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Research Article

Physicochemical and sensory evaluation of cookies from germinated maize (*Zea mays*)-kpaakpa (*Hildegardia barteri*) - blanched plantain (*Musa paradisiaca*) composite flour

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Abstract

Composite flours are recently manufactured not only to improve the desired functional properties of end products based on them but also to improve nutritional composition. This study is aimed at determining the physicochemical qualities and sensory properties of composite flour cookies. Germinated maize (*Zea mays*), *Hildegardia barteri ("Kpaakpa"),* and blanched plantain *(Musa paradiciaca)* flour were processed into flours and mixed into various blends using a mixture design. Cookies were produced from the composite flours using the creaming method. The physicochemical and organoleptic properties of the cookies were evaluated. The proximate results showed that increasing the level of *Hildegardia barteri* flour in the mixture enhanced the protein, fat, ash, and crude fiber contents of the cookies. Micronutrient results showed that iron and zinc increased with the high inclusion of *Hildegardia barteri* flour. The cookies' physical properties did not significantly deviate from the control sample. The panelists' mean score for overall acceptability ranged from 2.65 – 7.75 for all of the samples using HMP_1 and HMP9 scoring the lowest. Most of the samples had sensory scores above the midpoints and were generally perceived as acceptable by the panelists. Cookies made with 33.3% of each component were most preferable as they were found to be the best in terms of overall quality. The results obtained from this study

demonstrate the possible use of the *Hildegardia barteri* -based composite flours in bakery products up to 50 % level of substitution. This information can be used for designing food processing protocols which will target consumer requirements and overall acceptability.

INTRODUCTION

Cookies are biscuits that are widely accepted and consumed in many developing countries and other parts of the world. They are high in carbohydrates, fat, and calorie, but low in fiber, vitamins, protein, and minerals. Conventionally, cookies are produced from wheat flour or wheat-based composite flour. These flours are predominantly carbohydrate and are limited in lysine and other nutrients such as vitamins and minerals. This has led to novel biscuit formulations with improved functionality and nutritive value. Composite flour describes the blend of various proportions of flour from other food commodities such as cereals, legumes, roots, and tubers with or without wheat flour (1). The manufacture of composite flours is aimed at improving the desired functional properties of the finished products made from them and also enhancing the nutritional composition (2). The use of other cereals to substitute wheat has an economic advantage and the nutritional deficiencies of wheat flour can as well be overcome by these cereal substitutions. The use of non-wheat composite flour (maize), plantain flour containing functional ingredients with protein-rich legume *("Kpaakpa")* flour in proportions that will improve protein intake which will help to overcome the low protein quality of cereal-based cookies and other bakery products were the basis of this research. *Hildegardia barteri* ("kpaakpa") is one of the lesser-known legumes: that is consumed in a few rural communities in Ebonyi and Enugu states of Southeastern Nigeria, as a soup condiment and for chewing after it is roasted. Currently, it has no commercial value. Extensive research on various applications of *Hildegardia barteri* flour especially in convenience foods will further generate scientific information that contributes immensely to the nutritional well-being of diverse human diets. Specifically, the aim of this study is to determine the physicochemical properties, micronutrient composition and sensory properties of composite flour cookies.

MATERIALS AND METHODS

Materials

*Hildegard*ia *barteri* seeds were obtained from the independent Layout Area of Enugu. Maize, plantain, and other materials- wheat flour, baking soda, granulated sugar, fat, flavor, etc were purchased from Ogbete Market, Enugu, Nigeria.

Table 1. Percentage of each ingredient of ten formulations of H. barteri, germinated maize and blanched plantain flours respectively

Blend no.	*H. barteri*	Germinated Maize	Plantain
1	100	0	0
2	50	50	0
3	0	100	0
4	33.3	33.3	33.3
5	0	0	100
6	0	50	50
7	50	0	50
8	16.7	16.7	66.7
9	66.7	16.7	16.7
10	16.7	66.7	16.7

Experimental design/ formulation of flour blends

This research was designed using Minitab software version 14.0. It had a mixture response surface methodology with three components (Germinated maize flour (GMF), *Hildergardia barteri* flour (HBF), and blanched unripe plantain flour (BPF)) making a total of ten runs. Flour blends of HBF and BPF were prepared to fit into the experimental design as shown in Table 1. The flours were thoroughly blended at predetermined proportions using a Panasonic MX-AC 2105 blending machine to obtain a homogenous mixture.

Cookies production

The recipe for digestive biscuits as described by Okaka (3) was used for making the cookies samples. The percentage of the major ingredients used were as follows: Flour 46.7 %, Fat 18.7 %, sugar 11.7 %, Milk powder 7.0 %, Baking powder 0.5 %, Vanilla flavor 0.1 %, Nutmeg 0.1 %, Salt 0.5 %, and Egg 14.6 %.

Procedure

The fat and sugar were mixed thoroughly until both formed a homogenous mixture (fluffy). The beaten egg was added to fluffy during the mixing for a total of 30 min. Other ingredients (flour, milk powder, salt and baking powder, Vanilla, and Nutmeg were thoroughly mixed in a separate bowl and added to the cream mixture to form a dough. The dough was rolled and cut into circular shapes which was 5 cm in diameter. Baking was carried out at 185 ^{0}C for 15-25 min. Baking was terminated when the cookies gained developed golden brown color. Cookie samples were removed from the oven, allowed to cool at ambient temperature (29 ^{0}C) for 30 min, and stored in cellophane bags prior to evaluation.

METHODS

The chemical and micronutrient composition, physical properties, and organoleptic properties of the cookies were determined using standard analytical methods.

Chemical composition of cookies

All the cookie samples were evaluated for proximate composition using standard procedures of AOAC (4). The carbohydrate content of each cookie sample was calculated by difference (5). The calculation was made by the equation:

$$\text{Carbohydrate (\%)} = 100 - (\text{Moisture} + \text{Protein} + \text{Fat} + \text{Ash} + \text{Fiber}) \quad (1)$$

The method of Onuh *et al*. (6) was used to evaluate the food energy content of each cookie. This was determined by multiplying the percentages of crude protein, carbohydrate and fat by the Atwater constants of 4, 4 and 9 respectively, and adding the figures together.

$$\text{Energy content} = (4 \times \text{Protein \%}) + (4 \times \text{Carbohydrate \%}) + (9 \times \text{Fat \%}) \quad (2)$$

Micronutrient Analysis

Vitamin B1 (Thiamin), vitamin B2 (Riboflavin), vitamin B3 (Niacin), iron, and zinc were determined in the cookies using standard methods of AOAC (4).

Prior to mineral analysis, the mineral was initially extracted from each sample according to the dry Ash extraction methods of Chapman and Pratt (7).

Atomic Absorption Spectrophotometer (model 320N) was used to determine the nutritionally important minerals, iron and zinc.

Physical properties of cookies

The diameter, weight, stack height, thickness, and Spread ratio of the cookies were measured. The diameter (D) of the cookies was determined according to the method of AACC (8).

Sensory evaluation

The 9-point Hedonic scale for product acceptance testing following the Iwe (9) method was adopted. Twenty-five (25) partially trained panelists were selected randomly from the Food Science and Technology Department Students and some staff of Madonna University, Nigeria, Akpugo Campus Enugu State in order to evaluate the consumer acceptance of each of the cookies. The panelist assessed the cookies for appearance, flavor, texture, mouth feel, crispness, and overall acceptability on a 1–9- point hedonic scale.

Statistical analysis

The data obtained from the evaluation of the physicochemical and sensory properties of the cookies were statistically analyzed to compare different sources of variance within a data set and to test whether two or more groups differ from each other significantly in one or more characteristics. This was done by using Statistical Package for Social Sciences (SPSS) Version 17.0 for Windows, SPSS Inc. Illinois, USA). The Least Significant Difference (LSD) was used for mean separation. Statistical significance was accepted at a 0.05 level of probability ($p \leq 0.05$).

Results and discussion

The results of the proximate composition of the cookies are presented in Table 2. The results showed that the protein content ranged from 5.56 - 11.48 g/100 g in cookies made with H100:M0.0:P0.0: ratios having the highest value while that made with $H_{16.7}M_{66.7}P_{16.7}$: ratios had the lowest value. Samples $H_{100}M_{0.0}P_{0.0}$, $H_{33.3}M_{33.3}P_{33.3}$, $H_{50.0}M_{50.0}P_{0.0}$, and $H_{66.7}M_{16.7}P_{16.7}$ recorded values ranging from 10.18 - 11.48. These high protein levels were observed to be due to the high level of *Hildegardia barteri (Kpaakpa)* flour incorporation into the flour. The observed increase in protein values of the cookies sample could be attributed to the rich protein composition of *Hildegardia barteri* as reported in an earlier study by Anyadioha *et al*., (10). These results were also complied with the reports of a recent study which suggested usage of legume flours for improving the protein contents of cereal-based flours (11). The results obtained from sample $H_{100}M_{0.0}P_{0.0}$, (11.48±0.67) $H_{50.0}M_{50.0}P_{0.0}$ (10.13±0.88) $H_{33.3}M_{33.3}P_{33.3}$ (10.64±0.04) and $H_{66.7}M_{16.7}P_{16.7}$ (10.18±0.03) were in line with the FAO/WHO minimum standard for protein content of 10 % (12).

The values for fat ranged from 3.94 -12.5 with sample $H_{100}M_{0.0}P_{0.0}$ and $H_{16.7}M_{16.7}P_{6.7}$ having the highest and least values respectively. The fat content was generally high, especially with increasing levels of *Hildegardia barteri* flour addition. This could be attributed to the very high level of fat contained in *Hildegardia barteri* flour. The fatty acid profile of *Hildegardia barteri* had been reported to contain a percentage unsaturated fatty acid of Oleic (C18:1) (omega 9) 0.03, Linoleic (C18:2) (Parent omega 6) 1.43, Linolenic (C18:3) 21.5 respectively (13). Therefore, cookies made with *Hildegardia barteri* flour substitute could supply the body with this special type of protective essential fatty acid which the body could not synthesize.

The results obtained for crude fiber, ash, and carbohydrate of the cookies ranged from 1.66 - 2.61, 1.85 - 3.86, 60.31 - 81.15 % respectively. The crude fiber of all the cookie samples was within the FAO/WHO standard (≤ 5 % dietary fiber per 100 g dry matter). The value ranged from 1.66-2.91 with sample H16.7M66.7P16.7 having the highest value while $H_{33.3}M_{33.3}P_{33.3}$ having the least. It was observed that the percentage of crude fiber increased by increasing substitution of maize and *Hildegardia barteri (Kpaakpa)* flour respectively. This may be due to the high level of crude fiber obtained in the original component flours. Fiber plays a significant role in the digestion and absorption of food in the human body.

The values recorded for ash content were above the Standard Organization of Nigeria (SON) standard (14) of 2.0 % except for samples $H_{33.3}M_{33.3}P_{33.3}$, $H_{16.7}M_{16.7}P_{66.7}$, and W_{100} which had 1.96, 1.96 and 1.85 % ash content respectively. These values did not vary significantly ($P<0.05$) from the 2.0 % SON stipulated standard. Sample $H_{50.0}M_{50.0}P_{0.0}$ had the highest ash content of 3.86 %.

The cookies made from the ternary blends had carbohydrate values ranging from 71.65 to 73.76 %. The cookies made from increasing levels of

Hildegardia barteri (Kpaakpa) flour recorded low carbohydrate values.

The moisture of samples $H_{66.7}M_{16.7}P_{16.7}$ and $H_{16.7}M_{16.7}P_{66.7}$ were significantly the highest. Generally, the values obtained from this study were above the maximum standard moisture of 6 % which is recommended by the Standard Organization of Nigeria (14). However, these values deviated from the results obtained by Okpala et al. (1) and Okpala et al. (15), who reported that the moisture content of cookies below 10 % is less likely to cause any adverse effect on the product.

The energy content of the cookie samples ranged from 363.10 kJ/100 g (H0.0M 50P50) to 407.99 kJ/100 g (control). From Table 2, an inverse relationship between energy content and fiber was observed. Sample $H_{33.3}M_{33.3}P_{33.3}$, $H_{16.7}M_{16.7}P_{66.7}$, and W_{100} had low fibers and high energy content respectively indicating that high-fiber foods tend to have low energy and vice versa.

The vitamin and mineral content of cookies made from blends of germinated *Hildegardia barteri* (Kpaakpa*)*, germinated maize, and blanched plantain are shown in Table 3 below.

Vitamin B1, B2, and B3 content of the cookies ranged from 0.01 - 0.47 mg/100 g, 0 .26 - 5.1 mg/100 g, and 0.19 -1.6 mg/100 g respectively. Sample $H_{33.3}M_{33.3}P_{33.3}$ recorded the highest Vitamin B1 value while the reference sample (100 % wheat flour cookies) had the lowest value of 0.01 mg/100 g. Vitamin B1 is good for circulation, carbohydrate metabolism, cognitive activity, brain function, and nervous system health (16).

Table 2. Proximate composition of cookies (%)

Sample	Protein	Ash	Moisture	Fiber	Fat	CHO	Energy (KJ/100 g)
$H_{100}M_{0.0}P_{0.0}$	11.48±0.67^{a}	3.39±0.01^{b}	7.9±0.14^{ab}	2.49±0.01^{ab}	12.5±0.14^{a}	60.31±0.07^{c}	400.86±0.02^{ab}
$H_{50.0}M_{50.0}P_{0.0}$	10.13±0.88^{ab}	2.86±0.00^{a}	7.89±0.09^{ab}	2.39±0.04^{ab}	10.48±0.67^{ab}	65.43±0.26^{bc}	396.56±4.6^{ab}
$H_{0.0}M_{100}P_{0.0}$	9.18±0.02^{b}	2.89±0.01^{b}	7.98±0.00^{ab}	2.10±0.14^{b}	4.81±0.03^{cd}	72.93±0.12^{bc}	371.78±0.71^{bc}
$H_{33.3}M_{33.3}P_{33.3}$	10.64±0.04^{a}	2.85±0.02^{c}	7.52±0.16^{abc}	1.66±0.01^{bc}	7.80±0.16^{bc}	70.41±0.09^{b}	384.14±12.4^{ab}
$H_{0.0}M_{0.0}P_{100}$	5.78±0.02^{c}	2.29±0.01^{bc}	7.38±0.02^{abc}	2.4±0.28^{ab}	2.9±0.01^{dc}	81.15±0.21^{a}	366.63±1.08^{bc}
$H_{0.0}M_{50.0}P_{50.0}$	6.39±0.07^{c}	2.75±0.15^{b}	8.21±0.32^{ab}	2.4±0.04^{ab}	6.41±0.06	73.86±0.61^{ba}	377.02±0.86^{bc}
$H_{50.0}M_{0.0}P_{50.0}$	7.96±0.05^{bc}	3.41±0.26^{ab}	9.53±0.74^{a}	2.61±0.01^{ab}	8.22±0.84^{c}	68.82±0.93^{c}	363.10±3.67^{bc}
$H_{16.7}M_{16.7}P_{66.7}$	6.48±0.64^{c}	1.96±0.00^{c}	10.05±0.07^{a}	1.71±0.28^{bc}	3.64±0.50^{b}	71.65±0.46^{b}	390.3±0.14^{ab}
$H_{66.7}M_{16.7}P_{16.7}$	10.18±0.03^{a}	3.00±0.00^{b}	10.50±0.02^{a}	1.97±0.01^{c}	9.94±0.02^{cd}	72.67±0.04^{bc}	365.3±2.07^{bc}
$H_{16.7}M_{66.7}P_{16.7}$	5.56±0.04^{c}	2.96±0.00^{b}	7.96±0.38^{ab}	2.91±0.12^{a}	6.84±1.34^{c}	73.76±0.07^{ab}	376.18±5.59^{bc}
W_{100}	8.98±0.02^{a}	1.85±0.04^{c}	9.67±0.07^{a}	1.78±0.14^{bc}	4.74±0.08^{cd}	80.33±0.18^{a}	407.99±2.81^{ab}

Means ±standard deviations of triplicate determinations. Means within a column with the same superscript are not significantly different (p≤0.05). **Key**: M.C= Moisture Content; CHO = Carbohydrate; H =Hildegardia barteri flour; M= Malted Maize flour; P= Blanched Plantain flour.$H_{100}M_{0.00}p_{0.00}$ = (100: 0:0: ratios of *H. barteri*- Malted Maize-Blanched Plantain)**,** $H_{50}M_{50.0}P_{0.00}$ = (50: 50:0: ratios of *H. barteri*- Malted Maize-Blanched Plantain), $H_{0.00}M_{100.0}P_{0.00}$ =(0: 100:0: ratios of *H. barteri*- Malted Maize-Blanched Plantain, $H_{33.3}M_{33.3}P_{33.3}$ =(33.3: 33.3:33.3 ratios of *H. barteri*- Malted Maize-Blanched Plantain**,** $H_{0.0}M_{0.0}P_{100.0}$ =(0: 0:100: ratios of *H. barteri*- Malted Maize-Blanched Plantain)**,** $H_{0.0}M_{50.0}P_{50.0}$ = (0: 50:50: ratios of *H. barteri*- Malted Maize-Blanched Plantain)**,** $H_{50.0}M_{0.0}P_{50.0}$ = (50: 0:50: ratios of *H. barteri*- Malted Maize-Blanched Plantain)**,** $H_{16.7}M_{16.7}P_{66.7}$ = (16,7: 16.7:66.7: ratios of *H. barteri*- Malted Maize-Blanched Plantain)**,** $H_{66.7}M_{16.7}P_{16.7}$ = (66,7: 16.7:16.7: ratios of *H. barteri*- Malted Maize-Blanched Plantain)**,** $H_{16.7}M_{66.7}P_{16.7}$ = (16,7: 66.7:16.7: ratios of *H. barteri*- Malted Maize-Blanched Plantain)**,** W_{100} = 100 % wheat flour (Control sample)

There was an increase in vitamin B2 (riboflavin) contents of samples $H_{50.0}M_{0.0}P_{50.0}$ and H66.7M16.7P16.7 due to the high inclusion level of *Hildegardia barteri* (Kpaakpa) flour. However, the abnormal rise in riboflavin in sample $H_{16.7}M_{66.7}P_{16.7}$ could be attributed to extraneous factors during the determination. Vitamin B2 is needed for the digestion of macronutrients and also for cell respiration. It is required in the body for the formation of red blood cells and antibodies (17) and so is essential for life and for optimal functioning of the body (18).

The vitamin B3 content ranged from 0.08 - 0.99 with sample $H_{0.00}M_{100}P_{0.00}$ recording the highest value while sample $H_{50.0}M_{0.0}P_{50.0}$ had the least. Sample $H_{16.7}M_{66.7}P_{16.7}$ compared favorably with sample W100 (Control) and there were no significant differences between them. Vitamin B3 content of sample H50.0M0.0P50.0 and that of W100 (Control) sample. Generally, there were enhanced levels of vitamin B3 in most of the flour blends when compared to 100 % *Hidegardia barteri-based* cookies. Vitamin B3 is useful in reducing serum cholesterol, lowering high blood pressure, checking fatty buildup in the liver, maintaining the nervous system, and helping to minimize depression (19).

The mean iron values ranged from 0.25 – 6.32 mg/100 g with sample $H_{0.0}M_{50.0}P_{50.0}$ having the lowest value and sample W_{100} (100 %) wheat having the highest value. There was a significant reduction in the iron content of the cookies. This result was in conformity with the findings of Kashlan *et al.* (20), who reported that during baking significant loss of most minerals such as iron was found. Iron is an important component

Table 3. Micronutrient composition of cookies (mg/100g)

Samples	Thiamin	Riboflavin	Niacin	Iron	Zinc
$H_{100}M_{0.00}P_{0.00}$	0.29 ± 0.01^{bc}	2.40 ± 0.07^{ab}	0.27 ± 0.04^{d}	2.60 ± 0.14^{ab}	2.98 ± 0.04^{a}
$H_{50.0}M_{50}P_{0.00}$	0.35 ± 0.02^{b}	1.30 ± 0.14^{bc}	0.83 ± 0.04^{ab}	2.4 ± 0.07^{ab}	2.49 ± 0.01
$H_{0.00}M_{100}P_{0.00}$	0.40 ± 0.03^{ab}	0.71 ± 0.01^{c}	0.99 ± 0.02^{a}	2.48 ± 0.25^{ab}	1.98 ± 0.01^{bc}
$H_{33.3}M_{33.3}P_{33.3}$	0.10 ± 0.01^{c}	1.26 ± 0.00^{bc}	0.44 ± 0.00^{c}	0.52 ± 0.00^{bc}	0.61 ± 0.34^{d}
$H_{0.00}M_{0.00}P_{100}$	0.06 ± 0.01^{c}	0.07 ± 0.01^{dc}	0.28 ± 0.02^{d}	0.26 ± 0.03^{c}	0.25 ± 0.01^{d}
$H_{0.00}M_{50.0}P_{50.0}$	0.90 ± 0.01^{a}	0.45 ± 0.02^{cd}	0.91 ± 0.02^{a}	0.25 ± 0.03^{c}	0.25 ± 0.02
$H_{50.0}M_{0.0}P_{50.0}$	0.90 ± 0.00^{a}	1.19 ± 0.01^{bc}	0.08 ± 0.01^{dc}	1.19 ± 0.01^{b}	0.08 ± 0.01^{c}
$H_{16.7}M_{16.7}P_{66.7}$	0.06 ± 0.00^{e}	1.15 ± 0.05^{bc}	0.53 ± 0.01^{c}	1.27 ± 0.01^{b}	0.62 ± 0.00^{d}
$H_{66.7}M_{16.7}P_{16.7}$	0.21 ± 0.00^{a}	2.14 ± 0.03^{b}	0.39 ± 0.01^{c}	1.27 ± 0.01^{b}	2.98 ± 0.16^{ab}
$H_{16.7}M_{66.7}P_{16.7}$	0.05 ± 0.00^{e}	5.90 ± 0.06^{a}	0.61 ± 0.00^{b}	0.26 ± 0.00^{c}	0.41 ± 0.01^{d}
W_{100} (Control)	0.02 ± 0.00^{e}	0.31 ± 0.02^{d}	0.61 ± 0.02^{b}	6.32 ± 0.03^{a}	1.40 ± 0.01^{c}

Means + standard deviation of duplicate determinations with different superscripts along the same column are significantly different (p≤0.05). **Key:**$H_{100}M_{0.00}P_{0.00}$ = (100: 0:0: ratios of *H. barteri*- Malted Maize-Blanched Plantain), H50M50.0P0.00 = (50: 50:0: ratios of *H. barteri*- Malted Maize-Blanched Plantain), H0.00M100.0P0.00 =(0: 100:0: ratios of *H. barteri*- Malted Maize-Blanched Plantain, $H_{33.3}M_{33.3}P_{33.3}$ =(33.3: 33.3:33.3 ratios of *H. barteri*- Malted Maize-Blanched Plantain, H0.0M0.0P100.0 =(0: 0:100: ratios of *H. barteri*- Malted Maize-Blanched Plantain), $H_{0.0}M_{50.0}P_{50.0}$ = (0: 50:50: ratios of *H. barteri*- Malted Maize-Blanched Plantain), $H_{50.0}M_{0.0}P_{50.0}$ = (50: 0:50: ratios of *H. barteri*- Malted Maize-Blanched Plantain), $H_{16.7}M_{16.7}P_{66.7}$ = (16,7: 16.7:66.7: ratios of *H. barteri*- Malted Maize-Blanched Plantain), $H_{66.7}M_{16.7}P_{16.7}$ = (66,7: 16.7:16.7: ratios of *H. barteri*- Malted Maize-Blanched Plantain), $H_{16.7}M_{66.7}P_{16.7}$= (16,7: 66.7:16.7: ratios of *H. barteri*- Malted Maize-Blanched Plantain), W100 = 100 % wheat flour (Control sample) of red blood cells, and enzymes is very essential in the oxygen transport and cell respiration mechanisms.

The average values for zinc ranged from 0.08-2.98 mg/100 g with sample 100 % *Hildegardia barteri* flour cookies having the highest value of 2.98 mg/100 g whereas sample $H_{50.0}M_{0.0}P5_{0.0}$ had the lowest value. From Table 3, it was observed that cookies made from samples $H_{100}M_{0.00}P_{0.00}$, $H_{50.0}M_{0.0}P_{50.0}$, and $H_{66.7}M_{16.7}P_{16.7}$ composite flour which had higher levels of *Hildegardia barteri* (kpaakpa) substitution had higher levels of zinc than other cookies samples. This could be attributed to the fact *Hildegardia barteri* (kpaakpa) is a legume and Zinc is a plentiful microelement in the body which is found in nuts, and legumes (21). Generally, there was a decrease in the zinc content of the cookies when compared to that of the composite flour. This may be attributed to heat processing. Zinc is very essential in cell division, protein synthesis, and growth such that its deficiency places children, pregnant women, and adolescents at risk. Zinc enhances reproduction, growth, taste and night vision, wound healing, DNA synthesis, appetite, and immune system functioning (22). Zinc deficiency had been reported to aggravate carbohydrate intolerance in certain individuals (9).

The physical properties of cookies:

The physical properties of cookies prepared from blends of *Hildegardia barter (kpaakpa)*, plantain, and maize flour respectively as well as 100 % wheat flour are presented in Table 4.

Table 4. Physical Properties of Cookies

Samples	Diameter (cm)	Thickness (cm)	Spread Ratio	Stack Height (cm)	Weight (g)
$H_{100}M_{0.00}P_{0.00}$	3.90 ± 0.05[a]	0.89 ± 0.00[a]	4.39 ± 0.01a	8.8 ± 0.26[a]	8.00 ± 0.15[a]
$H_{50}M_{50}P_{0.00}$	3.56.00 ± 0.15[c]	0.83 ± 0.01ab	4.25 ± 0.22[a]	8.4 ± 0.10[c]	8.13±1.81
$H_{0\cdot00}M_{100}:P_{0.00}$	3.96 ± 0.05[a]	0.82 ± 0.06[ab]	4.76 ± 0.32[ab]	7.96 ± 0.05[d]	9.32 ± 0.44[a]
$H_{33.3}\ M_{33.3}P_{33.3}$	3.66 ± 0.25[bc]	0.75 ± 0.05[ab]	5.63 ± 0.75[ab]	6.83± 0.05[e]	8.93 ±0.25[a]
$H_{0.0}M_{0\cdot0}P_{100.0}$	3.56 ± 0.15[bc]	0.77 ± 0.02[ab]	4.56 ± 0.05[a]	8.13 ± 0.32[d]	9.35 ± 0.02[a]
$H_{0}M_{50.0}P_{50.0}$	3.9 ± 0.00[a]	0.90 ± 0.0[a]	4.3 ± 0.00[b]	8.96 ± 0.05[a]	7.6 ± 0.32[a]
$H_{50.0}M_{0.0}P_{50.0}$	3.83 ± 0.05[a]	0.77 ± 0.02[ab]	4.93 ± 0.11[ab]	7.73 ± 0.05[d]	9.28 ± 0.02[a]
$H_{16.7}M_{16.7}\ P_{66\cdot7}$	3.66 ± 0.05[a]	0.80 ± 0.00[ab]	4.56 ± 0.05[ab]	8.66 ± 0.15[a]	9.35 ± 0.5[a]
$H_{66.7}M_{16\cdot7}\ P_{16\cdot7}$	3.96 ± 0.05[a]	0.79 ± 0.01[ab]	4.93± 0.11[ab]	8.93 ± 0.05[a]	8.86 ± 0.80[a]
$H_{16.7}M_{66.7}\ P_{16\cdot7}$.	3.96 ± 0.05[a]	0.8 ± 0.00ab	4.96 ± 0.05[ab]	8.93 ± 0.05[a]	8.62 ± 0.12[a]
$W_{100.00}$	3.25±0.07[cd]	0.92 ±0.05[a]	3.51±0.22[bc]	7.97 ± 0.05[d]	9.16±0.22[a]

Means + standard deviation of duplicate determinations with different superscripts along the same column are significantly different (p≤0.05). **Key:** $H_{100}M_{0.00}p_{0.00}$ = (100: 0:0: ratios of *H. barteri*- Malted Maize-Blanched Plantain), $H_{50}M5_{0.0}P_{0.00}$ = (50: 50:0: ratios of *H. barteri*- Malted Maize-Blanched Plantain), $H_{0.00}M_{100}.0P_{0.00}$ =(0: 100:0: ratios of *H. barteri*- Malted Maize-Blanched Plantain, $H_{33.3}\ M_{33.3}P_{33.3}$ =(33.3: 33.3:33.3 ratios of *H. barteri*- Malted Maize-Blanched Plantain, H0.0M0.0P100.0 =(0: 0:100: ratios of *H. barteri*- Malted Maize-Blanched Plantain), $H_{0.0}M_{50.0}P_{50.0}$ = (0: 50:50: ratios of *H. barteri*- Malted Maize-Blanched Plantain), $H_{50.0}M_{0.0}P_{50.0}$ = (50: 0:50: ratios of *H. barteri*- Malted Maize-Blanched Plantain), $H_{16.7}M_{16.7}\ P_{66.7}$ = (16,7: 16.7:66.7: ratios of *H. barteri*- Malted Maize-Blanched Plantain), $H_{66.7}M_{16.7}\ P_{16.7}$ = (66,7: 16.7:16.7: ratios of *H. barteri*- Malted Maize-Blanched Plantain), H16.7M66.7 P16.7 = (16,7: 66.7:16.7: ratios of *H. barteri*- Malted Maize-Blanched Plantain), W100 = 100 % wheat flour (Control sample).

The weight of the cookies ranged from 7.60 to 9.35 with 100 % *Hildegardia barteri* flour cookies having the least value while samples $H_{0.0}M_{0.0}P_{100.0}$ and $H_{16.7}M_{16.7}P_{66.7}$ had the highest weight of 9.35 g respectively. There was no statistically significant difference in weight of the test samples and the 100 % wheat cookies ($p<0.05$). However, the weight of the cookies recorded a slight increase with the increasing inclusion of plantain flour and a decrease with the increasing inclusion of *Hildegardia barteri* (kpaakpa) flour. This may be attributed to the high bulk density recorded in plantain flour and the higher fat content of high ratio *Hildegardia barteri* (kpaakpa) flour.

The results obtained for thickness ranged from 0.75 - 0.92 cm with sample $H_{33.3}M_{33.3}P_{33}$ having the least value of thickness (0.75 cm) whereas sample W100 recorded the highest value (0.92 cm). Most of the test cookies did not differ from each other except for samples $H_0M_{50.0}P_{50.0}$ and $H_{100}M_{0.0}P_{0.0}$. However, these test samples deviated in thickness from the control sample. The implication of this could be that virtually all the cookies made had uniform thickness.

The values for spread ratio ranged from 4.25-5.63. Cookies made from 33.3 % of each component ($H_{33.3}M_{33.3}P_{33}$) had the highest values of 5.63 compared to 100 % wheat flour cookies which had the lowest spread ratio of 3.5. The values for the spread ratio of the test samples varied significantly ($p\leq 0.05$) from that of 100 % wheat cookies (reference sample). The spread ratio is a parameter used to show the ability of cookies to raise (23), hence the higher the spread ratio of cookies the more preferable it is (24).

The mean value of the diameter of both the 100 % wheat cookies and the cookies produced from the three components ranged from 3.25 cm (W100) – 3.96 for cookie samples made from $H_{0.00}M_{100}$:$P_{0.00}$, $H_{100}M_{0.00}P_{0.00}$, $H_{66.7}M_{16.7}P_{16.7}$, and $H_{16.7}M_{66.7}P_{16.7}$ flour blends respectively. These results suggest that there were no significant differences ($p\geq 0.05$) between most of the cookie samples produced due to the diameter. This showed that the diameters of the cookies were mostly uniform.

Sensory Properties of composite flour cookies

The organoleptic evaluation results were presented in Table 5. The results indicated that some of the *Hildegardia barteri* (kpaakpa) cookies statistically differed from the control with respect to the attributes tested. The attributes included appearance, flavor, crispiness, texture, mouth feel, and overall acceptability. The mean score for appearance ranged from 4.20 – 8.4 with sample HMP_2 having the least sample and sample HMP_3 recording the highest score. In terms of appearance, samples HMP1 and HMP_2 were rated the poorest. This may be due to the high level of *Hildegardia barteri (*kpaaakpa) flour including high level of fat which got fried at a high temperature of baking. The rest of the samples did not differ significantly from the control sample so that they were compared favorably well and acceptable.

The mean scores for flavor ranged from 2.7 to 7.5 for all the samples with sample HMP8 having the highest score while sample HMP_1 having the lowest. There were significant differences ($p < 0.05$) in flavor among the various samples. Sample HMP_3 and HMP_7 were rated the same by the panelists while HMP_8 was the most preferred in terms of flavor as it compared favorably well with the reference sample. Sample HMP_1 and HMP_9 were mostly rated the least in terms of flavor. This may be attributed to the specific taste and aroma associated with *Hildegardia barteri* (*Kpaakpa)* flour which made the panelists who were not conversant with it reject it.

The panelist mean score for texture ranged from 3.05-7.5 with HMP1 (100 % *Hildegardia barteri*flour cookies) scoring the lowest while WFC had the highest. Samples HMP_3, HMP_4, and HMP_7 had the same rating and seemed to have the best texture according to the decision of panelists. Texture is an important parameter related to the structure and composition of food thus, texture is the sensory manifestation of the structure of food and has a strong influence on food intake and nutrition (25).

The ratings for mouth feel ranged from 3.66 (HMP_1) to 7.85 (control). Generally, all of the test samples recorded had mean scores above 5.0 except HMP_1 and HMP_9 which had the lowest scores. Mouth feel refers to the physical sensation in the mouth caused by food (initial bite) (26). Mouth feel is fundamental sensory property with great importance of which, along with taste and aroma determines the overall flavor of food and is consequently associated with consumer acceptability.

The overall acceptability score for all of the composite flour cookies were ranged from 4.35 to 7.70. Sample HMP9 had the lowest score (4.35) that was disliked slightly while sample HMP8 recorded the highest score (7.70). The samples did not vary significantly (P >0.05) - HMP_4, HMP_7, HMP_8, and WFC with mean scores of 7.50, 7.50, 7.77, and 7.75 respectively which means that four samples were perceived as similar by the panelist. They were moderately liked by the panelists in terms of overall acceptability, most preferred and accepted. Generally, cookies made from higher levels of *Hildegardia barteri* flour content had the least sensory scores in terms of all the attributes studied. The three component blends of 33.3:33.3:33.3 maize - *Hildegardia barteri* – plantain and ternary blend with 66.7 % maize and plantain flour respectively produced cookies that were favorably in compared to the control sample in terms of all the organoleptic properties studied. Cookies made with 16.7: 16.7:66.7: ratios of *H. barteri*- malted maize-blanched plantain (HMP8) had the best rating for appearance and general acceptability.

Table 5. Sensory properties of cookies made from germinated Hildegardia barteri, germinated maize, and blanched plantain composite flours

Samples	Appearance	Flavor	Texture	Mouthfeel	Crispiness	Overall Acceptability
HMP_1	4.26 ± 0.08^{e}	2.7 ± 0.07^{f}	3.05 ± 0.07^{d}	3.66 ± 0.21^{d}	2.70 ± 0.14^{dc}	2.65 ± 0.07^{e}
HMP_2	4.20 ± 0.07^{e}	5.8 ± 0.00^{dc}	6.2 ± 0.00^{bc}	5.55 ± 0.07^{c}	6.40 ± 0.07^{bc}	6.15 ± 0.07^{c}
HMP_3	8.4 ± 0.00^{a}	7.0 ± 0.07^{b}	6.8 ± 0.00^{b}	6.00 ± 0.00^{bc}	7.00 ± 0.00^{ab}	6.40 ± 0.14^{bc}
HMP_4	7.4 ± 0.07^{bc}	6.8 ± 0.07^{bc}	7.0 ± 0.00^{ab}	7.30 ± 0.00^{bc}	7.00 ± 0.00^{ab}	7.50 ± 0.00^{bc}
HMP_5	6.95 ± 0.07^{bc}	6.65 ± 0.07^{cd}	6.1 ± 0.14^{c}	5.65 ± 0.07^{c}	6.55 ± 0.07^{bc}	6.65 ± 0.07^{bc}
HMP_6	6.35 ± 0.07^{d}	6.85 ± 0.07^{bc}	6.7 ± 0.00^{b}	6.3 ± 0.00^{bc}	6.85 ± 0.07^{b}	7.25 ± 0.07^{ab}
HMP_7	6.75 ± 0.07^{bc}	7.00 ± 0.00^{b}	7.0 ± 0.00^{ab}	7.4 ± 0.00^{ab}	6.70 ± 0.00^{b}	7.5 ± 0.14^{a}
HMP_8	7.75 ± 0.07^{ab}	7.25 ± 0.07^{ab}	6.45 ± 0.07^{bc}	7.0 ± 0.07^{b}	6.80 ± 0.00^{b}	7.7 ± 0.28^{a}
HMP_9	5.4 ± 0.007^{dc}	5.15 ± 0.07^{c}	4.2 ± 0.07^{cd}	4.5 ± 0.00^{cd}	3.95 ± 0.07^{d}	4.35 ± 0.07^{d}
HMP_{10}	7.3 ± 0.28^{bc}	6.40 ± 0.00^{d}	6.3 ± 0.14^{bc}	7.0 ± 0.00^{b}	6.40 ± 0.14^{c}	6.70 ± 0.14^{bc}
WFC	7.4 ± 0.00^{bc}	7.5 ± 0.00^{a}	7.5 ± 0.07^{a}	7.85 ± 0.07^{a}	7.26 ± 0.07^{a}	7.75 ± 0.21^{a}

Means ±standard deviations of twenty semi-trained panelists' judgments. Means within a column with the same superscript are not significantly different (p≤0.05).**Key:** HMP_1 = Cookies made with 100: 0.0:0.0 ratios of *H. barteri*- Malted Maize-Blanched Plantain, HMP_2 = Cookies made with 50: 50:0: ratios of *H. barteri*- Malted Maize-Blanched Plantain)HMP_3 = Cookies made with 0: 100:0: ratios of *H. barteri*- Malted Maize-Blanched Plantain, H MP_4 = Cookies made with33.3: 33.3:33.3 ratios of *H. barteri*- Malted Maize-Blanched Plantain H MP 5 = Cookies made with0: 0:100: ratios of *H. barteri*- Malted Maize-Blanched Plantain), HMP_6 = Cookies made with 0: 50:50: ratios of *H. barteri*- Malted Maize-Blanched Plantain)HMP_7 = Cookies made with 50: 0:50: ratios of *H. barteri*- Malted Maize-Blanched Plantain), HMP_8 = Cookies made with 16,7: 16.7:66.7: ratios of *H. barteri*- Malted Maize-Blanched PlantainHMP_9 = Cookies made with 66.7: 16.7:16.7: ratios of *H. barteri*- Malted Maize-Blanched Plantain, HMP_{10} = Cookies made with 16.7: 66.7:16.7: ratios of *H. barteri*- Malted Maize-Blanched Plantain, WFC= Cookies made with 100 % pure blend of wheat

CONCLUSION

The findings of this research indicated that cookies made with up to 50 % content of *Hildegardia barteri* (Kpaakpa) flour were generally accepted in terms of both nutritional and sensory quality. This was due to the significant increase in protein, fat, iron, and zinc content and the overall sensory score. With the exception of cookies made from 100 % *Hildegardia barteri* (Kpaakpa) flour and sample HMP9 (Cookies made with 66.7: 16.7:16.7: ratios of *Hildegardia barteri* (Kpaakpa) which were rejected by the panelists, all other test samples had sensory scores above the midpoints and were generally perceived as acceptable by the panelists. However, cookies made with 33.3% of the three components (*Hildegardia barteri*, maize, and plantain) were most preferable as they were found to be the best in terms of sensory attributes and overall quality. Therefore, this study demonstrates the possible use of the *Hildegardia barteri* (kpaakpa) based composite flours in bakery products. Furthermore, this information can be used in designing food processing protocols that will target consumer requirements and overall acceptability.

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Conflict of interest

All authors declared that they have no conflict of interest.

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Appendices

Maize

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Sorting

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Weighing

↓

Steeping (for 24 h)

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Germinating

↓

Kilning (Oven dry at 50 ^{0}C)

↓

Milling

↓

Sieving

↓

Flour

Figure 1. Flow chart on the production of Maize flour

Unripe Plantain

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Peeling

↓

Slicing

↓

Drying (air oven at 60 ^{0}C)

↓

Milling

↓

Sieving

↓

Unripe Plantain flour

Source: Ketiku (1978).

Figure 2. Flow chart on the production of unripe plantain flour

Plate 1a *H.barteri* kernel in pods

Plate 2 Undehulled *H.barteri* seeds

Plate 3 Raw Dehulled H.barteri Seed

Plate 4 Cookie sample made from H16.7M16.7P66.7

Plate 5 Cookie sample made from H66.7M16.7P16.7

Plate 6 Cookie sample made from H33.3M33.3P33.3