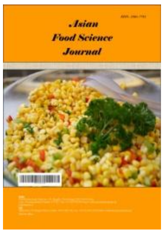

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Effect of Crayfish (*Procombarus clarkia*) Supplementation on the Quality of Cookies from Wheat Flour

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Authors' contributions

This work was carried out in collaboration among all authors Author SI designed the study, performed the statistical analysis. Author EDI wrote the protocol, wrote the first draft of the manuscript and managed the analysis of the study. Author OAK managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

The utilization of composite flour from wheat and crayfish in the production of cookies was investigated. The wheat and crayfish flour were blended at the ratios of 100:0, 97.5:2.5, 95:5, 92.5:7.5, and 90:10, respectively. The cookies were evaluated for their proximate, minerals, physical and Sensory properties; The results of the proximate analysis showed an increase in the protein content (7.88-38.94%), moisture (4.61-6.27%), fiber (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 crayfish supplementation increased but decreased phosphorus content as the level of crayfish supplementation increased. Iron ranged from 4.70-to 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 cookies' weight, diameter, and thickness decreased as the level of crayfish supplementation increased. There was a significant

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(p<0.05) difference observed in the appearance, flavor, 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.

Keywords: Crayfish; cookies; wheat flour; procombarus clarkia.

1. INTRODUCTION

Cookies are baked confections that have been dried to a low moisture level of less than 5%. (except for soft type cookies). Its recipe is more flexible than that of other bakery items [1]. Adeleke and Odedeji [2] claim that Due to their ready-to-eat nature, good nutritional content, lower cost, and longer shelf life, cookies are the most extensively consumed bakery product. They are also enriched with dietary fibre. Cookies are widely consumed as a snack or in significant quantities in underdeveloped nations with high levels of protein and caloric deficiencies [3]. Our diet and daily food requirements benefit from the iron, calcium, protein, calorie, fibre, and some B-vitamins found in cookies. They are frequently recognised as a vital baked product in the human diet, and are frequently consumed with beverages and used as newborn wearing meals [4].

Organizations such as the Food and Agricultural Organization (FAO) and the United Nations Refugee Feeding Programs [5,6] have emphasised the need of strategic development in the use of local and low-cost raw resources in the manufacture of staple foods. This forced the start of the composite flour initiative, which tried to find ways to replace as much wheat as possible in baked goods with flours, starches, and protein concentrates derived from indigenous crops or raw materials [6]. Animal-derived food is a good source of protein for humans, and livestock farming has long been a major supply of protein for humans. However, there have recently been worries about the environmental impacts of cattle farming. Traditional cattle husbandry contributes to an unsustainable increase in greenhouse emissions [7]. Because around 10.7% (815 million) of the world's population is currently suffering from chronic undernourishment, the drop in animal production may improve the environment while increasing malnutrition rates [8]. Crayfish (*Procombarus clarkia)*, are known as crawfish, crawdads, freshwater lobsters, or mudbugs, are freshwater crustaceans are similar to lobsters in which they look-alikes; they belong to the members of the superfamilies Astacoidea and Parastacoidea. They breathe in-out through their feather-like gills and are primarily found in the bodies of water; Many species are found in brooks and streams where there is fresh water running, while others multiply in swamps, ditches, and rice paddies; Most crayfish accommodate uncleaned; Crayfish feed on living and dead animals and plants [9].

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

2. MATERIALS AND METHODS

2.1 Source of Raw Materials

Purchased baking materials such as wheat flour, sugar, baking powder, margarine, salt, Dry crayfish, filled milk (Cowbell) from an Alsahab supermarket in Kaura Namoda Zamfara State, Nigeria. Johnson's polyethylene ziplock storage bags (26.8 x 27.3 cm; 17.7 x 19.5 cm) were purchased from the Central Market, Gusau, Zamfara State. Laboratory reagents and materials were of analytical grade and adequately cleaned raw materials by removing extraneous matter before subjecting them to different processing treatments.

2.2 Processing of Crayfish into Flour

Cleaned and dried crayfish (*Procombarus clarkia)* was winnowed manually by sorting out unwanted materials (head, tails, and stones), followed by processing into flour using ATLAS milling machine (model no. YL 112M-4, Japan) and sieved with (0.3 mm aperture size sieve) to produce crayfish flour.

2.3 Preparation of Flour Blends

Wheat and crayfish flour was 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

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*

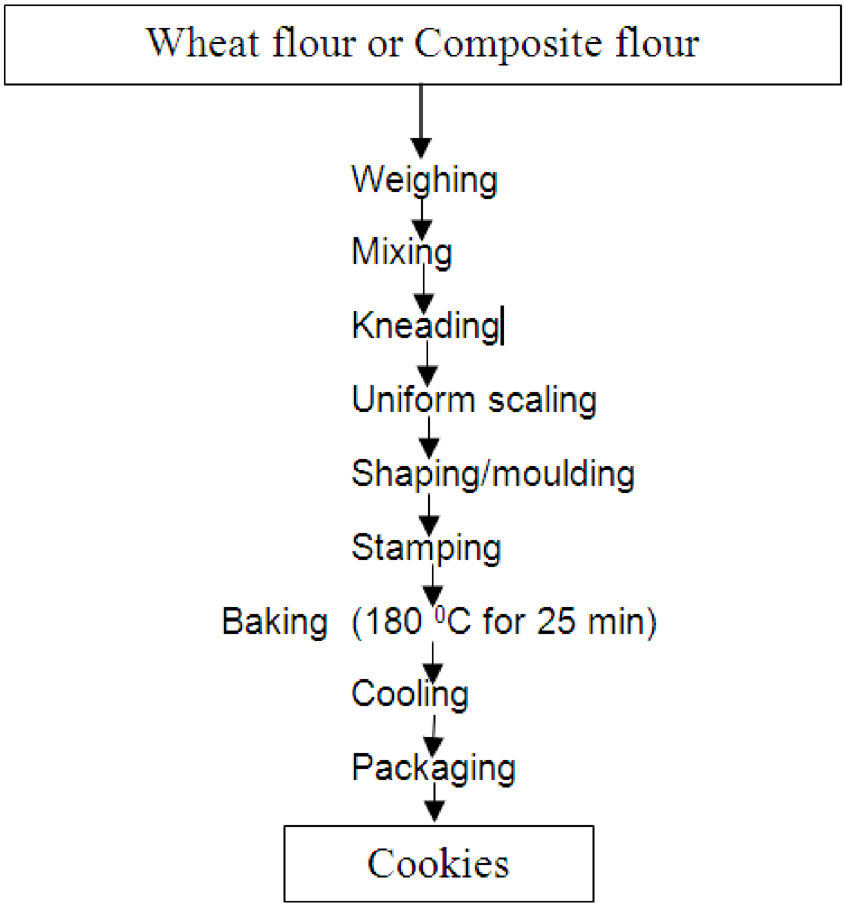

Fig. 1. Flow Process for the Production of Cookies and Composite Cookies
Source: Ndife et al. [10] with modification

2.4 Production of Cookies and Composite Cookies

Cookies and composite cookies were made using the method published by Ndife et al. [10] with some modifications, as shown in Figure 1. Sugar and margarine were weighed and combined at medium speed in a Master Chef mixer (model MC HM 5577) until frothy. While combining, milk powder was added, and mixing continued for around 30 minutes. Sifted wheat flour or composite flours, baking powder, and salt were gradually added to the mixture, and water was gradually added with continuous mixing and kneading to form the dough; the dough was then rolled out to a uniform thickness on a flat rolling board (sprinkled with flour), cut with a cookies cutter, placed in greased baking trays, and baked for 25 minutes at 180^{0}C. 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 the production of cookies.

2.5 Determination of the Proximate Composition of *Cookies*

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

2.5.1 Determination of Moisture Content

Moisture determination was carried out using the air oven-dry method. A clean dish was dried in an oven (Uniscope-Surgifriend Medicals, England) at 100 0C for 30 min. The content was allowed to cooled in a desiccator and weighed. Two (2g) of the sample was then weighed into the crucible dish. The dish and the content were then put in the oven at 105 0C and dried to a constant weight. The weight lost from the original weight (before heating) was reported as percentage moisture content.

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

$Where$:

$W_1 = Weight \ of \ dish,$
$W_2 = \ Weight \ of \ dish + sample \ before \ drying,$
$W_3 = \ Weight \ of \ dish + sample \ before \ drying.$

2.5.2 Ash Content Determination

Two (2 g) grams of sample was measured into dish which had been pre-heated, cooled inside a desiccator and re-measured at room temperature. It was heated at a temperature of 550 ^{0}C for 6 hrs inside a muffle furnace. The dish was allowed to cooled down in a desiccator and weighed soon after reaching room temperature. The percentage ash was calculated as follows.

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

$Where$:

$W_1 = weight \ of \ crucible, W_2$
$= \ weight \ of \ crucible$ and $sample \ before \ ashing,$
W_3
$= \ weight \ of \ crucible$ and $content \ after \ ashing$

2.5.3 Crude Fibre Determination

Two (2g) 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 desiccator 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

The Soxhlet technique was used to determine fat. The samples were weighed into a thimble, and the top of the thimble was fitted with loose plug fat free cotton wool, which was then put into the bottom extractor of the Soxhlet apparatus. The extraction was fitted with a flat bottom flask (250 ml) of known weight containing 200 ml of hexane. For 8 hours, the equipment was heated and fat was removed. The solvent was recovered, and the flask (containing the oil and solvent mixture) was placed in a hot air oven (Uniscope-Surgifriend Medicals, England) for 1 hour at 105°C to eliminate any remaining moisture and 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

Determination of protein was carried out using the Kjeldahl apparatus. Two (2g) grams of sample were weighed into a Kjeldahl digestion flask using a digital weighing balance (Uniscope-Surgifriend Medicals, England: Max. 180 g). 96 percent anhydrous sodium sulphate, 3.5 percent copper sulphate, and 0.5 percent selenium dioxide were added to a catalyst mixture weighing 0.88 g. 7 mL concentrated sulphuric acid was added and stirred to thoroughly combine the contents. In the fume chamber, the Kjeldahl flask was gradually heated in an inclined position until no sample particles stuck to the flask's side. The solution was heated more vigorously to bring the liquid to a boil, and the flask was shaken intermittently until the solution was clear. The solution was allowed to cool before being diluted to 25 mL in a volumetric flask with distilled water. A steam distillation apparatus was filled with ten (10) ml of the diluted digest. The digest was made alkaline with 8 ml of 40 % NaOH. 5 ml of 2 % boric acid solution was added to the receiving flask, and three drops of the mixed indicator were dropped. The distillation apparatus was connected to the receiving flask. The delivery tube was dipped into the 100ml conical flask and titrated with 0.01ml HCl. A blank titration was done. The percentage of 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 according to the method described by [12].

2.6.1 Determination of Calcium

Calcium was determined with atomic absorption spectrophotometer. Ca2+ (2.495 g) were dissolved and diluted to 100 ml with de-ionized water. This solution contains 1000 mg Ca^{2+} ions, and from this stock solution, prepared calcium standards of the following concentration levels 0.0, 3.0, 6.0, 9.0 were made. The sample's absorbance and standard working aliquot were determined in the atomic absorption spectrophotometer (Uniscope-Surgifriends, England) at 239.9 nm. The concentration of the tested mineral in the sample was calculated regarding 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

A spectrophotometer was used to determine the amount of phosphorus in the sample. Phosphorus in the sample was determined using the molybdate method, which included the use of hydroquinone as a reducing agent. 1 ml of the sample digest was mixed with 1.0 ml sodium sulphate, 1.0 ml ammonium molybdate, and 1 ml hydroquinone. The mixture was stirred and set aside for 30 minutes to create the blue colour. The sample's absorbance was measured at 600 nm using a spectrophotometer. The phosphorus standard was made by dissolving 1.1 g of monobasic potassium phosphorus (KH2PO4) in 500 mL of distilled water in a volumetric flask. To reduce microbial activity, five drops of toluene were applied. This contained 100 ppm. Standard stock (0.1 ml) = 0.2 ppm. Zero to one milliliter of the 100 ppm phosphorus stock solution was poured into a 100 ml volumetric flask separately and treated the same way as the sample. The reading of the standard was taken at 600 nm in a 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 was determined using 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

1 g of pure iron wire was used to make a standard solution containing 100 mg/ml Fe3+ ions. The wire was dissolved in 20 mL concentrated HNO3, heated in a water bath, and then diluted with purified water to 1000 mL. Standard solutions were made with concentrations of 0, 0.5, 1.0, 2.0, and 4.0 ppm. Two milliliters of sample aliquot were diluted to 100 ml and were used to determine the absorbance of the sample using an atomic absorption spectrophotometer (Uniscope-Surgifriends Medicals, England) at 510 nm. The absorbance of the standard and the sample were measured, and the quantity of iron in the sample was calculated using the standard curve.

2.7 Determination of Physical Properties of the Cookies

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

2.8 Sensory Evaluation of the *Cookies*

The sensory qualities of cookie samples were determined using the approach outlined by [13]. A group of twenty (20) students and staff members from the Federal Polytechnic Kaura Namoda, Nigeria's Food Science and Technology Department. Panelists were recruited based on their familiarity with and expertise with cookies for sensory evaluation. Cookies made with each flour blend and the reference sample (100 percent wheat flour) were provided to the panellists in coded form (A-C) and at random. Between evaluations, the panellists were given portable water to rinse their mouths. However, a questionnaire describing the quality attributes (appearance, taste, flavor, texture, crispness, and overall acceptability) of the Cookies samples were given to each panelist. The sensory parameters were rated on a 9-point hedonic scale (1 = dislike extremely and 9 = like significantly). Cookies were produced from wheat flour (100 %) as a control.

2.9 Statistical Analysis

For data analysis, the GENSTAT Statistical Software (version 17.0) was employed. 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

3.1 Effect of Crayfish Supplementation on the Proximate Composition of Cookies

The results of the proximate composition are presented in table 3. The results showed that sample E had the highest protein content while sample; the control sample (100:0; wheat: crayfish flour) had the lowest. There is a significant ($p<0.05$) difference in the protein content among the samples. The high protein content observed in sample E was due to the high protein content of crayfish; these findings do not agree with that of [16], who reported a protein range of 12-19 % protein. Sample E recorded the highest moisture content, while sample A had the lowest. There was an increasing trend in the moisture content from sample A down to sample E. Significant difference exists among the samples. The rising value of moisture as the wheat flour decreases and crayfish flour increases was due to the decreased quantity of the presence of max cellulose and other non-starch polysaccharides that hold water several times higher than its weight. There was an increase in the fiber content of the cookies samples as the quantity of crayfish increased. There was a significant (p<0.05) difference between the samples. The increasing fiber 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 to 7.89. No significant (p<0.05) difference existed between sample B and sample E. This may be a result of improper mixing of the ingredients during the mixing operation. Sample E had the highest fat content, and sample A had the lowest fat content; however, these findings agree [16]. An increasing trend in fat was observed as the level of crayfish supplementation increased. Carbohydrates decreased as the level of crayfish supplementation increased. There was a significant (p<0.05) difference in the carbohydrate contents of the cookie samples.

3.2 Effect of Crayfish Supplementation on the Mineral Composition of Cookies

The results of the mineral content were as presented 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 was no significant (p<0.05) difference between samples A and B but a significant (p<0.05) difference exists between samples A and B and samples C, D, and E. The potassium contents of the cookies decreased as the level of crayfish supplementation increased, but there was a significant (p<0.05) difference between the samples. The highest iron content was observed in sample E, while the lowest was in sample A. There was no significant (p<0.05) difference in the 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 a significant (p<0.05) difference existing among the samples. Potassium was the most common mineral in the cookies, followed by phosphorus, which was consistent with the findings of [18]. The cookies' high potassium, salt, and phosphorus content will make them acceptable for hypertensive people [18]

Table 3. Effect of Crayfish Supplementation on the Proximate Composition of Cookies

Sample	Moisture (%)	Protein (%)	Fibre (%)	Ash (%)	Fat (%)	Carbohydrate (%)
A	4.61^{e}±0.01	7.88^{e}±0.01	1.95^{e}±0.01	6.62^{d}±0.05	0.98^{e}±0.01	77.94^{a}±0.06
B	4.90^{d}±0.01	15.14^{d}±0.00	2.14^{d}±0.01	7.89^{b}±0.01	1.62^{d}±0.01	68.29^{b}±0.01
C	5.13^{c}±0.01	18.50^{c}±0.00	2.64^{c}±0.01	5.77^{e}±0.01	1.91^{c}±0.01	66.03^{c}±0.01
D	5.34^{b}±0.01	22.94^{b}±0.00	3.49^{b}±0.00	7.06^{c}±0.00	2.04^{b}±0.01	59.12^{d}±0.00
E	6.27^{a}±0.01	38.94^{a}0.01	3.65^{a}±0.01	7.58^{b}±0.01	3.11^{a}±0.01	40.45^{e}±0.01
LSD	0.022	0.011	0.016	0.058	0.018	0.077

Values are mean ± standard deviation of duplicate determination
Means on the same column that have different 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

Table 4. Effect on Crayfish 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 on the same column that have different 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

Table 5. Effect of Crayfish Supplementation on the Physical Properties of Cookies

Samples	Weight (g)	Diameter (mm)	Thickness (mm)	Spread Ratio
A	14.31^{a}±0.69	49.50^{a}±0.71	13.99^{a}±0.03	3.53^{a}±0.01
B	12.75^{b}±0.21	49.39^{a}±1.20	13.82^{a}±0.97	3.57^{a}±0.01
C	12.19^{b}±0.21	48.03^{ab}±0.33	13.75^{a}±0.35	3.49^{a}±0.30
D	11.66^{bc}±0.55	47.02^{b}±1.37	12.66^{a}±.0.93	3.71^{a}±0.01
E	10.67^{c}±0.50	46.16^{b}±1.07	10.53^{b}±0.32	4.37^{b}±0.01
LSD	1.28	2.20	1.63	0.35

Values are mean ± standard deviation of duplicate determination
Means on the same column that have different 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

Table 6. Effect of Crayfish 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 on the same column that have different 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 Supplementation on the Physical Properties of Cookies

The results of the physical characteristics were as presented in table 5. The cookie weight showed a significant (p<0.05) difference between sample A and the samples, such as B, C, D, and E, there was a decreased trend in the weight of the cookies samples, with sample A having the highest. These findings are not in line with the findings of Arshad et al. [16]. Crayfish flour addition decreased the diameter of the cookies, as shown in Table 5 above, with sample A having the highest value and sample E with the lowest value. No significant (p<0.05) difference between the control sample A with samples B and C, a significant (p<0.05) difference existed between samples A, B, C, D, and E. These findings are in line with the research of [19], who stated that "too much in elasticity in the gluten and dough will spring back to give cookies with a smaller diameter. The cookies' thickness decreased as the supplementation of crayfish increased. Sample A scored the highest value and E the lowest. There was no significant (p<0.05) difference between the cookies samples. These results are also in line with Arshad *et al*. [16]. The spread ratio is the ratio of the diameter to the thickness of the cookies.

3.4 Effect of Crayfish Supplementation on the Sensory Properties of Cookies

The result of the sensory characteristics of the cookies was presented in table 6. Appearance is an important sensory attribute of any food because of its influence on acceptability, and The brown color cookies were a result of Maillard's reactions which are 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 were no significant (p<0.05) differences between samples A and B due to the level of supplementation of crayfish in sample B. But a significant difference (p<0.05) existed between A and other samples C, D, E. Appearance change could be due to caramelization, dextrinization of starch, or Maillard reaction involving the interaction of reducing sugar or proteins [20]. Flavors are essential sensory attributes that influence acceptance of baked goods products before consumption. A reduction in trend was observed in the mean score of flavor as the level of supplementation increased downwards. The results are inconsistent with those observed in earlier studies by [19]. In supplemented soybeans and maize flour to produce cookies that did not significantly (p£0.05) affect the sensory score of flavor. Crispness is a desirable quality of cookies. The quality score in response to the crispness of cookies implied that sample A got the highest mean score, followed by sample B. The lowest score was observed in sample E. Taste is one of the sensory parameters affecting food products' quality and acceptability. No matter how rich or nutritious a portion of food is, such food will not be accepted by the consumers if it tastes terrible. The decrease in overall acceptability was due to the reduction in the above sensory characteristics.

4. CONCLUSION

Cookies produced from a 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). The cookies would be of nutritional importance for celiac disease and diabetic patients in most developing countries, including 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 appearance, taste, crispness, and texture. Supplementation of wheat flours with crayfish had greatly improved the cookies' protein, quality, and nutritional benefits.

DISCLAIMER

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.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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