Original Research Article

Effect of supplementation of crayfish flour on the quality of Cookies from wheat flour

ABSTRACT

The utilization of composite flour from wheat and crayfish in the production of cookies was investigated. The wheat flour was blended with crayfish flour at the ratios of 100:0, 97.5:2.5, 95:5, 92.5:7.5 and 90:10, respectively. The proximate and mineral compositions of the cookies were determined using standard methods. Also the cookies were evaluated for their physical properties. Sensory evaluation of the cookies was also conducted on the 9 point hedonic scale to determine their consumer acceptability. The results of the proximate analysis showed an increase protein content (7.88-38.94%), moisture (4.61-6.27%), fibre (1.95-3.65%) and fat (0.98-3.11%) as the level of crayfish flour increased while there was a decrease in the carbohydrate content (77.94-40.45%) as the level of crayfish flour increased. The ash content ranged from 5.77 to 7.89%. The mineral compositions showed an increased trend in calcium, potassium and sodium contents of the cookies as the level of crayfish supplementation increases but decreased phosphorus content as the level of crayfish supplementation increased. Iron ranged between 4.70-5.20. The calcium, potassium, iron, sodium and phosphorus ranged from 5.35-6.60 mg/100g, 650-930 mg/100g, 4.75-5.20 mg/100g, 670-870 mg/100g and 1577-23420 mg/100g respectively. The weight, diameter and thickness of the cookies decreased as the level of crayfish supplementation increased. There was a significant ($p<0.05$) difference observed in the appearance, flavour, taste, texture, crispness and general acceptability of the cookies. Taste panel scores indicate that up to 10% addition of crayfish flour was acceptable in cookie preparation. The study also indicates that protein enriched composite flour could be produced from wheat/crayfish flour blend.

1. INTRODUCTION

Cookies are baked flour confectionery dried down to low moisture content of generally less than 5 % (except for soft-type cookies). Its recipe is more variable than those of other types of bakery products [1]. According to Adeleke and Odedeji [2], cookies are the most widely consumed bakery product due to its ready to eat nature, good nutritional quality, low cost and longer shelf life that has also been enriched with dietary fibre. Cookies are consumed extensively all over the world as a snack food and on a large scale in developing countries where protein and caloric malnutrition are prevalent [3].
Cookies contribute valuable quantities of iron, calcium, protein, calorie, fibre and some of B-vitamins to our diet and daily food requirement. They are important baked product in human diet, which are usually consumed with beverage and also used as wearing foods for infants [4].

The need for strategic development in the use of inexpensive local resources in the production of staple foods have been promoted by organizations, such as; Food and Agricultural Organization (FAO) and the United Nations Refugee feeding programs [5]; [6]. However, this resulted to the initiation of the composite flour program, the aim of which was to seek ways of substituting flours, starches and protein concentrates from indigenous crops, for as much wheat as possible in baked products [6].
Animals are known to be a rich source of protein, and livestock production has over the years been a major source of providing the human species with their protein requirements. In recent times, however, there have been concerns with regard to the environmental effects of livestock production. Increasing animal protein production through the traditional livestock rearing is said to lead to an unsustainable rise in greenhouse emissions [7]. Decreasing livestock production on the other hand may be beneficial to the environment but will increase malnutrition incidences, because about 10.7% (815 million) of the world's population currently suffer from chronic undernourishment [8]. This prompts the need for more balanced and environmentally friendly methods for producing nutritious foods.

Crayfish (*Procombarus clarkia)*, also known as crawfish, crawdads, freshwater lobsters, or mudbugs, are freshwater crustaceans resembling small lobsters, to which they are related; taxonomically, they are members of the super families Astacoidea and Parastacoidea. They breathe through feather-like gills and are found in bodies of water; Some species are found in brooks and streams where there is fresh water running, while others thrive in swamps, ditches, and rice paddies. Most crayfish cannot tolerate polluted water; Crayfish feed on living and dead animals and plants [9].

Therefore, this study is aimed at producing wheat flour-based cookies enriched with crayfish flour in order to improve the nutritional quality of the cookies and increase the utilization of crayfish as another source of animal protein.

2. Materials and Methods

2.1 Source of Raw Materials

Baking materials: wheat flour (Dangote), sugar (Dangote), baking powder (STK Royal), margarine (Simas), salt (Mr. Chef), Dry crayfish, filled milk (Cowbell), were purchased from a Supermarket in Kaura Namoda, Zamfara State. Packaging material: Johnson's polyethylene ziplock double zipper storage bags (26.8 x 27.3 cm; 17.7 x 19.5 cm) were purchased from the Central Market, Gusau, Zamfara State. All laboratory materials and reagents used were of analytical grade. The raw materials were properly cleaned by removing extraneous matter prior to their subjection to different processing treatments.

2.2 Processing of Crayfish into Flour

Dried crayfish (*Procombarus clarkia)* was cleaned and winnowed manually by sorting out foreign matters like stones and removing crayfish tails and heads before processing into flour using ATLAS milling achine (model no. YL 112M-4, Japan) and sieved (0.3 mm aperture size sieve). milling machine to produce crayfish flour.

2.3 Preparation of Flour Blends

Wheat and crayfish flour were mixed at different proportions to obtain five (5) flour blends as shown in Table 1:

Table 1: Formulation of Flour Blend for Cookies

Sample	Wheat flour (WF) %	Crayfish flour (CFF) %
A	100	-
B	97.5	2.5
C	95	5
D	92.5	7.5
E	90	10

2.4 Production of cookies and composite cookies

The method described by Ndife *et al.* [10] with modification was used to produce cookies and composite cookies (Figure 1). Sugar and margarine were weighed into a Master Chef mixer (MC HM 5577) and mixed at medium speed until fluffy. Milk powder was added while mixing and then mixing continued for about 30 min. Sifted wheat flour or composite flours, baking powder and salt were slowly added to the mixture, water was added with continual mixing and kneading to form dough. It was then rolled on a flat rolling board (sprinkled with flour) to a uniform thickness, cut using cookies cutter, placed in greased baking trays and baked in the oven at 180 ^{0}C for 25 min. Other samples with different blends ratio and the control with 100 % wheat flour were baked in the same manner. Table 2 provides the Ingredients for production of cookies.

Table 2: Ingredients for Production of Cookies

Component	Cookie composition
Flour (g)*	100
Sugar (g)	7
Salt (g)	1
Fat (g)	8
Baking powder (g)	1
Egg (whole)	1
Skimmed milk (g)	7.5
Water (ml)	70

***** Wheat or composite flour
Source: Olapade and Adeyemo [11] with modification

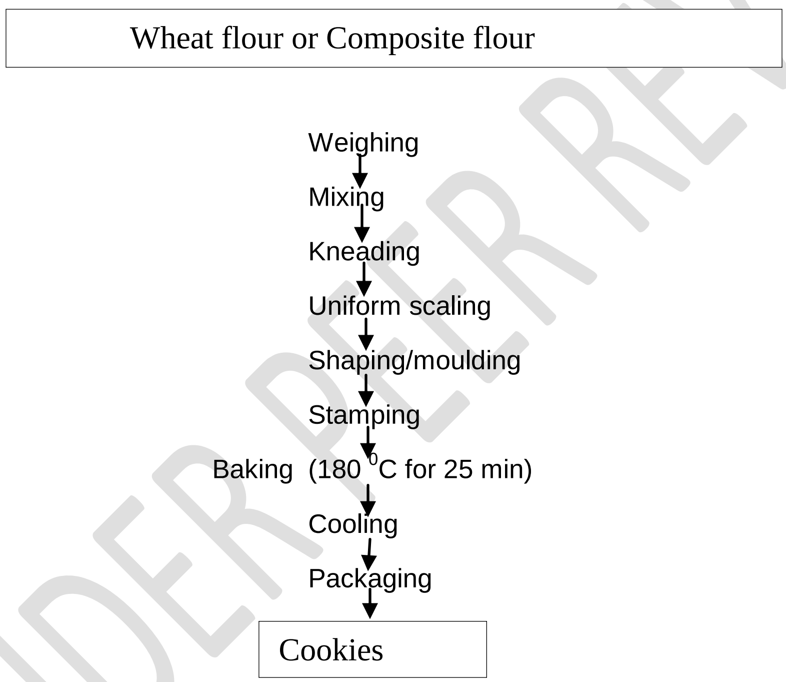

Figure 1: Flow Chart for the Production of Cookies and Composite Cookies

Source: Ndife *et al.* [10] with modification.

2.5 Determination of the Proximate Composition of *Cookies*

The proximate composition of cookies produced from wheat and crayfish flour were determined according to the methods described by [12] and Carbohydrate content was determined by difference according to [13].

2.5.1 Moisture Content Determination

Moisture content was determined using the air oven dry method. A clean dish with a lid was dried in an oven (Uniscope Surgifriend Medicals, England) at 100 ^{0}C for 30 min. It was cooled in desiccator and weighed. Two (2) grams of sample was then weighed into the dish. The dish with its content was then put in the oven at 105 ^{0}C and dried to a fairly constant weight. The loss in weight from the original sample (before heating) was reported as percentage moisture.

$$\% \; Moisture = \frac{Weight\ Loss\ (W_2 - W_3)}{Weight\ of\ Sample\ (W_2 - W_1)}\ x\ 100$$

$Where$:
$W_1 = Weight\ of\ dish,$

$W_2 = \ Weight\ of\ dish + sample\ before\ drying,$

$W_3 = \ Weight\ of\ dish + sample\ before\ drying.$

2.5.2 Ash Content Determination
Two (2) gram of sample was weighed into an ashing dish which had been pre-heated, cooled in a desiccator and weighed soon after reaching room temperature. The crucible and content was then heated in a muffle furnace at 550 ^{0}C for 6 hrs. The dish was cooled in a desiccator and weighed soon after reaching room temperature. The total ash was calculated as percentage of the original sample weight.

$$\% \; Ash = \frac{(W_3 - W_1)}{(W_2 - W_1)}\ x\ 100$$

$Where$:
$W_1 = weight\ of\ empty\ crucible, W_2 = \ weight\ of\ crucible + sample\ before\ ashing,$

$W_3 = \ weight\ of\ crucible + content\ after\ ashing$

2.5.3 Crude Fibre Determination
Two (2) grams of the sample was extracted using Diethyl ether. This was digested and filtered through the California Buchner system. The resulting residue was dried at 130 ^{0}C for 2 hrs, cooled in a dessicator and weighed. The residue was then transferred into a muffle furnace (Uniscope Surgifriend Medicals, England) and ignited at 550 ^{0}C for 30 min, cooled and weighed. The percentage crude fibre content was calculated as:

$$\% \; Crude\ Fibre \ \ = \frac{Loss\ in\ weight\ after\ incineration}{Weight\ of\ original\ food} \times 100$$

2.5.4 Crude Fat Determination
Fat was determined using Soxhlet method. Samples were weighed into a thimble and loose plug fat free cotton wool was fitted into the top of the thimble with its content inserted into the bottom extractor of the Soxhlet apparatus. Flat bottom flask (250 ml) of known weight containing 200 ml of hexane was fitted to the extractor. The apparatus was heated and fat extracted for 8 hrs. The solvent was recovered and the flask (containing oil and solvent mixture) was transferred into a hot air oven (Uniscope Surgifriend Medicals, England) at 105 ^{0}C for 1 hr to remove the residual moisture and to evaporate the solvent. It was later transferred into desiccator to cool for 15 min before weighing. Percentage fat content was calculated as

$$\% \; Crude\ Fat = \frac{weight\ of\ extracted\ fat}{Weight\ of\ Sample}\ x\ 100$$

2.5.5 Crude Protein Determination

The Kjeldahl method was used to determine the percentage crude protein. Two (2) grams of sample was weighed into a Kjeldahl digestion flask using a digital weighing balance (Uniscope Surgifriend Medicals, England: Max. 180 g). A catalyst mixture weighing 0.88 g (96 % anhydrous sodium sulphate, 3.5 % copper sulphate and 0.5 % selenium dioxide) was added. Concentrated sulphuric acid (7 ml) was added and swirled to mix content. The Kjeldahl flask was heated gently in an inclined position in the fume chamber until no particles of the sample was adhered to the side of flask. The solution was heated more strongly to make the liquid boil with intermittent shaking of the flask until clear solution was obtained. The solution was allowed to cool and diluted to 25 ml with distilled water in a volumetric flask. Ten (10) ml of diluted digest was transferred into a steam distillation apparatus. The digest was made alkaline with 8 ml of 40 % NaOH. To the receiving flask, 5 ml of 2 % boric acid solution was added and 3 drops of mixed indicator was dropped. The distillation apparatus was connected to the receiving flask with the delivery tube dipped into the 100ml conical flask and titrated with 0.01 HCl. A blank titration was done. The percentage nitrogen was calculated from the formula:

$$\% \, Nitrogen = \frac{(S-B)\times 0.0014\times 100\times D}{Sample\ Weight}$$

$Where\ S = sample\ titre, B = blank\ titre, S - B = corrected\ titre, D = diluted\ factor$

$\% \, Crude\ Protein = \% \, Nitrogen \times 6.25\ (correction\ factor)$

2.5.6 Carbohydrate Determination

Carbohydrate content was determined by difference as follows:

$\% \, Carbohydrate = 100 - (\% \, Moisture + \% \, Ash + \% \, Fibre + \% \, Fat + \% \, Protein)$

2.6 Determination of the Mineral Content (mg/100g) of Cookies

The minerals contents were determined by the method described by [12].

2.6.1 Determination of Calcium

Calcium was determined using the atomic absorption spectrophotometer. Calcium carbonate (2.495 g) was dissolved and diluted to 100 ml with de-ionized water. This solution contains 1000 mg Ca2+ ions and from this stock solution, calcium standard of the following concentration levels 0.0, 3.0, 6.0, 9.0 were prepared. The absorbance of both the sample and the standard working aliquot were determined in the atomic absorption spectrophotometer (Uniscope Surgifriends, England) at 239.9 nm. The concentration of the test mineral in the sample was calculated with reference to the graph (standard curve) and obtained as follows:

$$Calcium = \frac{100 \times \mathrm{Y} \times \mathrm{Vf} \times \mathrm{D}}{\mathrm{W} \times 100 \times \mathrm{Va}}$$

$Where$
$W = weight\ of\ the\ sample\ analyzed$
$\mathrm{Y} = Concentration\ of\ Calcium\ obtained\ from\ the\ standard\ curve,$
$Vf = Total\ volume\ of\ extract$
$Va = volume\ of\ extract\ used$
$D = Dilution\ factor$

2.6.2 Determination of Phosphorus

Phosphorus was determined using spectrophotometer. Phosphorus in the sample was determined by the molybdate method using hydroquinone as a reducing agent. Sodium sulphate (1.0 ml), 1.0 ml of ammonium molybdate and 1 ml of hydroquinone were added to 1 ml of the sample digest. The mixture was agitated and allowed to stand for 30 minutes for the blue colour to develop. The absorbance of the sample was determined using the spectrophotometer at 600 nm. The phosphorus standard was prepared by dissolving 1.1 g of monobasic potassium phosphorus ($KA_2\ PO_4$) into a 500 ml volumetric flask containing 500 ml of distilled water. Five drops of toluene were added to diminish microbial activity. Twenty millilitre of the Standard stock was collected and made up to 100 ml. This contained 100 ppm. Standard stock (0.1 ml) = 0.2 ppm. Zero to one millilitre of the 100 ppm phosphorus stock solution was poured into 100 ml volumetric flask separately and treated the same way as the sample. The reading of the standard was taken at 600 nm in UV/VIS spectrophotometer (Uniscope Surgifriend Medicals, England) and a standard curve was plotted.

$$P = \frac{100 \times \mathrm{Au} \times \mathrm{C} \times \mathrm{Vf}}{\mathrm{W} \times \mathrm{As} \times \mathrm{Va}}$$

$Where$
$W = Weight\ of\ sample\ analyzed$
$Au = Absorbance\ of\ test\ sample$
As =*Absorbance of standard phosphorus solution*
C =*Concentration (in mg/ml) of sample*
$Vf = Total\ vomule\ of\ extract$
Va =*Volume of extract analyzed*

2.6.3 Determination of Potassium

Potassium determination was by Flame Photometry. One (1) gram of sample was dissolved in 20 ml of acid mixture (650 ml of concentrated HNO_3; 80 ml PCA; 20 ml conc. H_2SO_4) and aliquots of the diluted clear digest were taken for photometry using Flame analyzer.

2.6.4 Determination of Iron

Standard solution containing 100 mg/ml of Fe^{3+} ions was prepared from 1 g pure iron wire. The wire was dissolved in 20 ml concentrated HNO3, boiled in water bath and diluted to 1000 ml with distilled water. Standard solutions with concentrations 0, 0.5, 1.0, 2.0 and 4.0 ppm was prepared. Two milliliter of sample aliquot was diluted to 100 ml and was used to determine the absorbance of the sample using an atomic absorption spectrophotometer (Uniscope Surgifriends Medicals, England) at 510 nm. The standard and samples absorbance were noted and concentration of iron in the sample was determined from the standard curve.

2.7 Determination of Physical Properties of the Cookies

The weight of the cookies was determined using Electronic compact weighing balance (model KDBN2010) as described by AOAC [12]. The thickness (mm) and diameter (mm) of the cookies were measured with digital Vernier calipers with 0.01 mm precision according to the method of Ayo et al. [14]. And spread ratio was also determined according to the method of spread ratio was determined according to method described by Okaka [15].

2.8 Sensory Evaluation of the *Cookies*

Sensory evaluation of the *cookies* samples was carried out according to the method described by [13]. A panel of twenty (20) members consisting of students and members of staff from Food Science and Technology Department, Federal Polytechnic Kaura Namoda, Nigeria. Panelists were chosen based on their familiarity and experience with cookies for sensory evaluation. Cookies produced from each flour blend, along with the reference sample were presented in coded form (A-C) and were randomly presented to the panelists. The panelists were provided with portable water to rinse their mouth between evaluations. However, a questionnaire describing the quality attributes (appearance, taste, flavour, texture, crispness and overall acceptability) of the Cookies samples was given to each panelist. Each sensory attribute was rated on a 9-point hedonic scale (1 = dislike extremely and 9 = like extremely). Cookies was produced from wheat flour (100 %) as control.

2.9 Statistical Analysis

The GENSTAT Statistical Software (version 17.0) was used for data analyses. Data were subjected to analysis of variance (ANOVA) and the separation of means was done using Fisher's Least Significant Difference (LSD) at ($P<0.05$).

3. RESULTS AND DISCUSSIONS

Table 3: Effect of Crayfish Flour Supplementation on the Proximate Composition of Cookies

Sample	Moisture (%)	Protein (%)	Fibre (%)	Ash (%)	Fat (%)	Charbohydrate (%)
A	$4.61^{e}\pm0.01$	$7.88^{e}\pm0.01$	$1.95^{e}\pm0.01$	$6.62^{d}\pm0.05$	$0.98^{e}\pm0.01$	$77.94^{a}\pm0.06$
B	$4.90^{d}\pm0.01$	$15.14^{d}\pm0.00$	$2.14^{d}\pm0.01$	$7.89^{b}\pm0.01$	$1.62^{d}\pm0.01$	$68.29^{b}\pm0.01$
C	$5.13^{c}\pm0.01$	$18.50^{c}\pm0.00$	$2.64^{c}\pm0.01$	$5.77^{e}\pm0.01$	$1.91^{c}\pm0.01$	$66.03^{c}\pm0.01$
D	$5.34^{b}\pm0.01$	$22.94^{b}\pm0.00$	$3.49^{b}\pm0.00$	$7.06^{c}\pm0.00$	$2.04^{b}\pm0.01$	$59.12^{d}\pm0.00$
E	$6.27^{a}\pm0.01$	$38.94^{a}0.01$	$3.65^{a}\pm0.01$	$7.58^{b}\pm0.01$	$3.11^{a}\pm0.01$	$40.45^{e}\pm0.01$
LSD	0.022	0.011	0.016	0.058	0.018	0.077

Values are mean ± standard deviation of duplicate determination.

Means in the same column not followed by the same superscript are significantly different at ($p<0.05$).

Key: A = 100% wheat flour; B = 97.5% Wheat Flour and 2.5% Crayfish Flour; C = 95% Wheat Flour and 5% Crayfish Flour; D = 92.5% Wheat Flour and 7.5% Crayfish Flour; E = 90% Wheat Flour and 10% Crayfish Flour.

3.1 Effect of Crayfish Flour Supplementation on the Proximate Composition of Cookies

The results of the proximate composition of cookies are presented in table 3. The results showed that sample E had the highest protein content while sample; the control (100:0) had the lowest. There is significant (p<0.05) difference in the protein content among the samples. The high protein content in sample E is due to the level of supplementation of crayfish which is due to high protein content of crayfish, these findings does not agree with that of [16] who reported a range of 12-19 % protein. Sample E had the highest moisture content while sample A had the lowest. There is an increasing trend in the moisture content from sample A down to sample E. Significant difference exists among the samples. The increasing value of moisture as the wheat flour decreases and crayfish flour increases is due primarily to the decrease quantity of the presence of max cellulose and other non-starch polysaccharides that hold moisture several times higher to its weight. The result also showed the ranges in fibre content of the cookies from (in sample A-E) with 100% crayfish flour having the highest (p<0.05) amount of fibre compared to 100% wheat flour with the lowest fibre content. There is significant (p<0.05) difference between the samples. The increasing fibre content of the cookies is similar to those observed by Arshad et al., [17] and Ubbor et al., [18]. The ash content ranges from 5.77-7.89. There is no significant (p<0.05) difference in sample B and sample E. This may be as a result of improper mixing of the ingredients during the mixing operation. Sample E had the highest fat content and sample A with the lowest fat content, findings agree with [16]. There is an increased trend in the fat mean scores of the cookies as the level of crayfish supplementation increased. There is significant (p<0.05) difference between the samples as shown in table 6. Carbohydrate decreased as the level of crayfish supplementation increased. There is significant (p<0.05) difference in the carbohydrate contents of the cookie samples. This could be as a result of high carbohydrate content and less carbohydrate contents in wheat and crayfish respectively.

Table 4: Effect on Crayfish Flour Supplementation on the Mineral Composition of Cookies (mg/100g)

Sample	Calcium	Potassium	Iron	Sodium	Phosphorus
A	535^{a}±0.01	650^{a}±00	5.20^{a}±0.42	670^{b}±0.00	23420^{a}±0.00
B	550^{a}±0.00	690^{b}±14.14	5.20^{a}±0.00	710^{b}±0.00	21185^{b}±0.00
C	600^{b}±0.00	770^{c}±0.00	4.75^{a}±0.21	810^{a}±0.71	19180^{c}±0.02
D	660^{c}±0.00	840^{d}±0.00	4.70^{a}±0.00	810^{a}±0.00	17395^{d}±0.01
E	720^{d}±0.00	930^{e}±14.14	5.1^{a}±0.71	870^{a}±0.00	15770^{e}±0.43
LSD	40.64	22.99	0.98	81.30	19.91

Values are mean ± standard deviation of duplicate determination.

Means in the same column not followed by the same superscript are significantly different at (p<0.05).

Key: A = 100% wheat flour; B = 97.5% Wheat Flour and 2.5% Crayfish Flour; C = 95% Wheat Flour and 5% Crayfish Flour; D = 92.5% Wheat Flour and 7.5% Crayfish Flour; E = 90% Wheat Flour and 10% Crayfish Flour.

3.2 Effect on Crayfish Flour Supplementation on the Mineral Composition of Cookies

The results of the mineral analysis of cookies are shown in table 4. Sample E had the highest value followed by samples D, C, B and sample A, which had the lowest value in the calcium content of the cookies. There is no significant ($p<0.05$) difference between samples A and B but significant ($p<0.05$) difference exists between samples A and B and samples C, D and E. The potassium contents of the cookies decreased down as the level of crayfish supplementation increased but there is significant ($p<0.05$) difference between the samples. The highest iron content was found in sample E while the lowest was in sample A. There is no significant ($p<0.05$) difference in iron contents of the samples. Sodium increased as the level of supplementation increased. Sample E had the highest sodium content followed by samples D and C and then B with A having the lowest value. There was a decreasing trend in the phosphorus content of the cookies as the level of crayfish supplementation increased. Sample A had the highest value while sample E had the lowest but with significant ($p<0.05$) difference existing among the samples. The most abundant mineral in the cookies was potassium followed by phosphorus which agreed and correspond with the finding of [18]. The high potassium, sodium and phosphorus contents of the cookies will make them suitable for use by hypertensive individuals [18].

Table 5: Effect of Crayfish Flour Supplementation on the Physical Properties of Cookies

Samples	Weight (g)	Diameter (mm)	Thickness (mm)	Spread Ratio
A	$14.31^{a}\pm0.69$	$49.50^{a}\pm0.71$	$13.99^{a}\pm0.03$	$3.53^{a}\pm0.01$
B	$12.75^{b}\pm0.21$	$49.39^{a}\pm1.20$	$13.82^{a}\pm0.97$	$3.57^{a}\pm0.01$
C	$12.19^{b}\pm0.21$	$48.03^{ab}\pm0.33$	$13.75^{a}\pm0.35$	$3.49^{a}\pm0.30$
D	$11.66^{bc}\pm0.55$	$47.02^{b}\pm1.37$	$12.66^{a}\pm.0.93$	$3.71^{a}\pm0.01$
E	$10.67^{c}\pm0.50$	$46.16^{b}\pm1.07$	$10.53^{b}\pm0.32$	$4.37^{b}\pm0.01$
LSD	1.28	2.20	1.63	0.35

Values are mean ± standard deviation of duplicate determination.

Means in the same column not followed by the same superscript are significantly different at ($p<0.05$).

Key: A = 100% wheat flour; B = 97.5% Wheat Flour and 2.5% Crayfish Flour; C = 95% Wheat Flour and 5% Crayfish Flour; D = 92.5% Wheat Flour and 7.5% Crayfish Flour; E = 90% Wheat Flour and 10% Crayfish Flour.

3.3 Effect of Crayfish Flour Supplementation on the Physical Properties of Cookies

The results of the physical characteristics are shown in table 5 above. The cookie weight showed significant ($p<0.05$) difference between sample A and among the samples; such as B, C, D and E there was a decreasing trend in the weight of the samples with sample A having the highest mean score. This result is in consistent with the findings of Arshad et al., [16]. Crayfish flour addition decreased the diameter of the cookies as shown in table 8 below with sample A having the highest value and sample E with the lowest value. There is no significant ($p<0.05$) difference between the control, sample A with sample B and C but there is significant ($p<0.05$) difference between samples A, B, C and samples D and E. This is in line with the findings of [19], who stated that "too much in elasticity in the gluten and dough will spring back to give cookies with smaller diameter. The thickness of the cookies decreased as the level of supplementation of crayfish increased. The highest value was obtained in sample A and the lowest in sample E. There is no significant ($p<0.05$) difference between the samples. This result is also consistent with that of Arshad *et al*., [16]. Spread ratio is the ratio of the diameter to the thickness of the cookies.

Table 6: Effect of Crayfish Flour Supplementation on the Sensory Properties of Cookies

Samples	Appearance	Flavour	Taste	Texture	Crispness	General Acceptability

A	8.67^{a}	8.13^{a}	8.67^{a}	8.27^{a}	8.40^{a}	8.67^{a}
B	8.27^{a}	7.93^{ab}	7.80^{b}	7.80^{ab}	7.80^{ab}	7.93^{b}
C	7.40^{b}	7.33^{bc}	7.27^{bc}	7.40^{b}	7.40^{bc}	7.67^{bc}
D	6.87^{bc}	6.80^{cd}	7.00^{c}	7.33^{b}	7.06^{c}	7.13^{cd}
E	6.53^{c}	6.40^{d}	6.93^{c}	7.07^{b}	6.80^{c}	6.93^{d}
LSD	0.57	0.60	0.64	0.69	0.65	0.68

Means in the same column not followed by the same superscript are significantly different at ($p<0.05$).

Key: A = 100% wheat flour; B = 97.5% Wheat Flour and 2.5% Crayfish Flour; C = 95% Wheat Flour and 5% Crayfish Flour; D = 92.5% Wheat Flour and 7.5% Crayfish Flour; E = 90% Wheat Flour and 10% Crayfish Flour.

3.4 Effect of Crayfish Flour Supplementation on the Sensory Properties of Cookies

Sensory evaluation is usually carried out towards the end of product development or formulation cycle and this done to assess the reactions of consumers/judges about the product to determine the acceptability of such product. It is carried out by giving out questionnaires to panelists to judge the product based on the parameters given to them. The result of the sensory evaluation of the cookies samples are presented in the table 6. Appearance is an important sensory attribute of any food because of its influence on acceptability. The brown colour resulting from Maillard reaction is always associated with baked goods. Sample A had the highest mean score followed by samples B, C, D and sample E having the lowest mean score. There is no significant ($p<0.05$) between samples A and B due to the level of supplementation of crayfish in sample B. But Significant different ($p<0.05$) existed between A and other samples C,D,E. Appearance change might be due to caramelization, dextrinization of starch or Maillard reaction involving the interaction of reducing sugar or proteins [20]. Flavour is another attribute that influences the acceptance of baked good products even before they are tasted. There was decreasing trend in the mean score of flavour as the level of supplementation increases downwards. The results are in consistent with those observed in earlier studies by [19] in which soybeans and maize flour was supplemented to produce cookies did not significantly ($p\leq0.05$) affect the sensory score of flavour. Crispness is a desirable quality of cookies. The quality score in response to crispness of cookies implied that sample A got the highest mean score followed by sample B and the lowest score is observed in sample E. Taste as sensory parameter that affects the quality and acceptability of food products. No matter how rich or nutritious a food is, if it tastes bad, such food would not be accepted by people. The decreased in overall acceptability was due to the decreased in the above sensory characteristics.

4. CONCLUSION

The cookie made with flour blend of 90 % wheat flour and 10 % crayfish gave the best overall acceptability and the best nutritional qualities in terms of the crude protein (38.94 %), ash (7.58 %), mineral elements (calcium, sodium and potassium). This would be of nutritional importance for coeliac disease and diabetic patients in most developing countries such as Nigeria, where people can hardly afford high proteinous foods from animals because of its expensive purchasing costs. The cookies produced had good sensory quality, which could compete with commercial cookies in terms of appearance, taste, crispness and texture. Supplementation of wheat flours with crayfish had greatly improved the protein, quality and nutritional benefits of the cookies

COMPETING INTERESTS DISCLAIMER:

Authors have declared that no competing interests exist. The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

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