Optimization of Sensory Attributes and Acceptability of Cookies made from Wheat-Tiger Nut Flour under different Storage Conditions

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ABSTRACT

Background: *The global demand of tiger nut for its nutritional, functional and medicinal properties in food fortification is constantly increasing and requires further analysis of its product.*

Objective: *In this work, sensory result of cookies produced from wheat flour blended with tiger nut flour under different storage conditions for three weeks was evaluated for each week of the storage.*

Methods: *Data generated from sensory attributes was validated using statistical control chart design to determine critical control points (CCPs) for quality product. At 5% level of significance, the degree of similarity during optimization of different formulated samples was further investigated to establish quality level of acceptability of each product sample based on control limits convergence.*

Results: *In the first week of storage, sample WTD 121 had close range of convergence indicating high level of acceptability. In the second and third week of storage, both samples WTD 141 and WTD 151 had high acceptability. Microbial analysis during storage at week 0, 1, 2 and 3 showed that under ambient condition, bacteria count ranges from 0 to 7 x 10^2 cfu/g and fungi count ranges from 0 to 4.5 x 10^2 cfu/g. Storage under refrigeration condition revealed that bacteria count ranges from 0 to 3 x 10^2 cfu/g and fungi count ranges from 0 to 1.5 x 10^2 cfu/g. Bacteria and fungi count ranges from 0 to 3.0 x 10^2 cfu/g and 0 to 1.0 x 10^2 cfu/g respectively under freezing storage condition.*

Conclusion: *The product falls within control limits and within standard of microbial specification for food.*

Keywords: *Cookies, optimization, attributes, quality, acceptability*

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INTRODUCTION

Cookies are snack made from different flours and distinguished by level of fortification, nutritional value, colour, processing method and type of flour used. Cookies are majorly made from flour, sugar, salt, fat and water. The water level is low relatively so as to prevent microbial spoilage and thus enhances long shelf-life [1]. Wheat is the most widely produced cereal in the world mostly for human consumption and its contribution to energy intake is significant [2]. The processing of whole wheat to wheat flour for the production of bread, biscuit, pasta and other products is a global concern that has gained overwhelming research interest. Because of its widespread geographic distribution, acceptance, stability, and versatility, wheat flour is a suitable vehicle for delivering micronutrients to the body [3]. Wheat is a good source of vitamins: thiamine, riboflavin, niacin and pyridoxine; minerals such as iron and zinc. Most of these nutrients are concentrated in the outer layers of the wheat grain; a significant proportion is lost during milling process.

Generally, in foods, the stability of vitamins is more precarious than that of minerals because vitamins are sensitive to heat, oxidizing and reducing agent, light, and other kind of physical and chemical stress. Kince et al., [4] reported that vitamins are stable in flour but adversely affected by high humidity and temperature.

There are three varieties of tiger nut (*Cyperus esculentus* L.) namely black, brown and yellow [5]. However, only yellow and brown varieties are readily available in the market. The yellow variety is preferred to all other varieties because of its inherent properties such as big size, attractive colour and fleshy body. Tiger nut can be eaten raw, roasted, dried, baked or be made into a refreshing beverage called *Horchata de shufas* or tiger nut milk [6]. Tiger nut milk is a nutritive and energetic drink for young and old people. It is tremendously high in carbohydrate, proteins, minerals and vitamins. Tiger nut milk contains a large amount of oleic acid and in the prevention of cardiac arrest, constipation and diarrhea [7, 8]. Tiger nut milk has never been found to produce allergy and it is useful in the preparation of *kunu,* a local beverage in Nigeria. The chemical composition and functional properties of flour produced from yellow and brown varieties of tiger nut have been studied and found useful in food formulation [9]. It has also been reported that, tiger nut, with its inherent nutritional and therapeutic advantage, could serve as good alternative to cassava in baking industry [9].

The date palm tree (*Phoenix dactylifera* L.) has over 2,500 species. The name of the species dactylifera means finger-bearing, referring to the clusters of fruit produced by the plant [10, 11]. Very recently, the entire date palm tree genome was re-sequenced to provide insights into a fruit tree crop's diversification [11 - 13]. Date contains many nutrients such as carbohydrates, dietary fibres, proteins, fat, minerals and vitamins. The Color, sugar, moisture and the absence of defects such as insects, injury, cracks and surface degradation are the most critical quality attributes of dates [14]. In more detail, carbohydrates form 70 percent of the date fruit and are usually fructose and glucose, while date proteins are high in amino acids containing the acidic side chain, but low in methionine and cysteine [12]. This research is to optimize sensory attributes of cookies made from wheat blended with tiger nut flour using date palm fruit as sweetener and determination of critical control limits, quality of the products and level of acceptability.

MATERIALS AND METHODS

Specimen Collection and Study Area

Date Palm Fruit, tiger nut and other ingredients such as wheat flour, milk, egg, salt, margarine (fat), baking powder, and sugar were purchased at Ota market in Ogun state, Nigeria. The experiment was carried out at Food Science and Technology Laboratory, Bells University of Technology, Ota, Ogun State, Nigeria between June and November, 2020.

Method

The Date Palm Fruit pulp was produced by washing the date palm fruits in tap water, removal of the seeds of the fruit manually and cut into small pieces with the aid of knife and weighing. The pulp with pericarp was then oven dried at 75°C for six hours and subsequently milled to powder (flour) using milling machine and sieved through a suitable mesh size to obtain fine homogeneous particles. The product was sealed in a cellophane bag and stored at room temperature. The unwanted material that can contaminate the tiger nut flour was removed by cleaning, sorting and washing of the tiger nuts. The tiger nut was then oven dried at 75°C for six hours and milled using hammer and attrition mill, and then sieved using the appropriate mesh size to obtain fine and homogeneous particles. The flour was sealed in a cellophane bag and stored at room temperature.

Cookies Flour Formulation Ratios

Date palm fruit pulp (DPFP) was substituted for granulated sugar in the cookies flour formulation. The ratio was such that whole wheat flour: tiger nut flour: date palm fruit flour for samples WTD 111, WTD 121, WTD 131, WTD 141, WTD 151 and WF were as described by Morris et al., [15] using statistical simulation method presented as shown. However, 100% whole wheat flour is treated as control sample. Flowchart for the production of cookies is presented in Figure 1.

WTD 111= 75% Wheat flour + 15% Tiger nut flour + 10% Date palm fruit flour
WTD 121= 70% Wheat flour + 20% Tiger nut flour + 10% Date palm fruit flour
WTD 131= 65% Wheat flour + 20% Tiger nut flour + 15% Date palm fruit flour
WTD 141= 60% Wheat flour + 15% Tiger nut flour + 25% Date palm fruit flour
WTD 151= 50% Wheat flour + 30% Tiger nut flour + 20% Date palm fruit flour
WF= 100% Wheat flour.

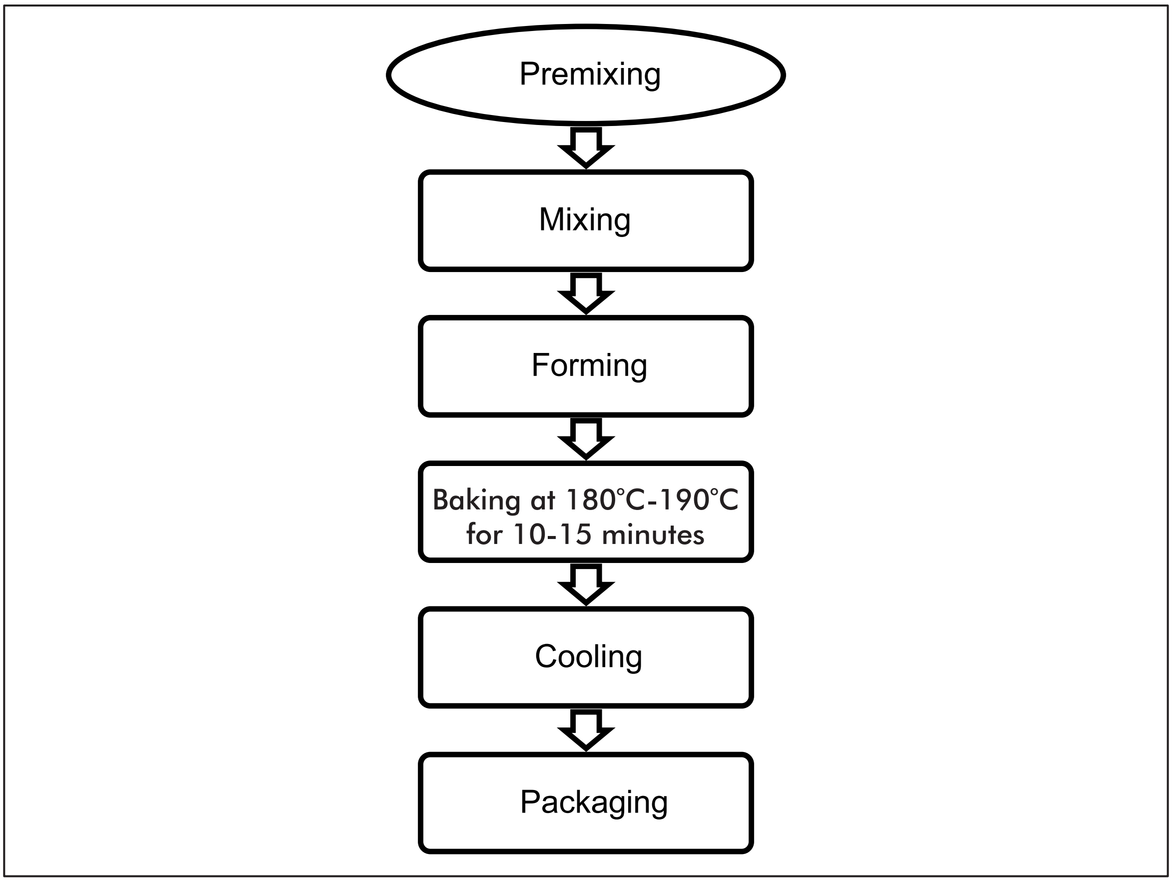


Figure 1. Flowchart for the production of cookies.

Evaluation of sensory attributes

Consumer assessment for acceptability of cookies was carried out according to Sanni et al., [16]. Forty (40) people were selected randomly from staff and students of Bells University of Technology, Ota, Nigeria for the evaluation. These are regular consumers of cookies. A designed questionnaire was distributed among the forty respondents to score the following attributes: colour, appearance, aroma, taste and overall acceptability on a Hedonic scale of 9 points namely 9 (like extremely), 8 (like very much), 7 (like moderately), 6 (like slightly), 5 (neither like nor dislike), 4 (dislike slightly), 3 (dislike moderately), 2 (dislike very much) and 1 (dislike extremely). Each of the samples from each storage condition (ambient, refrigeration and freezing) was coded differently and placed in separate identical, transparent and sealed package. Each of the samples was presented on a clean table at different times to each respondent to avoid any bias in judgement. This evaluation was done on the first, second and third week of storage. Between samples, the respondents were given unsalted crackers and distilled water to wipe away their palates. The responses were collated to compare the consumer preferences of the cookies.

Storability test

Microbial analysis was carried out according to Nicoli, [17] on each sample product and under ambient, refrigeration and freezing storage conditions for a period of three weeks.

Statistical analysis

The data obtained was analyzed and interpreted by analysis of variance (ANOVA) for each sample. Duncan's Multiple Range Test (DMRT) at a level of 5% significance, using Statistical Analysis System (SPSS version 2.3) and mean values in row with different superscript was significantly difference ($p<0.5$).

Sample optimization

The response of respondents on each sample product under different storage conditions was seems to be significantly similar. It is therefore necessary to optimize sensory attributes using statistical quality assessment procedure so as to determine critical control points (CCPs) and establish critical limits for each CCP.

Procedure for determining control limits

Below is the step-by-step procedure to determine control limit using $\bar{\bar{x}}$ **chart**

(i). Draw a sample size $\{x_1, x_2, x_3, \ldots\ldots\ldots x_k\}$

(ii). Repeat (i) for n samples at equal interval of time

(iii). Calculate the sum $\sum x$ for each sample

(iv). Calculate the mean $\bar{x} = \frac{\sum x}{k}$ for each sample

(v). Calculate the mean of the mean i$\bar{\bar{x}}$(iv) for all observation where $\bar{\bar{x}} = \frac{\sum \bar{x}}{n}$

(vi). Calculate the variance $S^2 = \frac{\sum (x - \bar{x})^2}{k}$ for each sample

(vii). Calculate the standard error (S) for every S^2 in (vi)

(viii). Calculate the mean $\bar{S} = \frac{\sum S}{n}$ for all standard errors in (vii)

(ix). Obtain the control limit for x as follow:

(a) $\bar{\bar{x}}$ - Central control limit (CCL)

(b) $\bar{\bar{x}} + \frac{3\bar{s}}{\sqrt{n-1}}$ - Upper control limit (UCL)

(c) $\bar{\bar{x}} - \frac{3\bar{s}}{\sqrt{n-1}}$ - Lower control limit (LCL).

RESULT AND DISCUSSION

Effect of sensory optimization on quality cookies under different storage conditions

In the first week of storage as shown in Table 1, optimization of cookies under different storage conditions reveals that sample WTD 111 showed significant difference in colour during refrigeration and freezing conditions ($P<0.5$) while samples WTD 121, WTD 131, WTD 141, WTD 151 and WF showed no significant difference in all the sensory attributes ($P>0.5$). Thus, the degree of similarity in optimization result of cookies made from different formulations call for further investigation to establish quality level of acceptability for each of the product samples based on control limits convergence. Other parameters as illustrated in the procedure were stated so as to determine upper, central and lower control limits. Figure 2 (week 1) showed mean storage condition in week 1 and varies between 6 and 6.33 in sample WTD 111; 6.33 and 6.83 in sample WTD 121; 6.67 and 7.17 in sample WTD 131; 6.67 and 7.50 in sample WTD 141; 6.83 and 8.33 in sample WTD 151; and 7.83 and 8.50 in sample WF. The production of cookies made from different formulations under different storage conditions and by consumer's perception is within control limits, therefore in state of statistical quality control similar to control experiment in the first week of storage. However, the range of convergence in samples WTD 111, WTD 141 and WTD 151 is significantly high which suggests wide variance of acceptability among the consumers. Close range of convergence in sample WTD 121 which indicates high level of acceptability may likely be the resultant effect of shelf stability in tiger nut [18].

In the second week of storage as shown in Table 2, optimization result of sample WTD 131 reveals significant variation in taste of cookies under refrigeration and freezing storage conditions. There was no difference in samples WTD 111, WTD 121, WTD 141, WTD 151 and WF significantly in all the sensory attributes at 5% level of significance. The mean storage condition in week 2 is shown in Figure 2 (week 2) and changes from 6 to 6.67 in sample WTD 111; 6.33 to 6.67 in sample WTD 121; 6.33 to 7.50 in sample WTD 131; 6.83 to 7.33 in sample WTD 141; 7.67 to 8.33 in sample WTD 151; and 7.17 to 8.50 in sample WF. The production of cookies made from samples WTD 111, WTD 121, WTD 131, WTD 141 and WTD 151 falls within upper and lower control limits and in state of quality control contrary to control sample. Cookies from control sample (WF) significantly falls outside control limits in the second week of storage and this may be due to low storage potential in refined wheat flour as a result of its substantial low phytochemicals [19]. Close range of convergence in samples WTD 141 and WTD 151 implies high level of acceptability

In the third week of storage as shown in Table 3, no significant difference in all the sensory attributes of cookies under ambient, refrigeration and freezing storage conditions ($P>0.5$). Figure 2 (week 3) showed mean storage condition in week 3, it ranges from 6.33 to 7.33 in sample WTD 111; 6.17 to 7 in sample WTD 121, 6.83 to 7.33 in sample WTD 131; 6.83 to 7.83 in sample WTD 141; 7.67 to 8.50 in sample WTD 151; and 7.50 to 8.33 in sample WF. Cookies from formulated samples under different storage conditions of ambient, refrigeration and freezing were within control limits. However, control sample also falls outside control limit in the third week of storage. High level of acceptability of samples WTD 141 and WTD 151 with close range of control limits of convergence across storage conditions in weeks 2 and 3 may likely be as a result of high tiger nut with date palm fruit inclusions.

Table 1. Optimization of sensory attributes of cookies during week one storage.

Samples	Sensory Attributes	Storage Conditions Amb.	Refr.	Freez.	$\sum x_1$	$\bar{x}$	S^2	S
WTD 111	Colour	6.5[a]	7.5[ab]	5.0[ac]	19	6.33	1.06	1.03
	Appearance	6.5[a]	7.5[a]	5.0[a]	19	6.33	1.06	1.03
	Aroma	7.0[b]	7.0[a]	5.0[ab]	19	6.33	0.89	0.94
	Taste	4.5[a]	8.0[ab]	5.5[a]	18	6.00	2.17	1.47
	Overall Acceptability	5.5[a]	7.5[b]	5.0[ab]	18	6.00	1.17	1.08
						30 99		**5.55**
WTD 121	Colour	6.5[a]	7.0[a]	7.0[a]	20.5	6.83	0.06	0.25
	Appearance	6.5[a]	6.5[a]	6.5[a]	19.5	6.50	0	0
	Aroma	6.0[a]	7.0[a]	6.0[a]	19	6.33	0.22	0.47
	Taste	6.5[a]	6.5[a]	7.5[a]	20.5	6.83	0.22	0.47
	Overall Acceptability	6.5[a]	6.5[a]	6.5[a]	19.5	6.50	0	0
						32.99		**1.19**
WTD 131	Colour	7.0[a]	7.0[a]	6.5[a]	20.5	6.83	0.06	0.25
	Appearance	6.5[a]	6.0[ab]	8.0[a]	20.5	6.83	0.72	0.85
	Aroma	7.0[a]	6.5[a]	7.0[a]	20.5	6.83	0.06	0.25
	Taste	6.0[a]	7.0[a]	7.0[a]	20	6.67	0.22	0.47
	Overall Acceptability	7.5[a]	7.0[b]	7.0[a]	21.5	7.17	0.06	0.25
						34.33		**2.07**
WTD 141	Colour	6.5[a]	8.0[a]	6.5[a]	21	7.00	0.50	0.71
	Appearance	7.0[a]	8.0[a]	6.5[a]	21.5	7.17	0.39	0.63
	Aroma	7.0[a]	8.0[a]	5.0[a]	20	6.67	1.56	1.25
	Taste	6.5[a]	8.0[a]	5.5[a]	20	6.67	1.06	1.03
	Overall Acceptability	7.5[a]	8.5[a]	6.5[a]	22.5	7.50	0.67	0.82
						35.01		**4.44**
WTD 151	Colour	6.0[a]	7.5[a]	8.5[a]	22	7.33	1.06	1.03
	Appearance	6.5[a]	7.0[a]	8.5[a]	22	7.33	0.72	0.85
	Aroma	7.5[ab]	7.5[a]	7.5[a]	22.5	7.50	0	0
	Taste	5.5[a]	7.5[a]	7.5[a]	20.5	6.83	0.89	0.94
	Overall Acceptability	7.5[a]	8.5[a]	9.0[a]	25	8.33	0.39	0.63
						37.32		**3.45**
WF	Colour	8.0[a]	8.5[a]	8.0[a]	24.5	8.17	0.06	0.25
	Appearance	9.0[a]	7.5[ab]	8.5[a]	25	8.33	0.39	0.63
	Aroma	8.5[a]	7.5[a]	7.5[a]	23.5	7.83	0.22	0.47
	Taste	8.0[ab]	8.0[a]	7.5[a]	23.5	7.83	0.06	0.25
	Overall Acceptability	9.0[a]	8.5[a]	8.0[a]	25.5	8.50	0.17	0.41
						40.66		**2.01**

Samples with different letters within column are significantly different (P < 0.5) from each other.

Table 2. Optimization of sensory attributes of cookies during week two storage.

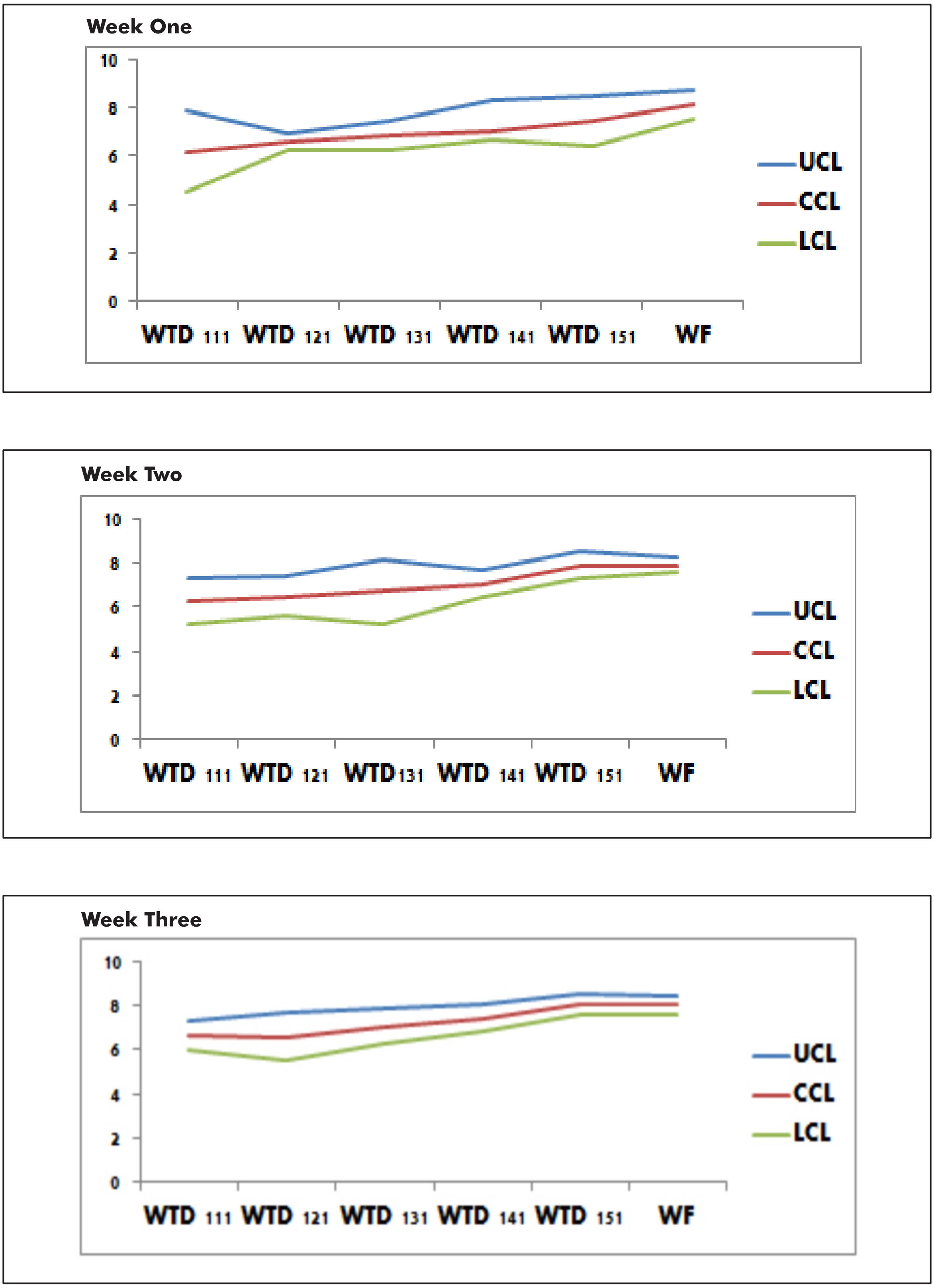
Samples	Sensory Attributes	Storage Conditions			$\sum x_1$	$\bar{x}$	S^2	S
		Amb.	Refr.	Freez.				
WTD 111	Colour	5.5	6.5	6.0	18	6.00	1.67	1.29
	Appearance	8.0^{b}	6.5^{a}	5.0^{a}	19.5	6.50	0.83	0.91
	Aroma	6.5^{a}	6.5^{ab}	5.5^{a}	18.5	6.17	0.22	0.47
	Taste	6.5^{a}	7.0^{a}	6.5^{a}	20	6.67	0.06	0.25
	Overall Acceptability	6.0^{a}	6.5^{b}	5.5^{a}	18	6.00	0.17	0.41
						31.34		**3.33**
WTD 121	Colour	7.0^{a}	6.0^{a}	7.0^{a}	20	6.67	0.22	0.47
	Appearance	6.0^{a}	6.0^{a}	7.0^{ab}	19	6.33	0.22	0.47
	Aroma	6.0^{ab}	6.0^{a}	7.0^{ab}	19	6.33	0.22	0.47
	Taste	6.5^{a}	6.0^{a}	7.5^{a}	20	6.67	0.39	0.63
	Overall Acceptability	7.0^{b}	5.5^{a}	7.0^{a}	19.5	6.50	0.50	0.71
						32.5		**2.75**
WTD 131	Colour	6.0^{a}	5.0^{ab}	8.0^{b}	19	6.33	1.56	1.25
	Appearance	7.0^{a}	6.0^{b}	7.5^{a}	20.5	6.83	0.39	0.63
	Aroma	8.0^{a}	6.5^{a}	8.0^{a}	22.5	7.50	0.50	0.71
	Taste	7.0^{a}	4.5^{ab}	8.0^{ac}	19.5	6.50	2.17	1.47
	Overall Acceptability	7.0^{a}	5.5^{ab}	7.0^{a}	19.5	6.50	0.50	0.71
						33.66		**4.77**
WTD 141	Colour	7.5^{a}	7.0^{a}	7.5^{a}	22	7.33	0.06	0.25
	Appearance	7.5^{a}	7.0^{a}	7.0^{ab}	21.5	7.17	0.06	0.25
	Aroma	7.5^{a}	6.5^{ab}	7.0^{a}	21	7.00	0.17	0.41
	Taste	7.5^{ab}	6.5^{a}	7.0^{a}	21	7.00	0.17	0.41
	Overall Acceptability	7.0^{a}	6.0^{a}	7.5^{a}	20.5	6.83	0.39	0.63
						35.33		**1.95**
WTD 151	Colour	8.0^{a}	7.5^{a}	8.5^{a}	24	8.00	0.17	0.41
	Appearance	7.5^{a}	7.0^{a}	8.5^{ab}	23	7.67	0.39	0.63
	Aroma	7.5^{a}	8.0^{a}	8.0^{a}	23.5	7.83	0.06	0.25
	Taste	7.0^{a}	7.5^{a}	8.5^{a}	23	7.67	0.39	0.63
	Overall Acceptability	8.5^{a}	8.5^{a}	8.0^{a}	25	8.33	0.06	0.25
						39.5		**2.17**
WF	Colour	8.0^{a}	7.5^{a}	7.5^{a}	23	7.67	0.06	0.25
	Appearance	7.0^{a}	7.0^{a}	7.5^{ab}	21.5	7.17	0.06	0.25
	Aroma	8.0^{a}	8.5^{a}	8.0^{a}	24.5	8.17	0.06	0.25
	Taste	8.0^{a}	8.0^{a}	8.0^{a}	24	8.00	0	0
	Overall Acceptability	9.0^{a}	8.5^{a}	8.0^{a}	25.5	8.50	0.17	0.41
						39.51		**1.16**

Samples with different letters within column are significantly different ($P < 0.5$) from each other.

Table 3. Optimization of sensory attributes of cookies during week three storage.

Samples	Sensory Attributes	Storage Conditions Amb.	Refr.	Freez.	$\sum x_1$	$\bar{x}$	S^2	S
WTD 111	Colour	7.0[a]	6.0[a]	6.5[a]	19.5	6.50	0.17	0.41
	Appearance	6.5[a]	7.0[a]	6.0[ab]	19.5	6.50	0.17	0.41
	Aroma	8.0[ab]	7.0[a]	7.0[a]	22	7.33	0.22	0.47
	Taste	7.0[a]	6.5[b]	6.0[a]	19.5	6.50	0.17	0.41
	Overall Acceptability	7.0[a]	6.0[a]	6.0[a]	19	6.33	0.22	0.47
						33.16		**2.17**
WTD 121	Colour	5.5[a]	7.5[a]	7.0[a]	20	6.67	0.72	0.85
	Appearance	5.5[ab]	7.0[a]	6.5[a]	19	6.33	0.39	0.63
	Aroma	5.0[b]	6.5[a]	7.0[a]	18.5	6.17	0.72	0.85
	Taste	6.0[a]	7.0[a]	8.0[a]	21	7.00	0.67	0.82
	Overall Acceptability	6.0[a]	7.0[a]	7.0[ab]	20	6.67	0.22	0.47
						32.84		**3.62**
WTD 131	Colour	6.5[a]	7.0[a]	8.0[a]	21.5	7.17	0.39	0.63
	Appearance	7.5[a]	6.0[ab]	7.5[ab]	21	7.00	0.50	0.71
	Aroma	7.0[a]	6.5[a]	7.5[a]	21	7.00	0.17	0.41
	Taste	7.0[a]	6.0[a]	7.5[a]	20.5	6.83	0.39	0.63
	Overall Acceptability	7.0[a]	7.5[a]	7.5[a]	22	7.33	0.06	0.25
						35.33		**2.63**
WTD 141	Colour	7.5[ab]	8.0[a]	7.5[a]	23	7.67	0.06	0.25
	Appearance	6.0[a]	7.5[a]	7.0[ab]	20.5	6.83	0.39	0.63
	Aroma	6.5[a]	7.5[a]	8.0[a]	22	7.33	0.39	0.63
	Taste	8.0[a]	7.5[ab]	8.0[a]	23.5	7.83	0.06	0.25
	Overall Acceptability	7.0[a]	8.0[a]	7.5[a]	22.5	7.50	0.17	0.41
						37.16		**2.17**
WTD 151	Colour	8.5[a]	8.0[a]	8.5[a]	25	8.33	0.06	0.25
	Appearance	7.5[a]	7.5[a]	8.0[a]	23	7.67	0.06	0.25
	Aroma	8.5[a]	7.0[a]	8.5[a]	24	8.00	0.50	0.71
	Taste	7.5[a]	7.5[ab]	8.5[a]	23.5	7.83	0.22	0.47
	Overall Acceptability	8.5[a]	8.5[a]	8.5[a]	25.5	8.50	0	0
						40.33		**1.68**
WF	Colour	7.0[a]	8.0[a]	7.5[a]	22.5	7.50	0.17	0.41
	Appearance	8.0[a]	8.0[a]	8.0[a]	24	8.00	0	0
	Aroma	8.0[a]	7.5[a]	9.0[a]	24.5	8.17	0.39	0.63
	Taste	8.0[a]	8.0[a]	8.5[a]	24.5	8.17	0.06	0.25
	Overall Acceptability	8.0[a]	8.5[a]	8.5[a]	25	8.33	0.06	0.25
						40.17		**1.54**

Samples with different letters within column are significantly different ($P < 0.5$) from each other.



UCL= Upper control limit; CCL = Central control limit; LCL = Lower control limit.

Figure 2. Samples control limits for week 1, 2 and 3.

Table 4. Microbial count of cookies during storage at week 0, 1, 2 and 3.

Week	Storage condition	Count	WTD111 (cfu/g)	WTD 121 (cfu/g)	WTD 131 (cfu/g)	WTD 141 (cfu/g)	WTD 151 (cfu/g)	WF (cfu/g)
Week 0	Ambient	Bacteria	0	0	0	0	0	0
		Fungi	0	0	0	0	0	0
	Refrigeration	Bacteria	0	0	0	0	0	0
		Fungi	0	0	0	0	0	0
	Freezing	Bacteria	0	0	0	0	0	0
		Fungi	0	0	0	0	0	0
Week 1	Ambient	Bacteria	$5.5x10^2$	$6.5x10^2$	$2.0x10^2$	$4.0x10^2$	$2.0x10^2$	$4.0x10^2$
		Fungi	$2.0x10^2$	$2.0x10^2$	$1.0x10^2$	$1.0x10^2$	$1.5x10^2$	$1.0x10^2$
	Refrigeration	Bacteria	$3.0x10^2$	$1.5x10^2$	$3.0x10^2$	$1.5x10^2$	$2.0x10^2$	$3.0x10^2$
		Fungi	$1.5x10^2$	$1.0x10^2$	$1.5x10^2$	$1.5x10^2$	$1.0x10^2$	$1.5x10^2$
	Freezing	Bacteria	$3.0x10^2$	$2.0x10^2$	$2.0x10^2$	$1.0x10^2$	$1.0x10^2$	$1.0x10^2$
		Fungi	$1.0x10^2$	$1.0x10^2$	$1.0x10^2$	$0.5x10^2$	$1.0x10^2$	$1.0x10^2$
Week 2	Ambient	Bacteria	$4.0x10^2$	$5.0x10^2$	$2.0x10^2$	$4.0x10^2$	$2.0x10^2$	$4.0x10^2$
		Fungi	$2.0x10^2$	$2.0x10^2$	$1.0x10^2$	$1.0x10^2$	$1.0x10^2$	$1.0x10^2$
	Refrigeration	Bacteria	$2.5x10^2$	$2.0x10^2$	$2.5x10^2$	$1.0x10^2$	$1.0x10^2$	$1.5x10^2$
		Fungi	$1.5x10^2$	$1.5x10^2$	$1.0x10^2$	$1.0x10^2$	$0.5x10^2$	$0.5x10^2$
	Freezing	Bacteria	$1.0x10^2$	$1.0x10^2$	$1.5x10^2$	$1.0x10^2$	$0.5x10^2$	$0.5x10^2$
		Fungi	$0.5x10^2$	$1.0x10^2$	$0.5x10^2$	$0.5x10^2$	$1.0x10^2$	$1.0x10^2$
Week 3	Ambient	Bacteria	$5.5x10^2$	$7.0x10^2$	$5.0x10^2$	$4.5x10^2$	$2.0x10^2$	$5.5x10^2$
		Fungi	$3.5x10^2$	$3.5x10^2$	$3.0x10^2$	$3.5x10^2$	$4.0x10^2$	$4.5x10^2$
	Refrigeration	Bacteria	$1.5x10^2$	$0.5x10^2$	$1.0x10^2$	$0.5x10^2$	$1.0x10^2$	$1.5x10^2$
		Fungi	$0.5x10^2$	$1.0x10^2$	$1.0x10^2$	$1.0x10^2$	$0.5x10^2$	$0.5x10^2$
	Freezing	Bacteria	$1.5x10^2$	$0.5x10^2$	$1.0x10^2$	$1.0x10^2$	$1.0x10^2$	$1.0x10^2$
		Fungi	$1.0x10^2$	$0.5x10^2$	$1.0x10^2$	$0.5x10^2$	$0.5x10^2$	$1.0x10^2$

CONCLUSION

Cookies made from wheat flour blended with tiger nut and date palm fruit were formulated and validated using statistical quality control chart design. Formulated samples fall within critical control points (CCPc) and therefore in the state of quality control under ambient, refrigeration and freezing conditions for period of three weeks. Sample WTD 121 in the first week of storage, samples WTD 141 and WTD 151 in the second and third week of storage respectively had close range of control limits of convergence which indicates high level of acceptability. The choice of date palm fruit inclusion as natural sweetener was in support of campaign against diabetics and other metabolic health related diseases. The product samples are stable and there were only few microbial counts in the third week of storage.

The counts fall within the standard of microbial specification for food.

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