umami. Cheese flavor emanates from the free fatty acids, probably hexanoic, butyric or methyl octanoic acids, resulting from the breakdown of amino acids, fatty acids, lactic acid and the metabolism of citrate from milk [31, 32]. The volatile fatty acids in the cheese could mask other flavors from the OFSP that is comprised of mostly starch polymers and soluble fiber that could be fermented along with milk ingredients, hence having a little contribution to cheese flavor, explaining the similarity of aroma and taste hedonic scores between the controls and the treatments.

Acidity loaded negatively on principal component 2 and had a negative effect on the taste and overall acceptability of the cheeses. The sour taste stimuli in this case comprised of acids mainly citric acid or lactic acid [33]. The acid development in cheese comes about from the breakdown of milk lactose to lactic acid by the action of starter microorganisms and thus affect cheese hedonic scores. Fernandez-Garcia and McGregor [34] reported that fiber addition did not significantly affect lactic acid production by the starter cultures. In this study, addition of OFSP did not affect acidity hedonic scores among the treatments and the control.

Evaluation of microbial quality was done through the analysis for total coliform, *Escherichia coli*, and yeasts and molds counts [35]. Total viable counts were excluded since starter microorganisms were found to be growing on the plate count agar. In all successive plating, there was no growth for total coliforms and *E. coli* but only for yeasts and molds and the results were not significantly different among the treatments and the control. This could be attributed to the lactic acid starter bacteria that acidified the cheese matrix through, presenting an inhibitory environment for the spoilage bacteria. The Codex Alimentarius Standard (CAC) for microbiological quality for mozzarella cheese require the total viable counts (TVC) of 400 cfu/g or less, mold count of less than100 cfu/g, and yeast counts of less than 10 cfu/g. This implied that hygienic standards were observed during the processing of the cheeses in this study and the microbial safety to consumers was assured.

Shelf life study of mozzarella-style cheeses enriched with OFSP showed that the higher the amount of OFSP incorporated into the cheese, the lower the shelf life of the product. The shelf life of the control (0% OFSP incorporation) was predicted to be 42 days compared with reduced shelf life of the treatments which was predicted to be 29 days for treatments with 5.5% OFSP incorporation. OFSP incorporation probably destabilized the protein-protein cheese matrix and provided an energy source for the growth of yeast and molds. Mozzarella cheese can be utilized just after processing as compared to the other specialty cheeses. It can also be stored, presenting a marketing opportunity for mozzarella-style cheeses that could be utilized for dietary interventions up to 5.5% OFSP incorporation. On the other hand, mold inhibitors along with modified atmosphere packaging could be used along with OFSP incorporation if longer shelf life of the cheeses is desired [36].

CONCLUSION

This study sought to determine the sensory acceptability of mozzarella-style cheeses incorporating orange-fleshed sweet potato (OFSP). Compared with the control, the treatments with OFSP did not exhibit significant differences in mean hedonic scores for overall acceptability and sensory attributes except for color. OFSP is orange/yellow in color due to high level of beta-carotene, hence its influence on color's hedonic scores. This indicated that incorporation of OFSP did not significantly alter consumer acceptability of the products. Incorporation of OFSP to the mozzarella cheese matrix did not significantly affect the initial microbial load of the cheese, meaning that it did not alter the overall microbiological quality of the products. The shelf life of the mozzarella-style cheeses incorporating OFSP was significantly affected by the substitution level. The higher the substitution level, the lower the shelf life as exhibited by higher microbial counts especially the molds. The use of OFSP enrichment of mozzarella cheese could therefore be promoted as a novel food. The products can be consumed immediately after manufacture or recruit food grade mold inhibitors for extended shelf lives.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

Not applicable.

HUMAN AND ANIMAL RIGHTS

No animals/humans were used for studies that are the basis of this research.

CONSENT FOR PUBLICATION

Not applicable.

FUNDING

This work was supported by a grant from the African Development Bank to Egerton University, Kenya (Grant Number: MOE/HEST/03/2017-2018).

AVAILABILITY OF DATA AND MATERIALS

The data supporting the findings of the article is available in the [Egerton University Library, Kenya] at [https://www.egerton.ac.ke/].

CONFLICT OF INTEREST

The authors declare no conflicts of interest, financial or otherwise.

ACKNOWLEDGEMENTS

Declared none.

REFERENCES

[1] Aryana KJ, Olson DW. A 100-Year Review: yogurt and other cultured dairy products. J Dairy Sci 2017; 100(12): 9987-10013. http://dx.doi.org/10.3168/jds.2017-12981 PMID: 29153184

[2] Ah J, Tagalpallewar GP. Functional properties of mozzarella cheese for its end use application. J Food Sci Technol 2017; 54(12): 3766-78. http://dx.doi.org/10.1007/s13197-017-2886-z PMID: 29085119

[3] Da Silva BV, Barreira JC, Oliveira MBP. Natural phytochemicals and probiotics as bioactive ingredients for functional foods: extraction, biochemistry and protected-delivery technologies. Trends Food Sci Technol 2016; 50: 144-58. http://dx.doi.org/10.1016/j.tifs.2015.12.007

[4] Hoque MZ, Alam MN, Nahid KA. Health consciousness and its effect on perceived knowledge, and belief in the purchase intent of liquid milk: consumer insights from an emerging market. Foods 2018; 7(9): 150. http://dx.doi.org/10.3390/foods7090150 PMID: 30205455

[5] Meyer KA, Kushi LH, Jacobs DR Jr, Slavin J, Sellers TA, Folsom AR. Carbohydrates, dietary fiber, and incident type 2 diabetes in older women. Am J Clin Nutr 2000; 71(4): 921-30. http://dx.doi.org/10.1093/ajcn/71.4.921 PMID: 10731498

[6] DiNicolantonio JJ, Lucan SC, O'Keefe JH. The evidence for saturated fat and for sugar related to coronary heart disease. Prog Cardiovasc Dis 2016; 58(5): 464-72. http://dx.doi.org/10.1016/j.pcad.2015.11.006 PMID: 26586275

[7] Jalal H, Ahmad PP, Ganguly S, *et al.* Fortification of dairy products: a review. World J Biol Med Sci 2016; 3: 23-35.

[8] Childs JL, Drake M. Consumer perception of fat reduction in cheese. J Sens Stud 2009; 24(6): 902-21. http://dx.doi.org/10.1111/j.1745-459X.2009.00243.x

[9] Karimi R, Azizi MH, Ghasemlou M, Vaziri M. Application of inulin in cheese as prebiotic, fat replacer and texturizer: a review. Carbohydr Polym 2015; 119: 85-100. http://dx.doi.org/10.1016/j.carbpol.2014.11.029 PMID: 25563948

[10] Yangilar F. The application of dietary fibre in food industry: structural features, effects on health and definition, obtaining and analysis of dietary fibre: a review. J Food Nutr Res 2013; 1: 13-23. http://dx.doi.org/10.12691/jfnr-1-3-1

[11] Sendra E, Fayos P, Lario Y, Fernández-López J, Sayas-Barberá E, Pérez-Alvarez JA. Incorporation of citrus fibers in fermented milk containing probiotic bacteria. Food Microbiol 2008; 25(1): 13-21.10.1016/j.fm.2007.09.003 http://dx.doi.org/10.1016/j.fm.2007.09.003 PMID: 17993372

[12] Hashim IB, Khalil AH, Afifi HS. Quality characteristics and consumer acceptance of yogurt fortified with date fiber. J Dairy Sci 2009; 92(11): 5403-7. http://dx.doi.org/10.3168/jds.2009-2234 PMID: 19841201

[13] Kiiru SN, Mahungu SM, Omwamba M. Preparation and analysis of goat milk mozzarella cheese containing soluble fiber from *Acacia senegal* var. *kerensis.* Afr J Food Sci 2018; 12: 46-53. http://dx.doi.org/10.5897/AJFS2017.1652

[14] Huang AS, Tanudjaja L, Lum D. Content of alpha-, beta-carotene, and dietary fiber in 18 sweet potato varieties grown in Hawaii. J Food Compos Anal 1999; 12: 147-51. http://dx.doi.org/10.1006/jfca.1999.0819

[15] Dibi KEB, Essis BS, N'zué B, *et al.* Participatory selection of orange-fleshed sweet potato varieties in North and North-East Côte d'Ivoire. Open Agric 2017; 2: 83-90.

[16] Soliman GA. Dietary Fiber, Atherosclerosis, and cardiovascular disease. Nutrients 2019; 11(5): 1155. http://dx.doi.org/10.3390/nu11051155 PMID: 31126110

[17] Dhingra D, Michael M, Rajput H, Patil RT. Dietary fibre in foods: a review. J Food Sci Technol 2012; 49(3): 255-66. http://dx.doi.org/10.1007/s13197-011-0365-5 PMID: 23729846

[18] Jeewanthi RK, Lee NK, Lee KA, Yoon YC, Paik HD. Comparative analysis of improved soy-mozzarella cheeses made of ultrafiltrated and partly skimmed soy blends with other mozzarella types. J Food Sci Technol 2015; 52(8): 5172-9. http://dx.doi.org/10.1007/s13197-014-1542-0 PMID: 26243939

[19] Meilgaard M, Civille GV, Carr BT. Sensory evaluation techniques 4. Boca Raton: Taylor & Francis 2006. http://dx.doi.org/10.1201/b16452

[20] Spitaels F, Wieme AD, Janssens M, *et al.* The microbial diversity of traditional spontaneously fermented lambic beer. PLoS One 2014; 9(4): e95384. http://dx.doi.org/10.1371/journal.pone.0095384 PMID: 24748344

[21] Labuza TP. Application of chemical kinetics to deterioration of foods. J Chem Educ 1984; 61(4): 348-54. http://dx.doi.org/10.1021/ed061p348

[22] Calligaris S, Manzocco L, Lagazio C. Modeling shelf life using chemical, physical, and sensory indicators. Shelf life assessment of food. Boca Raton, USA: CRC Press 2012; pp. 75-126. http://dx.doi.org/10.1201/b11871-6

[23] Murray J, Delahunty C. Mapping consumer preference for the sensory and packaging attributes of Cheddar cheese. Food Qual Prefer 2000; 11: 419-35. http://dx.doi.org/10.1016/S0950-3293(00)00017-3

[24] Neela S, Fanta SW. Review on nutritional composition of orange-fleshed sweet potato and its role in management of vitamin A deficiency. Food Sci Nutr 2019; 7(6): 1920-45. http://dx.doi.org/10.1002/fsn3.1063 PMID: 31289641

[25] Everitt M. Consumer-targeted sensory quality. Global issues in food science and technology. USA: Academic Press 2009. http://dx.doi.org/10.1016/B978-0-12-374124-0.00008-9

[26] Jürkenbeck K, Meyerding SGH. Preferences for fresh tomatoes with a focus on young consumers in Germany–Choice-experiment and latent class analysis. Eur J Hortic Sci 2019; 84: 325-31. http://dx.doi.org/10.17660/eJHS.2019/84.6.1

[27] Antmann G, Ares G, Varela P, Salvador A, Coste B, Fiszman SM. Consumers' texture vocabulary: results from a free listing study in three Spanish-speaking countries. Food Qual Prefer 2011; 22(1): 165-72. http://dx.doi.org/10.1016/j.foodqual.2010.09.007

[28] Szczesniak AS. Texture is a sensory property. Food Qual Prefer 2002; 13: 215-25. http://dx.doi.org/10.1016/S0950-3293(01)00039-8

[29] Bi W, Zhao W, Li D, *et al.* Effect of resistant starch and inulin on the properties of imitation mozzarella cheese. Int J Food Prop 2016; 19(1): 159-71. http://dx.doi.org/10.1080/10942912.2015.1013634

[30] Saffarionpour S, Ottens M. Recent advances in techniques for flavor recovery in liquid food processing. Food Eng Rev 2018; 10(2): 81-94. http://dx.doi.org/10.1007/s12393-017-9172-8

[31] De Luca L, Aiello A, Pizzolongo F, Valentino M, Torrieri E, Romano R. Quality indices of cheese oxidation during storage. Ital J Food Sci 2019; 1: 27-31.

[32] Reyes-Díaz R, González-Córdova AF, Del Carmen Estrada-Montoya M, *et al.* Volatile and sensory evaluation of Mexican Fresco cheese as affected by specific wild *Lactococcus lactis* strains. J Dairy Sci 2020; 103(1): 242-53. http://dx.doi.org/10.3168/jds.2019-17188 PMID: 31733845

[33] DeSimone JA, Lyall V, Heck GL, Feldman GM. Acid detection by taste receptor cells. Respir Physiol 2001; 129(1-2): 231-45. http://dx.doi.org/10.1016/S0034-5687(01)00293-6 PMID: 11738657

[34] Fernandez-Garcia E, McGregor JU. Fortification of sweetened plain yogurt with insoluble dietary fiber. Eur Food Res Technol 1997; 204: 433-7.

[35] Lázár V, Martins A, Spohn R, *et al.* Antibiotic-resistant bacteria show widespread collateral sensitivity to antimicrobial peptides. Nat Microbiol 2018; 3(6): 718-31. http://dx.doi.org/10.1038/s41564-018-0164-0 PMID: 29795541

[36] Guynot ME, Marín S, Sanchis V, Ramos AJ. An attempt to optimize potassium sorbate use to preserve low pH (4.5-5.5) intermediate moisture bakery products by modelling *Eurotium* spp., *Aspergillus* spp. and *Penicillium corylophilum* growth. Int J Food Microbiol 2005; 101(2): 169-77. http://dx.doi.org/10.1016/j.ijfoodmicro.2004.11.002 PMID: 15862879