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Study of Proximate Composition and Storage Stability of Selected Bakery Products from Developed Wheat-Sologold Sweet Potato Flour

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ABSTRACT

The proximate composition and storage stability of selected bakery products from composite wheat-sologold sweet potato flour (40:60) were investigated. This is crucial to harness the beneficial attributes of the composite flour coupled with the quality of its baked products. Results of the proximate composition of the baked products (bread, biscuit and cake) from composite wheat-sologold sweet potato flour were as follows: moisture content (10.60, 8.20, 6.80%), crude fiber (0.42, 0.38, 0.40%), ash content (1.20, 1.40, 1.30%), protein content (17.10, 16.50, 18.40%), oil extract (5.83, 5.33, 5.30%) and nitrogen free extract (64.85, 66.79, 67.80%) respectively. These values are within the range of good quality marketable baked products. During storage under room temperature, the total bacterial and fungi count of the baked products were found to be within was within the tolerable limit of edible food. The wheat-sologold sweet potato is therefore, a potential composite flour in the baking industry for improved quality and safety of baked products.

INTRODUCTION

In Nigeria, baked products are widely consumed daily and they take the highest cash expenditure within the stable food group (Shittu *et al.*, 2007). The basic ingredients in baked product making are wheat flour, water and yeast (Akobudu, 2006; Abdelghafor *et al.,* 2011). The unique baking properties of wheat flour are attributed mainly to the ability of its gluten to form a viscoelastic network when mixed with water (Mitiku *et al.,* 2018). However, the search for alternative sources of flour was prompted by the prevalence of wheat-related allergies and the need to diversify and have varieties in the food industry (Ahemen *et al.*, 2018). Other than wheat flour, we have rice, barley, maize, sorghum, oats, millet, legume and tuber flours (Aburime *et al.*, 2020). The purpose of combining multiple flours is to harness the beneficial attributes of each component and create a versatile and balanced flour blend that can be used in various food applications. The composition of composite flour can vary based on the desired characteristics and the availability of raw materials (Samia, 2013). Composite flour is a mixture of two or more types of flours derived from different sources, blended together to create a new flour product with enhanced nutritional, functional, and economic properties (Lee *et al.*, 2017). Composite flour can be used in various food applications, including bread, biscuits, cakes, pastries, noodles and other bakery products (Haruna *et al.*, 2018).

The stability of products from wheat flour and composite flour varies due to differences in nutritional composition, processing techniques, and ingredient interactions (Chuango *et al.*, 2019). Wheat flour-based products offer desirable texture and sensory attributes while composite flour-based products can provide improved shelf life and enhanced nutritional profiles (Hutasoit.*et al.*, 2018). Proper formulation, processing techniques, and storage conditions play vital roles in maintaining product stability and ensuring consumer satisfaction for both flour types (Julianti *et al.*, 2019). The shelf life of any product is the recommended maximum time the product can be effectively stored without deterioration. Within the shelf life period, a product is expected to retain all its standard, and defined qualities are also expected to be intact (Ouro-Gbeleou, 2018). The product equally remains acceptable under expected conditions of distribution, storage and display. The product must also be handled and stored in intact packaging, and according to the prescribed storage conditions. Shelf life could be directly affected by a number of factors which includes the intrinsic properties of the food, the handling/production, and other factors relating to the quality of the raw materials (Pambo *et al.*, 2017). Shelf life testing requires that the baked product will be stored at optimum conditions and distribution for a period of time until the point where chemical changes/ deterioration and spoilage occurs (Giami *et al.*, 2004).

According to FAO (2014) confectionaries and other baked products have a wide range of shelf life ranging from 2 days to 2 weeks but baked product specifically has a shelf life of between 2-4 days. The primary aim of baking is to use heat and air to alter the quality of food while the secondary aim is to enhance preservation by destroying the microorganisms present in the food; and the reduction of the moisture content of the surface of the food. Shelf life of composite baked product also depends on baking temperature, time, and the individual mix/ quality of the ingredients, variety of the crops and where the crops are grown (Pambo *et al.*, 2017). The utilization of locally available ingredients in composite flour promotes sustainable agriculture and supports local food systems (Fessehaye and Rungarun, 2017). Therefore, the objective of this study is to evaluate the proximate composition and storage stability of selected

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bakery products from already developed wheat-sologold sweet potato flour. The benefits and advantages of composite flour in bakery products are multifaceted and offer promising opportunities for the bakery industry.

MATERIALS AND METHODS

Equipment and Sourcing of Materials

The equipment used for this study includes hammer mill, mechanical sieves, electronic weighing balance, stop watch, electronic dough mixer, electronic PH meter, desiccators, stirrer, volumetric flasks, pipettes, beakers, crucibles, bowls, soxhlet apparatus, digestion flask, rapid visco-analyzer, ultraviolet/infrared and spectrophotometer. The materials include fresh sologold sweet potatoes, wheat flour, Margarine, baking improvers, Non-fat milk etc. The materials were all sourced from Urugba market, Umuahia in Nigeria.

Production Of Biscuit From Composite Wheat-Sologold Sweet Potato Flour

The biscuit samples were prepared according to the method described by Onabanjo and Dickson (2014) as illustrated in Figure 1.

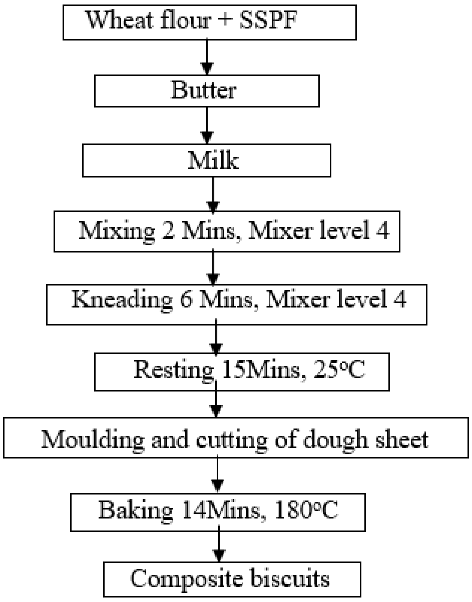

Figure1: Production of composite biscuit.

The samples were formulated using high gluten baking flour (Dangote flour). The composite baked products were produced by mixing the flours with other ingredients (recipes) as prepared and weighed according to the formulation in Table 1.

Table 1: Wheat-sologold sweet potato Baked product making formulation

	Samples										
Ingredients	**A1**	**B1**	**B2**	**B3**	**B4**	**B5**	**B6**	**B7**	**B8**	**B9**	**A2**
Wheat flour (g)	300	270	240	210	180	150	120	90	60	30	0
Sologoldflour (g)	0	30	60	90	120	150	180	210	240	270	300
Water (ml)	180	180	180	180	180	180	180	180	180	180	180
Instant yeast (g)	2	2	2	2	2	2	2	2	2	2	2
Non-fat milk (g)	60	60	60	60	60	60	60	60	60	60	60
Margarine (g)	10	10	10	10	10	10	10	10	10	10	10
Fine salt (g)	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Emulsifier (g)	5	5	5	5	5	5	5	5	5	5	5
Egg (g)	30	30	30	30	30	30	30	30	30	30	30
Granulated sugar (g)	15	15	15	15	15	15	15	15	15	15	15

A1= 100% WF, 0% SSPF B1= 90% WF, 10% SSPF B2= 80% WF, 20% SSPF B3= 70% WF, 30% SSPF B4= 60% WF, 40% SSPF B5= 50% WF, 50%SSPF B6= 40% WF, 60% SSPF B7= 30% WF, 70% SSPF B8= 20% WF, 80%SSPF B9= 10% WF, 90% SSPF A2= 0% WF, 100% SSPF

The samples were formulated using high gluten baking flour (Dangote flour). The composite baked products were produced by mixing the flours with other ingredients (recipes) as prepared and weighed according to the formulation in Table 1.

These were mixed and kneaded in an electronic mixer (Kenwood chef-KM201) for 1 minute at 1500 rpm. Water was then added and mixed further for 2 minutes at 1500 rpm. After resting the dough for 15 minutes at room temperature, the dough was sheeted to a thickness of 2mm using a guide board by manual rolling. Ingredients used for the baked samples are shown in Table 1. The biscuits were shaped with a cutter and baked in a conventional oven (Bistro AR6E, Sweden) on an aluminum tray at 180oC for 14 minutes. Biscuits were cooled for 30 minutes to room temperature of 28.5oC.

Production of Bread from Composite Wheat-Sologold Sweet Potato Flour

The bread samples were prepared according to the straight dough method described by Haruna et al., (2017). The ingredients which include the flour, shortening, salt, yeast, emulsifier, milk and sugar were prepared and weighed accurately into a mixing bowl. The ingredients such as flour, instant yeast and sugar were measured and mixed by a mixer while other ingredients such as non-fat milk, improver, salt, shortening and water were added to the mixture. The mixture kneaded into dough was assembled and then folded to allow for gas expulsion as well as the completion of distribution of yeast activity for further growth. The dough was then cut into the required sizes and rounded to shape into a smooth layer. The dough was left to rest for about 10-20 minutes before moulding. The moulded dough was placed in a baking tin and transferred into the proofer for the final proofing which takes between 45-55 minutes at 37oC. The dough was baked in baking oven at 220oC for 20 minutes. The bread produced was then brought out of the oven, de-panned and allowed to cool for about 30 minutes at room temperature.

Production of Cake from Composite Wheat-Sologold Sweet Potato Flour

Cake samples were prepared according to egg foaming method. The ingredients used for the cake making includes wheat flour and SSP flour, egg, butter, milk and sugar. The egg and sugar were whipped to a thick foam butter using a mixer. The milk was added then the sifted flour was added gradually into the butter and stirred well for uniform mixing to take place. The mixture was then poured to the baking pans (4x8 inches) and baked in oven at 180oC for 30 minutes. The cake was cooled at room temperature for an hour prior analysis.

Determination of The Proximate Composition of Wheat-Sologold Sweet Potato Composite Baked Products

The proximate analysis of the composite baked product which include crude protein, moisture content, crude fat, crude ash, crude fiber and carbohydrate was determined as prescribed by AOAC, (2016). All analyses were carried out in triplicates and the average values were recorded.

Composite Baked Product Microbial Analysis

A perti-dish containing casein hydrolyzate 4.0 (g/l), peptone 6.0 (g/l), nutrient agar medium (g/l) glucose 2.0 (mg/dL), beef extract 1.5(g), and agar 2.0 (PH 7.0) and yeast extract, 3.0 (mg) were used to determine the viable bacteria count. 0.5ml of each sample were measured into the individual plates for determination of total viable count (TVC) (Haruna et al., 2018). They were later incubated at 370C for 24 to 48 hours. The total number of colonies on each plate was counted with the help of colony counter as described by Onwuka (2001). The colony forming unit (CFU) was calculated using the equation 1.

CFU=(Number of colonies×dilution factor)/(sample volume (ml)) (1)

Determination of The Storage Stability of The Composite Baked Products

Microbial analyses was used for the assessment of the storage stability of the samples. Storability of the composite baked samples were carried out using polynomial model plot decision. With the initial total viable bacteria and fungi counts of the control sample namely 100% wheat sample determined, samples were packaged in sterilized polyethylene films and stored at ambient room conditions, 27-33oC and 65-75% Relative humidity (RH). The microbial analysis was carried out on each sample at 24 hours interval to determine the microbial growth within the period, as well as identify the microorganisms present in the baked samples.

RESULTS AND DISCUSSION

Proximate Properties of Wheat-Sologold Sweet Potato Flour Composite Baked Products

The result of the proximate composition of wheat-sologold sweet potato flour composite baked product and their estimated marginal means are presented in Figures 2 and 3 for proximate properties and composite samples respectively while the ANOVA is presented in Table 2.

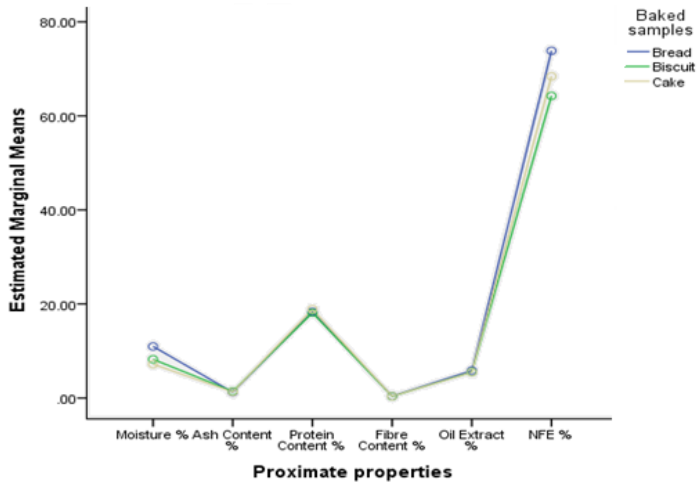

Figure 2: Proximate properties of composite wheat-sologold sweet potato baked products.

X1= Baked bread (100% WF, 0% SSPF) X2= Baked bread (40% WF, 60% SSPF) X3= Baked bread (0% WF, 100% SSPF) Y1= Baked biscuit (100% WF, 0% SSPF) Y2= Baked biscuit (40% WF, 60% SSPF) Y3= Baked biscuit (0% WF, 100%SSPF) Z1= Baked cake (100% WF, 0% SSPF) Z2= Baked cake (40% WF, 60% SSPF) Z3= Baked cake (0% WF, 100%SSPF).

The result showed that the average moisture content of

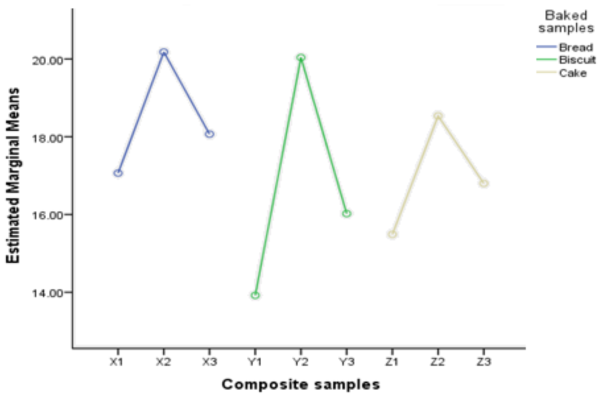

Figure 3: Proximate samples of composite wheat-sologold sweet potato baked products.

Table 2: ANOVA of the proximate properties of wheat-sologold composite baked products.

Composition		Sum of Squares	Df.	Mean Square	F	Sig.
MC	Between Groups	980.4322	17	122.554	2.519611	1.060
	Within Groups	.021	2	.002		
	Total	5384.231	19			
Protein	Between Groups	70.66569	16	7.851743	2.758504	0.033
	Within Groups	.076	2	.006		
	Total	2450.332	18			
Ash	Between Groups	0.461157	17	0.057645	3.357969	0.210
	Within Groups	.001	2	.000		
	Total	1850.247	19			
Fibre content	Between Groups	0.060111	20	0.012022	1.112984	1.080
	Within Groups	.001	2	.000		
	Total	1850.247	22			
Oil extract	Between Groups	0.997733	23	0.498867	2.603644	0.022
	Within Groups	.001	2	.000		
	Total	1011.583	25			
NFE	Between Groups	959.6563	15	106.6282	1.7983536	0.010
	Within Groups	.001	2	.000		
	Total	1024.012	17			

the produced composite baked products (bread, biscuit and cake) had 10.60, 8.20 and 6.80% (wb) as presented in Figure 2. The moisture content of the samples had no significant difference (0>0.05) as recorded in Table 2. According to Malomo *et al.*, (2012) baked product with moisture content ranging from 7-13% is considered acceptable for storage with a relatively stable shelf life due to the low water activity in the samples. The substitution of 60% SSPF in X3, Y3 and Z3 baked samples caused a decrease in their moisture contents. According to Julianti *et al.*, (2016), moistness is a favourable sensory attribute in bakery products due to its effect on the softness and tenderness of the crumbs. However, excess moisture content accelerates food spoilage due to microbial growth. The average ash content value of composite baked products as presented in Figure 2 are 1.20, 1.40 and 1.30%. The ash contents in X3, Y3 and Z3 were shown to be higher than the X1, Y1 and Z1 (controls). The higher ash content was attributed to the SSPF which contains higher ash (Figure 2). This is in accordance with Okorie and Onyeneke (2012) who reported that baked products made from sweet potato flour has higher ash content than 100% wheat baked product. The statistical analysis of variance for the ash content of the samples presented in Table 2 is not significant (p 0.05). SSPF has higher ash content than wheat flour which leads to the increase in ash content of composite samples and 100% SSPF samples. The samples with higher ash contents showed a higher amount of minerals present which influence the physiochemical and nutritional properties.

The crude protein content of the wheat-sologold composite baked products produced are 17.10, 16.50 and 18.40%. The statistical analysis of variance for the protein content is significant ($p \leq 0.05$) as presented in Table 2. SSPF contained higher percentage of protein than wheat flour hence the higher values reported for the composite and 100% SSPF samples. Protein content enhances food sample structure and texture. Thus, samples with higher protein content have better structure and texture. The value of average fibre content of composite baked products is 0.42, 0.38 and 0.40%. The statistical analysis of variance of the crude fibre content is not significant as presented in Table 2. SSPF contained higher percentage of fibre than wheat flour hence the higher values reported for the composite and 100% SSPF samples. The fibre contents in X3, Y3 and Z3 were shown to be higher than the X1, Y1 and Z1. The higher fibre content was attributed to the SSPF which contains higher fibre (Figure 2). This is similar to the report by Okorie and Onyeneke (2012) who reported that baked products made from sweet potato flour has higher fibre content than 100% wheat baked product. Fibre contents are indigestible cellulose (insoluble carbohydrate) that lowers the blood pressure, balance cholesterol level and prevents blood sugar spikes. Therefore, samples with higher fibre contents are healthier options.

The average oil extract of the composite baked products produced are 5.83, 5.33 and 5.30%. The statistical analysis of the variance is significant ($p \leq 0.05$) as presented in Table 2. SSPF contained a higher percentage oil extract than wheat flour hence the higher values reported for the composite and 100% SSPF samples. According to Matsakidou et al., (2010) increase in the oil extract in baked product enhance the moistness and mouth feel of the product.

The average NFE of composite baked products produced are 64.85, 66.79 and 67.80% respectively. The statistical analysis of variance for NFE shows that it's significant (Table 2). The high NFE contents in samples X3, Y3 and Z3 may be attributed to the SSPF which had high NFE content than wheat flour. According to Hoover (2001), starch (60% amylopectin and 40% amylose) is the major NFE component in sweet potato. The high level of NFE is desirable in baked products because the starch granules swell with the presence of water upon heating. This leads to the formation of gel which is important for the texture and structure development of baked products.

Microbiological Properties of Wheat-Sologold Composite Baked Products in Storage

The microbial analyses carried out on the baked product samples were limited to total bacteria and fungi counts within the period. The results of the analysis of the total bacteria and fungi counts for the 4 days storage period of the composite baked products are presented in Figures 3 and 4 respectively.

The recommended unit for total bacteria counts on food fit for consumption is x ≤ 105cfu/g. However,

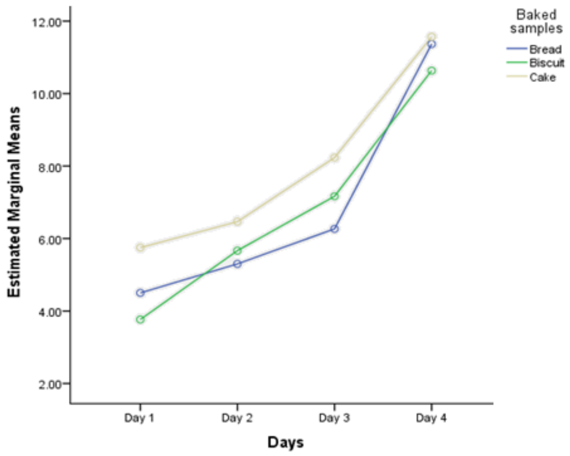

Figure 4: Bacteria count of composite wheat-sologold sweet potato baked products.

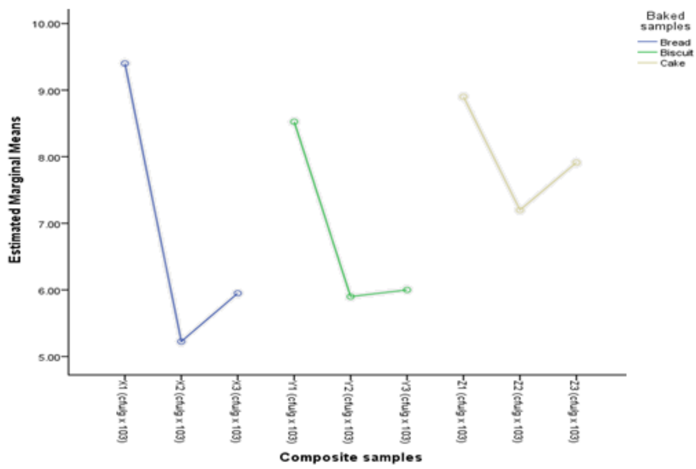

Figure 5: Total bacteria count for samples of wheat-sologold composite baked product.

$0\text{-}10^3$cfu/g is acceptable, 104-105cfu/g is tolerable, 105-106cfu/g is not ideal and x ≥ 106cfu/g is not fit for human consumption (International Commission on Microbiological specification for Food, 2016). The total bacteria count of samples for the four days of the storage of the composite baked product is presented in Figure 4. The result of the microbiological analysis shows that sample X2, Y2 and Z2 had a progressive increase of bacteria count within the storage period from 4.0×10^3cfu/g to 10.20×10^3cfu/g.

However, within the first two days the value of the bacteria counts for X1, Y1 and Z1 increased slowly from 6.0×10^3cfu/g to 7.50×10^3cfu/g while from the third to fourth day it increased abruptly from 9.0×10^3cfu/g to 13.0×10^3cfu/g as shown in Figure 4.

The result shows that as at the fourth days of storage, the stored baked product is close to the acceptable limit for bacteria counts on food. It may still be consumed, but the bacteria count is fast increasing to a level not ideal for human consumption. The slow increase in the total bacteria count within the first two days may likely indicate the period of adaptation; while the abrupt increase may mean that successful adaptation has taken place resulting to increasing feeding. Baked samples (X3, Y3 and Z3 with 40% WF, 60% SSPF) were more shelf stable than samples (X1, Y1 and Z1 with 100% WF, 0% SSPF). This is because of their lower moisture content which tend to decrease the rate of bacteria growth, hence delay spoilage.

Total fungi Count of wheat-sologold composite baked products

The total fungi count for the samples is presented in Figures 6 and 7. However, according to the global acceptable standard for total fungi counts 0 ≤ 106 is

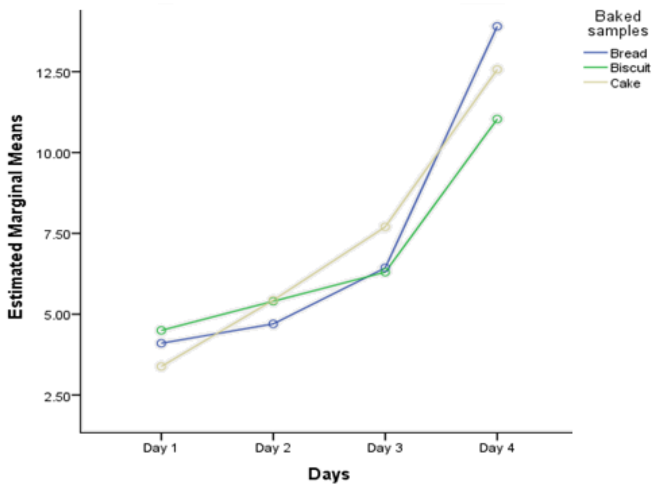

Figure 6: Fungi count of composite wheat-sologold sweet potato baked products.

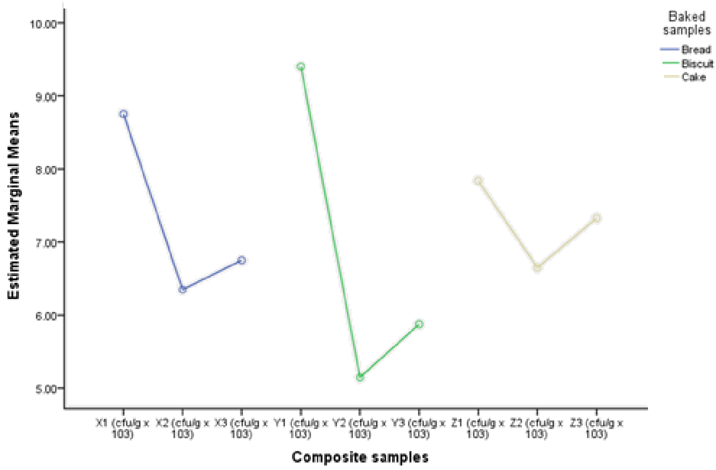

Figure 7: Total fungi count of composite wheat-sologold sweet potato baked products.

acceptable, 106-107cfu/g is tolerable, 107-108cfu/g is not ideal and x ≥108cfu/g is not fit for human consumption (International Commission on Microbiological Specification for Food, 2016). The result from fungi count analysis of the baked products shows that all the baked product samples X3, Y3 and Z3 recorded a progressive increase in total fungi load from 4.05×106cfu/g to 18.00x106cfu/g, 4.0×106cfu/g to 12.20x106cfu/g and 6.0×106cfu/g to 24.50x106cfu/g respectively.

These values are within the tolerable limit but on the threshold of allowable fungi count on food within the four days of storage under room temperature. The samples X2, Y2 and Z2 had a progressive increase from the first day of storage. Samples X1, Y1 and Z1 recorded a slight initial rise in fungi load in the first three days of composite baked product storage and then recorded a faster rise between the third and fourth day of the storage. The faster increase recorded may be due to the conventional geometrical growth which is expected due to sustained progressive increase in fungi colonies in the samples.

However, the increase in the fungi load recorded in most samples may be due to increasing feeding and multiplication of the fungi due to successful adaptation. The isolation of bacteria and fungi in the fourth day shows that, within the storage period of 4 days, the composite baked products are still fit for consumption. Considering the recorded total bacteria coupled with fungi counts and trend, the count is fast progressing to a state of not fit for human consumption, expectedly in the next one or two days; while some samples may stay a little more, considering the level of bacteria /fungi load at the fourth day of storage. This is in agreement with Haruna et al. (2018) where similar values were recorded for sweet potato flour products. Baked samples (X3, Y3 and Z3 with 40% WF, 60% SSPF) were more shelf stable than samples (X1, Y1 and Z1 with 100% WF, 0% SSPF) because of their lower moisture content which tends to decrease the rate of fungi growth.

CONCLUSION

The proximate composition of the developed composite wheat-sologold sweet potato flour has beneficial attributes and is within acceptable limits for baked products (bread, biscuit and cake) of improved quality and safety. During storage under room temperature, the total bacterial and fungi count of the baked products are also within the tolerable limit for edible food.

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