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SELECTED ENGINEERING AND SENSORY PROPERTIES OF BAKED PRODUCTS PREPARED FROM COMPOSITE WHEAT-SOLOGOLD SWEET POTATO FLOUR

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***Abstract**:* Flours from other sources have been incorporated into wheat flour to improve on the nutritional and sensory properties of baked products. However, the quality of production and sustainability of such baked product is still a challenge faced by bakery industries. The aim of this study is to evaluate selected engineering and sensory properties of baked products prepared from composite wheat sologold sweet potato flour; so as to guide the bakers to achieve improved product quality, development and sustainability. In this study, biscuit samples were prepared according to Onabanjo and Dickson method, the bread samples were prepared according to the Straight dough method, the cake samples were prepared according to Egg foaming method while the selected engineering and sensory properties were determined in accordance with standard procedures. The results obtained showed that the optimum blend (70% wheat: 30% sologold sweet potato) flour has specific volume of the baked products range from 4.12 to 0.50 ml/g, crumb moisture from 18.54 to 12.04%, oven spring from 2.38 to 1.12mm, sample height from 4.05 to 1.01mm, sample mass from 146.30 to 8.52g, appearance from 9.40 to 8.70, texture from 8.50 to 7.50, aroma 9.20 to 8.0, flavor from 9.0 to 8.10, crust color from 8.80 to 7.0, overall acceptability from 9.30 to 8.10, intension of consumption from 9.20 to 8.0 and browning index from 1.0 to 4.6.

These evaluated engineering and sensory properties of the optimum blend flour attest high quality baked products (bread, biscuit and cake).

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Hence could be utilized to enhance and facilitate product development, quality control and product sustainability of composite baked products. The optimum blend ratio is therefore recommended to bakers.

Keywords: *Wheat flour, sologold flour, baked products, engineering qualities, sensory properties.*

INTRODUCTION

Composite flour refers to 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 [1] . The type and quality of flour vary based on the source of material and processing methods employed [2, 3]. Composite flour can be derived from different grains, cereals, legumes, tubers and root crops.

The combination of different flours in composite flour is to enhance the overall quality of the final product which is based on the desired characteristics [4]. Each flour component contributes distinct characteristics, such as flavor, texture, color and nutritional profile which can be leveraged to achieve desired outcomes such as maintaining acceptable sensory qualities and consumer acceptance. Generally, wheat flour is the main flour for baking and it provides structure, texture and flavor to baked product [5]. It forms the foundation of bread, cakes, cookies, pastries, and other baked products. However, the incorporation of another flour to wheat flour which is the main flour for baking materials tend to reduce the gluten effect on the baked products, which may lead to changes in taste, texture, color, and appearance compared to complete wheat flour-based products [6].

Usually, when wheat flour is hydrated and mixed with yeast, the gluten protein in it will cause the formation of an elastic network that traps gases produced by yeast or leavening agents; leading to the rising of dough and a light, airy and sponge like texture in baked products [4, 7].

However, selected engineering properties of baked products include specific volume, crumb moisture, oven spring, sample volume, sample mass, sample color, appearance, texture, aroma, flavor, crust color, crumb color, browning index, overall acceptability and intention for consumption [8, 9]. They play crucial roles in determining the quality, desirability and marketability of baked products [5, 10]. A comprehensive understanding of these properties aids in the development of nutritious, functional, and cost-effective composite products [7]. It will also enhance bakers to produce consistent, high-quality baked products with desirable qualities and shelf life [11, 12]. More so, the bakery industry can optimize their production processes and meet consumer expectations in terms of sensory experience, product attributes, product development and product sustainability [13].

Reported [1], that bread was made from blend of orange sweet potato and wheat flour at various ratios (0:100, 5:95, 10:90, 15:85, 20:80 and 25:75). It was observed that the qualities of breads such as loaf size (volume, specific volume and height) significantly decreased while loaf weight increased as blending ratio of orange sweet potato flour increases.

[5] had reported also that the produced bread loaf weights ranged from 450 to 500 g; loaf volume, 1171.73-1239.84 cm3 and specific loaf volume, 2.48-2.62 cm3/g. There was no significant difference in the samples crust color, crumb holes, stability, elasticity, firmness, shape regularity, appearance; and no panelist showed a total dislike for the taste of any of the samples. [11] evaluated the quality of bread fortified with sesame seed. The average values of color, texture, flavor, overall acceptability, loaf volume, specific volume and shelf life of the bread samples increased with increasing sesame seed addition.
[10] worked on tiger nut and sesame flour partially substituted into wheat flour at six blend ratios of 100:0:0 (sample A), 90:10:0 (sample B), 85:10:5 (sample C), 80:10:10 (sample D), 75:10:15 (sample E) and 70:10:20 (sample F) respectively. It was reported that the physical properties of the bread loaves showed a significant decrease in quality with the addition of tiger nut and defatted sesame flour with the wheat flour. The bread weight ranged from 158.23 to 210.07 g, loaf volume varied from 360 to 672 cm3, bread specific volume was in the range of 1.71-4.14 cm3/g and oven spring lied between 0.43-2.80 cm. In this study, wheat flour and sologold sweet potato flour are combined so as to harness the beneficial attributes of each component and create a nutritious, versatile and balanced flour blend for the production of bakery products. Some of the engineering properties of baked products from composite wheat-sologold sweet potato flour, developed are essential to be determined. This will help in the assessment of the desirability, quality and marketability of these selected baked products.

MATERIALS AND METHODS

Material Sourcing and Equipment

Wheat flour and fresh sologold sweet potatoes used for the study were collected from National Root Crops Research Institute (NRCRI) Umudike, Abia State, Nigeria. The following equipment were employed: steel ruler, minolta spectrophotometer, sulphuric acid solution, microcrystalline cellulose, sharp knife, venier caliper, electronic dough mixer, electronic weighing balance, tape rule, hammer mill, mechanical sieves, stop watch, desiccators, bowls, crucibles and conventional oven.

Determination of optimum blend ratio based on engineering properties of the wheat-sologold potato composite flour

The wheat-sologold sweet potato composite flour engineering properties such as proximate composition, particle size, flowability, rheological, functional and thermal properties obtained for the best blend ratio per property assessed were further evaluated to obtain the blend ratio that would possess each of the assessed property at its optimum value with respect to their interactions in the composite flour.

The best blend ratio of the composite flour was chosen and used to produce baked products. Some of the engineering properties considered for baked products such as biscuit, cake and bread were evaluated to assist in product sustenance, development and quality control.

Production of some baked products from composite wheat-sologold sweet potato flour

(a) Production of Biscuit

The biscuit samples were prepared according to the method described by [14], as shown in Figure 1.

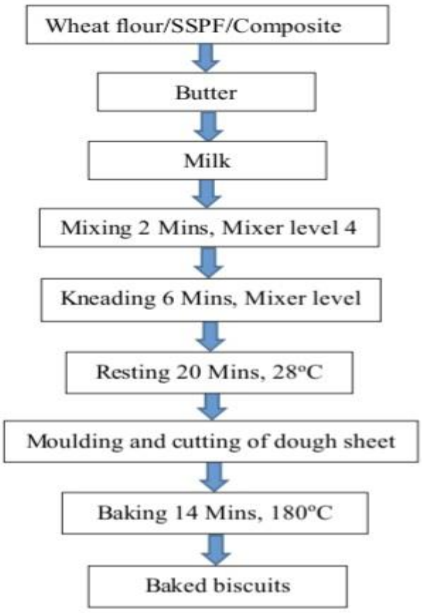

Figure 1. Flow chart for the production of biscuit

The samples were formulated using high gluten baking flour (Dangote flour) according to recipes in Table 1.

Table 1. Wheat-sologold sweet potato flour formulation

Samples	Flour Blend Ratio	SSPF (g)	WF (g)
A1	100% WF, 0% SSPF	0	300
B1	90% WF, 10% SSPF	30	270
B2	80% WF, 20% SSPF	60	240
B3	70% WF, 30% SSPF	90	210
B4	60% WF, 40% SSPF	120	180
B5	50% WF, 50% SSPF	150	150
B6	40% WF, 60% SSPF	180	120
B7	30% WF, 70% SSPF	210	90
B8	20% WF, 80% SSPF	240	60
B9	10% WF, 90% SSPF	270	30
A2	0% WF, 100% SSPF	300	0

SSPF=Orange fleshed sweet potato flour , WF= Wheat flour

Dough of the samples were made with 100% wheat, 100% SSPF (controls) and the optimum blend ratio of 70% wheat, 30% SSPF.
Ingredients were mixed thoroughly thereafter each of the flour samples was added to form dough which was obtained by mixing and kneading in an electronic mixer (Kenwood chef-KM201) for 1 minute using speed 4. Water was then added and mixed further for 2 minutes. The dough was left to rest for 15 minutes at room temperature and thereafter followed by sheeting to a thickness of 2mm using a guide board by manual rolling.

The biscuits were shaped with a cutter and baked in a conventional oven (Bistro AR6E, Sweden) on an aluminium tray at 180ºC for 14 minutes. Biscuits were cooled for 30 minutes to room temperature of 28.5ºC. The appropriate engineering properties were then analyzed.

Production of Bread

The bread samples were prepared according to the straight dough method described by [15]. The ingredients which include the flour, shortening, salt, yeast, emulsifier, milk and sugar were prepared and weighed accurately into a mixing bowl. The optimum blend (70% wheat and 30% sologold sweet potato flour) and the two controls (100% wheat and 100% sologold sweet potato flour) were also prepared. The ingredients such as flour, instant yeast and sugar were measured and mixed in a mixer. The other ingredients such non-fat milk, improver, salt, shortening and water were then added to the mixture. The mixture was kneaded into dough and then assembled, thereafter folded to allow gas expulsion as well as 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 then left to rest for about 10-20 minutes before molding. The molded 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

Cake samples were prepared according to egg foaming method [16]. The cakes were made from 100% wheat, 100% SSPF (controls) and blend of 70% wheat and 30% SSPF. 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 selected engineering and sensory properties of the produced composite baked products

(a) Determination of selected engineering properties of composite wheat-SSP baked products

The composite baked products engineering properties such as sample volume, sample mass, specific volume, oven spring, sample height and crumb moisture were determined in accordance to the method described by [17].

I. Seed displacement method was used to determine the sample volume. In this method, sesames seeds were used to cover the composite baked product sample inside a container of known volume, until the seeds fill the entire container.

A steel ruler was used to cut off the excess seed that have overfilled the container. The volume of the sesame seeds used was determined by pouring it into a graduated volume measuring cylinder.

The same sesame seeds were also used to fill the same container of known volume in the absence of the baked product. The sample volume was calculated as the difference of the two values.

$$\text{Sample volume} = V_1 - V_2 \quad \ldots\ldots\ldots\ldots (1)$$

Where,
V_1 = the volume of the seed displaced without the baked product sample, and
V_2 = the volume of the seed displaced with the baked product sample

II. Specific volume was calculated by dividing the volume of a composite baked product sample by the mass of the same composite baked product sample. It is expressed in (cm^3/g)

$$\text{Specific volume} = \frac{volume\ of\ a\ composite\ bread}{mass\ of\ the\ same\ composite\ bread} \ldots\ldots\ldots\ldots (2)$$

III. The crumb moisture were determined using the methods prescribed by [18] for the determination of crumb moisture content. It involves the use of standard sorption isotherm curve for microcrystalline cellulose, established using standard sulphuric acid solution (H_2So_4). 50 grams weight of the baked product sample was measured into a desiccator along with a weighing bottles and dry microcrystalline cellulose for 24 hours. The baked product crumb moisture was determined by measuring the weight gained by the microcrystalline cellulose that naturally absorbs moisture from the sample, and referring to the standard isotherm curve for the read the corresponding crumb moisture value [19, 20].

IV. The oven spring of the baked products were determined by measuring the crust height of the baked samples with the use of venire caliper and the readings were taken in millimeter (mm).

V. The sample height of the baked products was determined by measuring from the base to the top of the sample with the use of the measuring ruler and readings were taken in millimeter (mm).

VI. The sample mass of the baked products were determined by weighing the samples on an electronic weighing balance and readings were taken in grams (g).

(b) Determination of the sensory attributes of wheat-sologold composite baked product

I. The sensory attributes were determined by human interpretation of those attributes as perceived by senses of smell, taste, touch and sight, [1].

The sensory evaluations were carried out immediately after production and cooling of the composite baked product.

The evaluation was useful in determining and assessing how people feel about the product by allowing them to practically test the baked products and comment based on personal assessment and feelings about the product.

The sensory qualities evaluated are appearance, aroma, taste, texture and overall acceptability. The sensory evaluation was designed based on 5-point hedonic scale which enabled panelists to express exactly the regiment of choice between acceptance and rejection. Sensory attributes such as flavor, texture and taste were evaluated using a nine-point hedonic scale [21]. Panelists featured were students and staff whom are organoleptically familiar with the baked products. The hedonic scale was ranked as follows: 10-8 scores: like extremely to very much, 7-5 scores: moderately to slightly like, 4-2 scores: neither like nor dislike to dislike slightly to dislike moderately and 1-0 scores: dislike very much to dislike extremely. A total of 20 respondents were used to evaluate the sensory attributes of the composite baked product.

II. The color of the composite baked product was determined using Minolta spectrophotometer (CM-3630 MINOLTA, JAPAN). The various color components were determined using the following procedure: The spectrophotometer was set up, and connected to a computer. The spectrophotometer was turned on with the computer for booting. After the computer the booting process, the computer was logged on to the Minolta color spectrophotometer software. In a few second the computer asked for a zero calibration which was subsequently done using input buttons. The equipment also asked for a white calibration which was done using a white board placed in the specimen medium 0 (Absolute black) to 100 (pure white). In a few seconds the equipment demanded for loading of the specimen which was done. Selection of color component to be measured was also demanded and was selected. The measurement was performed in few minutes and the result was read and recorded via the output medium which is the computer monitor. It was used as the measure the product lightness (L*), redness (a*) and chroma levels (b*) which were recorded respectively. Browning index assessment was carried out by measuring the visual brown area on each sample with the scale of 1 (no browning, excellent quality), 2 (slight browning), 3 (<25% browning), 4 (25-50% browning) and 5 (>50% browning), [8].

RESULTS AND DISCUSSION

I. Selected engineering properties of wheat-sologold sweet potato composite baked products

The results of the selected engineering properties of composite baked products evaluated include specific volume, crumb moisture, oven spring, sample height, sample volume and sample mass as presented in Figure 2; with Figure 3 showing the baked breads, biscuits and cakes produced from the composite flour sample while Figure 4 shows the selected engineering properties of baked samples from composite wheat-sologold sweet potato flour blends.

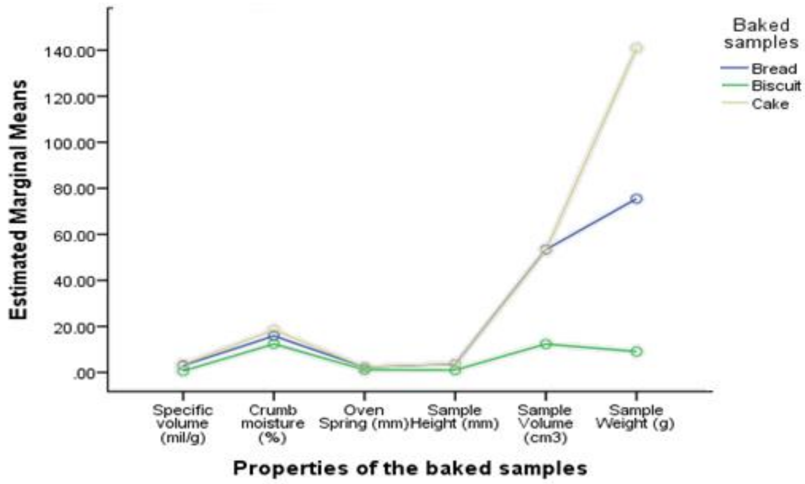

Figure 2. Selected engineering properties of composite wheat-sologold sweet potato baked products

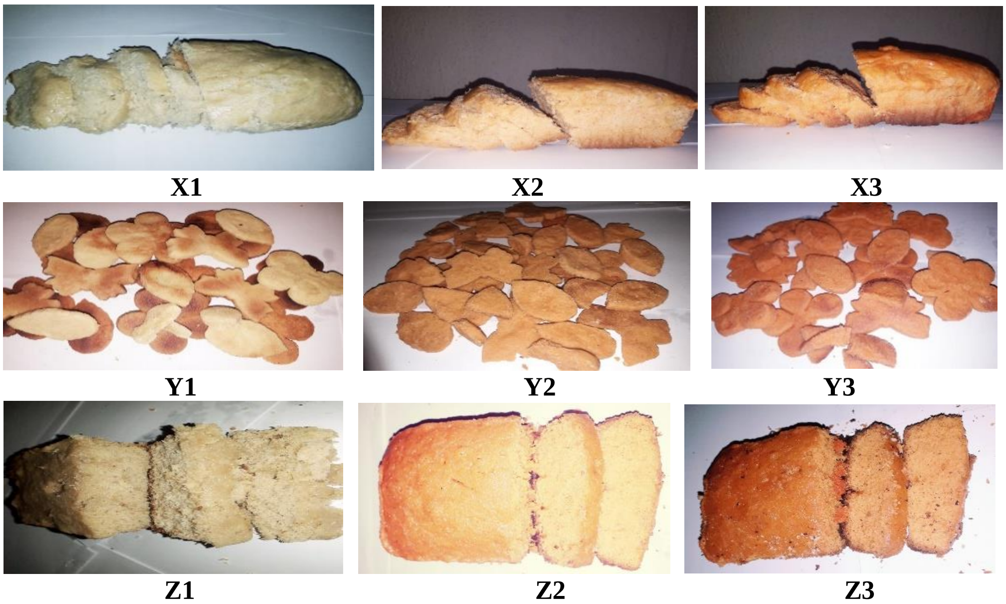

Figure 3. The composite baked breads, biscuits and cakes

X1: Bread (100% wheat flour, 0% sologold flour) X2: Bread (70% wheat flour, 30% sologold flour)
X3: Bread (0% wheat flour,100% sologold flour)
Y1: Biscuit (100% wheat flour, 0% sologold flour) Y2: Biscuit (70% wheat flour, 30% sologold flour)
Y3: Biscuit (0% wheat flour, 100% sologold flour)
Z1: Cake (100% wheat flour, 0% sologold flour) Z2: Cake (70% wheat flour, 30% sologold flour)
Z3: Cake (0% wheat flour, 100% sologold flour)

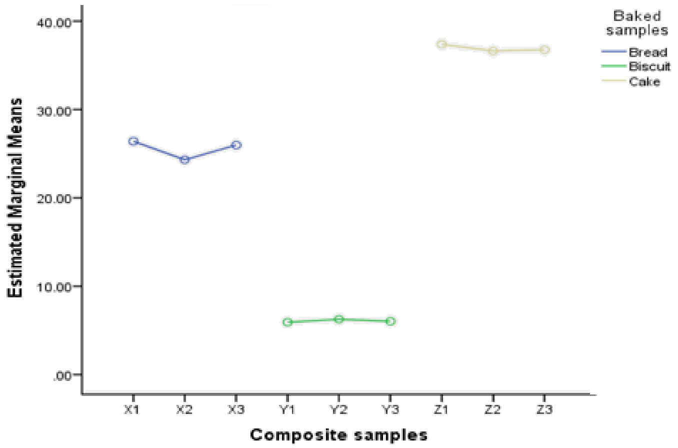

Figure 4. Selected engineering properties of baked samples from composite wheat-sologold sweet potato flour blends

(a) Specific volume of wheat-sologold flour composite baked products

Specific volume is an important parameter of baked products that indicate the texture and density of the product [22, 23]. A higher specific volume generally corresponds to a lighter and more airy texture, which is mostly desired for products like bread and cakes [24, 3]. The result obtained showed that the specific volume of the composite baked products and controls range from 0.50-4.12 ml/g as presented in Figure 2. It also shows that specific volume for the control experiments X1, Y1 and Z1 recorded the highest values of 3.64 ml/g, 0.58 ml/g and 4.12 ml/g which is due to the 100% wheat flour inclusion and X3, Y3 and Z3 had lower values of 3.28 ml/g, 0.50 ml/g and 4.04 ml/g while X2, Y2 and Z2 had the lowest values of 2.20 ml/g, 0.42 ml/g, 2.50 ml/g respectively. Considering the percentage inclusion of sologold sweet potato flour (SSPF) which accounted for the low values of specific volume, this inferred that specific volume depend on percentage inclusion of SSPF. The result is in agreement with [24] who reported significant decrease in specific volume with increase in white sweet potato flour substitution when most process parameters were kept constant. According to [25], the specific volume indicates the amount of air that can remain in the final product, where higher gas retention of the product leads to a higher specific volume. This indicates that samples containing SSPF had lower gas retention than that of 100% wheat flour. The baked products from the optimum blend all have modest specific volume due to the high ratio of wheat (70%) in the blend.

(b) Crumb moisture of wheat-sologold flour composite baked products

An optimal crumb moisture level ensures a moist and tender crumb while preventing excessive dryness or sogginess [26, 27]. This is crucial because moisture content affects the shelf life, softness, and overall quality of baked products.

The results showed that the crumb moisture range from 12.04% to 18.54% for the wheat-sologold composite baked products and controls.

However, the crumb moisture values for the baked products and the control experiments had slight variation; with higher percentages recorded in the control samples (Figure 4). Crumb moisture enables bakers to assess the quality processes and storage conditions accordingly. Hence, it is essential to control crumb moisture to prevent staling or excessive moisture loss during storage, which can lead to low product quality and decreased consumer satisfaction [2, 28]. The crumb moisture content of the baked products from the optimum blend of wheat-sologold sweet potato induced that the quality of the baked products are good and appealing to consumers.

(c) Oven spring of wheat-sologold flour composite baked product

Oven spring is the rapid rise in volume that occurs during the first few minutes of baking [25, 29]. It is primarily attributed to the expansion of trapped gases within the dough due to the heat of the oven [25]. The result shows that the highest values of the oven spring were recorded in X1, Y1 and Z1 as 2.30mm, 1.14 and 2.38 while X2, Y2 and Z2 recorded the lowest values of 2.20mm, 1.12mm and 2.30mm respectively (Figure 2). The result of this study is in agreement with [30] which reported that oven spring of bread made from 100% wheat and 100% sweet potato flour were 2.32 and 2.18mm. Oven spring occurs due to the expansion of gases, such as carbon dioxide, trapped within the dough [31]. It contributes to the formation of desirable, well-risen structure and an open crumb texture [6, 32]. The oven spring values of the baked products from the optimum blend of wheat and sologold sweet potato showed their desirable and well-risen structures.

(d) Sample height of wheat-sologold flour composite baked product

Sample height provides an objective assessment of the height of the final product. By monitoring and controlling baked product height, bakers can ensure consistent quality, portion control, and optimize ingredient usage [32, 33]. The sample height for the control samples X1, Y1 and Z1 were 4.05mm, 1.03mm and 4.04mm while X2, Y2 and Z2 had 3.10mm, 1.01mm and 3.09mm respectively which recorded the lowest sample height.

This may be due to the absence of gluten which is responsible for elasticity and rising in wheat flour. It is in agreement with the report of [23, 29] where lower values were reported for 100% wheat baked product. Baked products with heights are generally preferred as they indicate a well-risen, light, and fluffy texture [13, 32]. Hence, the respective heights recorded for the baked products from the optimum blend of wheat and sologold sweet potato indicated well-risen baked products.

(e) Sample volume of wheat-sologold flour composite baked product

Sample volume is an essential parameter for assessing the quality and consumer acceptability of baked products [27, 34]. The volumes of baked samples: X3, Y3 and Z3 were 53.12 cm^3, 12.32 cm^3 and 52.12cm^3 which are lower than those of X1, Y1 and Z1 but higher than values of X2, Y2 and Z2. The result implication is that sample volume is dependent on percentage inclusion of SSPF.

The result is in agreement with [7, 23, 25] which all reported increase in sample volume with decrease in the level of substitution. The incorporation of SSPF into samples preparation significantly decrease the volume of the baked samples. Gluten is vital to enhance the structural framework and rising volume of the baked products.

According to [17] low amount of gluten can cause reduction in the gas retention capacity during baking, thereby reducing the volume of the baked product.

The results obtained are in agreement with the observations of [27] which reported that baked products incorporated with sweet potato flour decreases the volume. Sample volume directly influences consumer perception of product value, as larger loaves are often associated with higher quality [34]. Hence, the volume of the baked products from the optimum blend of wheat and sologold sweet potato showed their well risen volumes.

(f) Sample mass of wheat-sologold flour composite baked product

Sample mass is an essential parameter for assessing the yield and portioning of bakery products [23, 35]. By accurately measuring sample mass, bakers can ensure consistency in product size and control costs by controlling the amount of dough used for each loaf [7]. The highest sample mass values were recorded in X2, Y2 and Z2 of 75.41g, 9.46g and 146.30g respectively while X1, Y1 and Z1 had the lowest sample mass of 72.26g, 8.52g and 135.62g. However, there were significant increase in sample mass of X3, Y3 and Z3 with 73.69g, 9.20g and 140.80g. This is as a result of 30% wheat flour been replaced with SSPF. Sample mass provides valuable information for ensuring consistency in portion sizes and meeting specific mass requirements for different product types. Sample mass is the actual mass of a baked product [8]. The mass of the respective baked products from the optimum blend of wheat and sologold sweet potato are appropriate and acceptable.

II. Statistical analysis on baked products engineering properties

Table 2 shows the ANOVA values of the selected engineering properties of the baked products.

Table 2: ANOVA of the selected engineering properties of baked products

Properties		Sum of Squares	Df.	Mean Square	F	Sig.
Specific volume	Between Groups	352.24	1	1536.577	0.425069	0.035
	Within Groups	6	10	.02		
	Total	358.24	11			
Crumb moisture	Between Groups	181.83	1	1714.127	0.009969	0.927
	Within Groups	6	10	.06		
	Total	187.83	11			
Oven spring	Between Groups	232.49	1	289.5919	0.105963	0.040
	Within Groups	6	10	.01		
	Total	238.49	11			
Sample height	Between Groups	173.54	1	2734.946	0.401251	0.021
	Within Groups	6	10	.03		
	Total	179.54	11			
Sample volume	Between Groups	289.919	1	6332.49	0.145337	0.019
	Within Groups	6	10	.04		
	Total	295.919	11			
Sample weight	Between Groups	350.365	1	40254.82	0.215752	0.043
	Within Groups	6	10	.02		
	Total	356.365	11			

Based on the statistical analysis of variance for specific volume of the baked samples presented in Table 2, there was significant difference in the specific volume of the samples ($p \leq 0.05$). Specific volume of samples increases significantly with increase in wheat flour added to the sample. Crumb moisture of the baked products show that there was no significant difference ($p > 0.05$) in the samples crumb moisture content. It plays a crucial role in determining the texture, shelf life, and overall quality of bakery goods. The result of the ANOVA for oven spring of the baked products show that it is significant ($p > 0.05$). Oven spring is critical in baked products, as it contributes to a desirable light and airy texture. Result for sample height, sample volume and sample mass of the baked products show that they are significant ($p \leq 0.05$). Consistency in sample height and volume is crucial for batch-to-batch reproducibility and ensuring the desired product characteristics. Samples containing SSPF showed significant increase in mass compared to samples with 100% wheat flour. Therefore, the engineering properties of the baked products from the optimum blend of wheat and sologold sweet potato is appropriate and recommendable.

III. Sensory properties of wheat- sologold flour composite baked products

The results of the sensory evaluation of the composite baked product are presented in Figures 5 and 6. The sensory attributes evaluated include appearance, texture, aroma, flavour, crust colour, overall acceptability and intension for consumption.

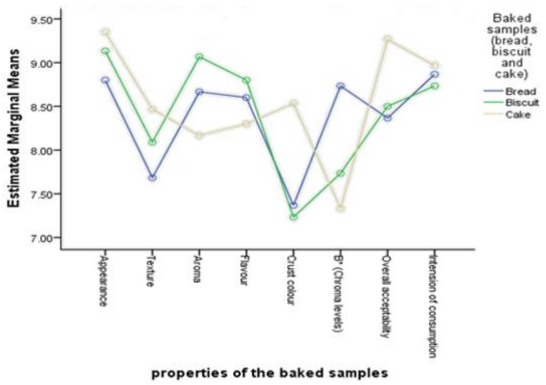

Figure 5. Sensory properties analysis of composite wheat-sologold sweet potato baked products

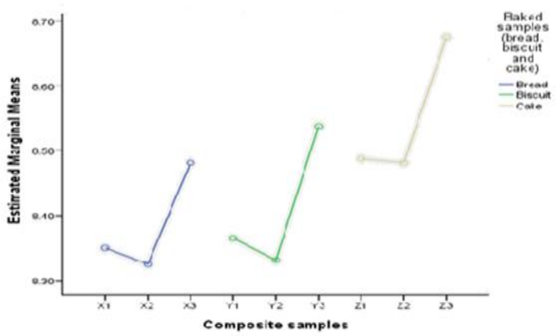

Figure 6. Sensory analysis of composite samples of wheat-sologold sweet potato

(a) Appearance of wheat-sologold flour composite baked product.

The appearance (visual appeal) of a baked product influences consumers' perception and purchase decision. The colour, shape, and overall presentation can create a sense of freshness and quality [1, 3]. The appearance of the composite baked products X3, Y3 and Z3 (8.90, 9.20 and 9.40) differs slightly from the control samples X1, Y1 and Z1 (8.70, 9.10 and 9.30) and X2, Y2 and Z2 (8.80, 9.10 and 9.35) respectively. The addition of wheat flour appear to make the samples more attractive and well accepted by the panelists than the one with 100% sologold flour. This is in agreement with [25] where similar result was reported. The result as also confirmed, what other researchers have reported regarding the reduction in quality appearance of composite baked products with increasing level of substitution [2, 16]. A well-shaped and evenly browned pastries with attractive toppings are more likely to be preferred by customers [13]. The attractive appearance of the baked products from the optimum blend of wheat and sologold sweet potato enhances their perceived quality, freshness and desirability.

(b) Texture of wheat-sologold flour composite baked product.

Texture refers to the tactile qualities of baked products such as its softness, crispiness, chewiness, or creaminess. The texture significantly impacts the sensory experience and consumer satisfaction [3, 34]. The texture of the composite baked products (X3, Y3 and Z3) showed texture values of 7.75, 8.10 and 8.50 (Figure 5). The control experiments X1, Y1 and Z1 had 7.80, 8.12 and 8.50 while the values recorded for X2, Y2 and Z2 was 7.50, 8.05 and 8.40. According to Wanjuu *et al*., (2018), texture contributes to the overall sensory experience and consumer satisfaction. The desired texture of baked products should be soft and fluffy on the inside with a crispy crust on the outside [16]. The right balance of tenderness of the baked products from the optimum blend created a pleasurable eating experience.

(c) Aroma of wheat-sologold flour composite baked product

Aromatic compounds in baked products contribute to the perception of freshness and quality [25]. The result of aroma of the composite baked products X3, Y3 and Z3 had 8.70, 9.20 and 8.20 as presented in Figure 5. The values obtained from X1, Y1, Z1 were 8.80, 9.20, 8.30 and X2, Y2, Z2 had 8.50, 8.80 and 8.00 respectively.

This implies that higher percentage of wheat flour does guarantee better aroma of the wheat-sologold composite baked product [1]. This result agrees with [2] which reported 100% wheat flour product had higher aroma score when compared with composite baked product. The aroma of the baked products from the optimum blend plays a crucial role in creating a pleasant environment that stimulates appetite.

(d) Flavour of wheat-sologold flour composite baked product.

Flavour is a combination of taste and aroma. It is a crucial factor in determining food preference and consumer acceptance [25]. The result of flavour for composite baked products X3, Y3 and Z3 showed high values of 8.70, 9.00 and 8.50; the control experiments X1, Y1 and Z1 recorded 8.60, 8.80 and 8.30 while X2, Y2 and Z2 had 8.50, 8.60 and 8.10.

A desirable flavour profile is crucial for consumer acceptance and repeat purchase. The flavour profile of a baked product determines its uniqueness and consumer preference [2]. The flavour of baked products from the optimum blend was appealing; which is essential for customer satisfaction.

(e) Crust colour of wheat-sologold flour composite baked product.

A consistent and appealing crust colour suggests proper baking, caramelization, and flavour development [23]. Control samples X1, Y1 and Z1 had 7.10, 7.00 and 8.10 for crust colour while X2, Y2 and Z2 recorded 7.60, 7.40 and 8.80 which implies that the crust colour as a factor is dependent on the level of SSPF substitution. The result is in agreement with the report of [29]. The desired colour can vary depending on the type of product, such as golden-brown crusts in bread or a deep golden colour in pastries [17]. The proper crust colour of the baked products from the optimum blend indicated appropriate baking time, temperature and ingredient quality.

(f) Overall acceptability of wheat-sologold flour composite baked product.

Overall acceptability refers to the consumers' overall perception and satisfaction with a baked product. It takes into account various sensory attributes including appearance, texture, aroma, and flavor [10]. Overall acceptability for samples X1, Y1 and Z1 recorded 8.40, 8.50 and 9.30 while samples X2, Y2 and Z2 recorded 8.10, 8.20 and 9.00. There was decline in the overall acceptability with increase in substitution of wheat with SSPF. The results of this study are in agreement with [13], who reported decrease in overall acceptability with increase in SSPF substitution. It takes into account multiple sensory attributes such as appearance, texture, aroma, and flavor.

Understanding what attributes contribute to overall acceptability can help bakers improve their products and meet consumer expectations. The high overall acceptability value by panelist on the baked products from the optimum blend showed their satisfaction and acceptance of the products.

(g) Intension of consumption of wheat-sologold flour composite baked products

Factors such as taste, visual appeal, aroma, and overall experience influence consumers' intention to consume a baked product [6]. The results of the intension of consumption of the composite baked products (X3, Y3 and Z3) showed highest values of 9.00, 8.90 and 9.20 while control samples X1, Y1 and Z1 recorded 9.00, 8.80 and 9.00 and X2, Y2 and Z2 recorded 8.60, 8.50 and 8.70.

Understanding consumer preferences and aligning product attributes with their expectations is crucial for success in the bakery industry [30]. The high intension of consumption rating by panellist of the baked products from optimum blend of wheat and sologold sweet potato showed their willingness to consume more of the baked products.

IV. Browning index of wheat-sologold flour composite baked product.

The color characteristics/browning index of the composite baked products and control samples were presented in Figures 7 and 8. These include the lightness (L*), measure of redness (a*) and chroma levels (b*). L* represents the degree of lightness (-value = black, +value = white), chroma a* indicates the red/green value (+value = redness, -value = greenness) and chroma b* denotes yellow/blue (+value = yellowness, -value = blueness).

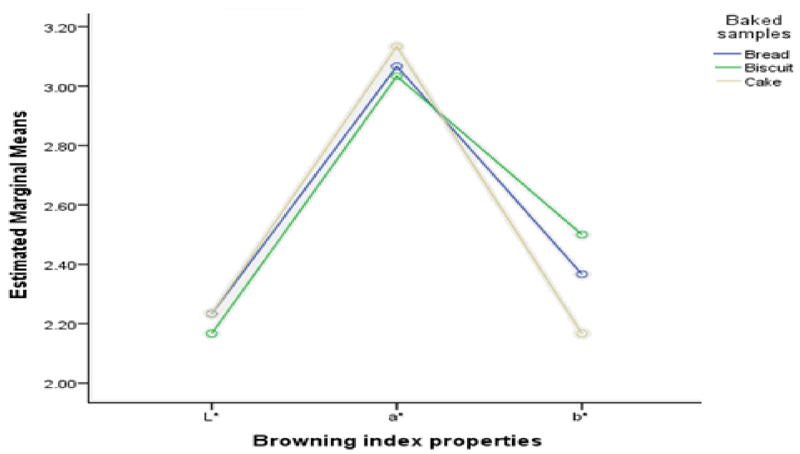

Figure 7. Browning index properties of composite wheat-sologold sweet potato baked products

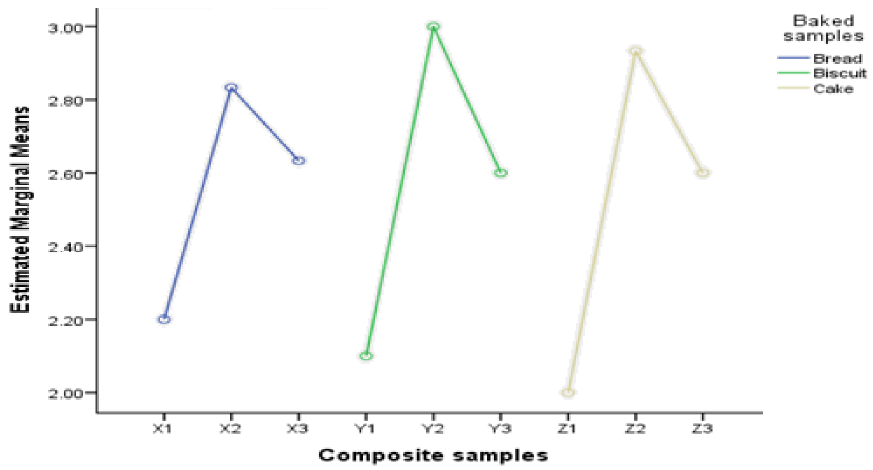

Figure 8. Browning index of composite wheat-sologold sweet potato baked products

Browning index refers to the degree of browning or Maillard reaction that occurs during baking. It affects the taste, aroma, and appearance of food products. The result of lightness (L*) of the composite baked products X3, Y3, Z3 showed 2.5, 2.0, 2.0 and values for the control experiments X1, Y1, Z1 recorded 3.2, 3.0, 3.5 for lightness (L*) while X2, Y2, Z2 recorded 1.0, 1.5, 1.2 (Figure 7).

Composite samples X3, Y3 and Z3 recorded for L* (2.5, 2.0, 2.0), a* (3.2, 3.0, 3.3) and b* (2.2, 2.8, 2.5) respectively which showed excellent and slight browning of the composite baked products. The browning index of baked products from the optimum blends showed the desirable browning, flavor development and consistent quality of the baked products.

V. Statistical analysis on baked product sensory properties

Statistical analysis on the sensory composition of the baked products is presented in Table 3.

Table 3. ANOVA of the sensory analysis of wheat-sologold composite baked products.

Composition		Sum of Squares	Df.	Mean Square	F	Sig.
Appearance	Between Groups	45.7	1	0.105625	0.28499	0.605
	Within Groups	8	14	.02		
	Total	53.7	15			
Texture	Between Groups	44.4	1	0.370625	0.10562	0.028
	Within Groups	8	14	.01		
	Total	52.4	15			
Flavor	Between Groups	60.5	1	0.653624	0.235273	1.034
	Within Groups	8	14	.01		
	Total	68.5	15			
Crust color	Between Groups	232.12	1	0.900584	0.55136	0.037
	Within Groups	8	14	.04		
	Total	240.13	15			
Aroma	Between Groups	174.96	1	7.952273	0.730237	0.690
	Within Groups	8	14	.03		
	Total	182.95	15			
Overall Acceptability	Between Groups	1645.68	1	0.748036	2.343567	0.027
	Within Groups	8	14	.05		
	Total	1653.68	15			
Intension of consumption	Between Groups	7269.38	1	0.330426 4	4.424616	0.016
	Within Groups	8	14	.06		
	Total	7277.38	15			

The statistical analysis of variance (ANOVA) in Table 3 shows the level of significance of texture, crust color, overall acceptability and intension of consumption to be significant (p≤0.05) which shows the texture, crust color, overall acceptability and intension of consumption between the samples differs significantly while the level of significance of appearance, flavor and aroma of the samples were greater than 0.05 (p>0.05).

The difference in the sensory properties between the optimum blend of the baked products and the other controls is significant in texture, crust color, overall acceptability and intension of consumption. The statistical analysis on the browning index of the baked products is shown in Table 4.

Table 4: ANOVA of the browning index of wheat-sologold composite baked product

Composition		Sum of Squares	Df.	Mean Square	F	Sig.
L*	Between Groups	539.944	16	59.99378	3.854499	0.026
	Within Groups	.021	2	.002		
	Total	5384.231	18			
a*	Between Groups	28.77422	23	14.38711	2.933013	0.048
	Within Groups	.076	2	.006		
	Total	2450.332	25			
b*	Between Groups	192.5039	17	24.06299	1.486901	1.010
	Within Groups	.001	2	.000		
	Total	1850.247	19			

The statistical analysis of variance (ANOVA) for chroma levels (L*, a*and b*) of the composite baked products are presented in Table 4 shows L* and a* to be significant ($p \leq 0.05$) which showed that lightness and redness between the baked products from the optimum blend and the control samples differs while the level of significance of b* were greater than 0.05 ($p>0.05$). Hence, there are no differences in the yellowness of the samples.

CONCLUSION

Evaluation of the selected engineering and sensory properties of composite baked products (bread, biscuit and cake) showed that composite baked products produced from 70% wheat and 30% sologold sweet potato flour exhibits high qualities and are recommended for bakers and consumers.

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IZABRANE INŽENJERSKE I OSNOVNE OSOBINE PEČENIH PROIZVODA PRIPREMLJENIH OD KOMPOZITNOG PŠENIČNO-SOLOGOLD BRAŠNA SLATKOG KROMPIRA

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Apstrakt: Brašno od drugih kultura je mešano sa pšeničnim brašnom, kako bi se poboljšale nutritivne i senzorne osobine pečenih proizvoda.
Međutim, kvalitet proizvodnje i održivost ovako pečenih proizvoda i dalje je izazov za pekarsku industriju. Cilj ovog rada je procena odabranih inžinjerijskih i senzornih osobina pečenih proizvoda pripremljenih od kompozitnog pšeničnog sologold brašna slatkog krompira, kako bi se pekari usmeravali za postizanje boljeg kvaliteta proizvoda, razvoj i održivost.

U ovoj studiji uzorci keksa su pripremljeni po Onabanjo o Dickson metodi, uzorci hleba su pripremljeni po metodi ravnog testa, uzorci kolača su pripremljeni po metodi dodavanja jaja u smesu, dok su odabrane inženjerske i senzorne osobine određene u skladu sa standardnim procedurama.

Dobijeni rezultati su pokazali da optimalna mešavina (70% od pšeničnog i 30% slatkog krompira) ima specifičnu zapreminu pečenih proizvoda u rasponu od 4,12 do 0,50 ml/g, vlažnost mrvice proizvoda od 18,54 do 12,04%, otvore kalupa u pećnici od 2,38 do 1,12 mm, visina uzorka od 4,05 do 1,01 mm, masa uzorka od 146,30 do 8,52 g, izgled od 9,40 do 8,70, tekstura od 8,50 do 7,50, aroma 9,20 do 8,0, ukus od 9,0 do 8,10, ukupna boja kore od 7. od 9.30 do 8.10, intenzitet potrošnje od 9.20 do 8.0 i ukupni braon indeks kora proizvoda (smeđa boja) od 1.0 do 4.6.

Ova procenjena inženjerska i senzorna svojstva optimalne mešavine brašna potvrđuju visokokvalitetne pečene proizvode (hleb, keks, kolači). Zato se mogu koristiti za poboljšanje i olakšavanje razvoja proizvoda, kontrole kvaliteta i održivosti proizvoda od kompozitnih pečenih proizvoda.

Zbog toga se pekarima preporučuje ptikazan optimalan odnos mešanja brašna.

Ključne reči: *Pšenično brašno, Sologold brašno, pekarski proizvodi, inženjerski kvaliteti, senzorna osobine.*

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