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Determination of Some Selected Properties of Composite Flour Produced From Wheat Flour, Edible Caterpillar and Lemon Peel Using Response Surface Methodology.

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ABSTRACT
The use of composite flour in different food productions has gained prominence from researchers. Also, edible caterpillars are rich in quality protein, fibre, vitamins and minerals that could support human nutritionally. This study evaluates the quality of composite flour produced from wheat flour, edible caterpillar and lemon peel. The edible caterpillar (Lepidoptera litoralia) was obtained from Sango market Saki, Oyo state while wheat flour, lemon fruits and other ingredients were obtained from Owode market in Offa, Kwara state. Rotatable Central Composite Design (RCCD) was used to design a mixture consisting of three variables (wheat flour 0-80 %, edible caterpillar 0-15 %, lemon peel 0-5 %) was used for this study. Eleven experimental runs were generated for the composite flours and the nutritional and anti-nutritional properties were evaluated. The protein, fibre, ash, water absorption capacity and total phenolics of the flour blends were in the ranges 15.75 to 18.39 %, 2.8- 6.08 %, 1.43-2.02 %, 139 to 169 g/cm^3 and 0.42 to 0.59 mg/GAE respectively. The moisture content, phytate and tannin ranged 8.21 and 10.12 %, 293.68-298 mg/100g and 275 mg/100g respectively. The values of the nutritional content were higher compared to white wheat flour, the anti-nutritional components in the composite flour were within the tolerable limits and the composite flour had significant antioxidants levels which have good health implications.

Key words: Composite flour, Edible caterpillar, Response surface methodology, Quality evaluation, Anti-nutritional properties.

I. INTRODUCTION

Composite flour as either binary or ternary mixtures of flours from some other crops with or without wheat flour (Shittuet al., 2007). The merits of incorporating flours from other sources to wheat flour in snack production in developing countries include i)Reducing the cost of importation; ii) Increased utilization of indigenous crops iii) a better supply of protein for human nutrition; and iv) better overall use of domestic agriculture production (Berghofer, 2000; Bugusuet al., 2001; Seibel, 2006).

Researchers throughout the world have paid more attention to the production of food products using composite flour, especially in the production of snack foods. Various researchers has reported the mixing of wheat flour with various sources of locally grown food crops such as tubers, legumes, cereals and fruit flour at different percentages to produce variety of food products. These food products made from composite flours have been reported to retain similar properties to products made from white-wheat flour only. The positive effects of the use of the composite flour are seen in the final product relating to the functional and physicochemical properties of raw blended wheat flour along with percentage of blending (Bugusuet al., 2001).

Only about three percent of Nigerian's total consumption of wheat flour is produced locally (Agu et al., 2007). As a result, 97% of wheat used for producing wheat-based products is imported.The unbridled importation of food by developing countries like Nigeria is detrimental to the local economy and threatens food security. Many developing countries spend a large proportion of their

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foreign exchange earnings on food especially wheat. Thereby, developing countries create wealth and employment in developed countries to the detriment of their local economy. Food importations especially from distant countries also have some sustainability challenges such as increase in food miles and energy consumption for food transportation (Ohimain, 2014). It is therefore of economic importance if wheat importation is reduced by substitution with other locally available raw materials (Oyekuet al., 2008) such as cassava, maize, potato and other protein rich flours.

Wheat importation has detrimental effects on the Nigerian economy. In order to reduce the impact on the economy, Nigeria released policy mandating the flour mills to partially substitute wheat flour with 10% cassava flour for bread making. The potential benefits of the policy include savings of the Nigeria's foreign exchange earnings of ₦254 billion per annum, reduction in the severity of coeliac disease, utilization of locally available crops and creation of employment and wealth (Dhingra and Jood, 2002).

Composite flour is therefore considered beneficial in developing countries because it decreases wheat flour importation and encourages the utilization of locally grown crops as flour (Hugo et al., 2000; Hasmadiet al., 2014). Local raw materials substitution for wheat flour is increasing due to the growing market for confectioneries (Noor and Komathi, 2009). Thus, several developing countries have encouraged the initiation of programs to evaluate the feasibility of alternative locally available flours as a substitute for wheat flour (Abdelghaforet al., 2011).

Recently, there is a growing interest in the use of alternative protein sources such as edible insects for humans to meet their protein demand as the world population skyrocket. The use of insects as human food, especially by indigenous people in the third world countries is well documented. Nigeria also has its own share of edible insects and caterpillars distributed across the various zones in the country. These are mostly gathered from bushes and farmland by women and children, and are prepared and eaten or sold in some local markets. Cultures in Nigeria are highly variable and these affect the consumption of the insects that vary from active avoidance to occasional and substantial consumption (Alamuet al., 2013).

Edible insects are rich in quality protein, fibre, vitamins and minerals that could support human nutritionally (Banjo et al., 2006). For every 100 grams of dried caterpillars, there are about 53 grams of protein, about 15 percent of fat and about 17 percent of carbohydrates. Their energy value amounts to around 430 kilocalories per 100 grams. The insects are also believed to have a higher proportion of protein and fat than beef and fish with a high energy value (FAO, 2004).

The increased awareness of consumers on the relationship between diet and health has prompted researchers to study the potentials of antioxidants-rich plant material such as fruits and fruit peels in snack production. Studies have shown that lemon peel is rich in useful nutrients such as vitamins, minerals and fiber, and each of them offers a range of health benefits. Reports showed that lemon peel is rich in antioxidants and compounds that could help human bodies fight chronic diseases (Stanway and Penny, 2013). This study is therefore aimed at development of functional composite flours of wheat flour, edible caterpillar and lemon peel.

II. MATERIALS AND METHODS

2.1 Materials

The major materials used for this research were wheat flour, edible caterpillar and lemon peel. The edible caterpillar (Lepidoptera litoralia) was obtained from Sango market Saki, Oyo state while wheat flour, lemon fruits and other ingredients such as vegetable oil, sugar and fat were obtained from Owode market in Offa, Kwara state. All chemicals and reagents used were of analytical grades.

2.2 Methods

2.2.1 Experimental design

Response Surface Methodology (RSM) was adopted to study the simultaneous effects of the composition of the wheat flour (WF), edible caterpillar (EC) and lemon peel (LP) on the nutritional quality of the chinchin. A three- variable (five levels of each variable) rotatable central composite design was employed (Montgomery, 2001; Singh et al., 2003). The independent variables selected for this study were wheat flour, (WF) (0-80%), edible caterpillar, (EC) (0-15%) and lemon peel, (LP) (0-5%). The composition of the composite flour blends had the form.

A (wheat flour) + B (edible caterpillar) + C (lemon peel) = 100% eqn. (1)

Equation 1 represented mathematical linear dependence of the variables if the amounts of the ingredients are used directly as variables.

$$A+B+C=100\%$$

(eqn. 2)

Table 1: Formula composition at the design centre point

Ingredient/variable	Total mixture basis (%)	Weight (g)
A Wheat Flour (WF)	80	800
B Edible caterpillar (EC)	15	150
C Lemon peel (LP)	5	50
Total	100	1000

Wheat flour (WF) = 800g = A

Edible caterpillar (EC) = 150g = B

Lemon Peel (LP) = 50g = C

Table 2: Levels and coded values of independent variables for wheat flour and edible caterpillar

Variable	± Increment	x_i coded Levels				
		-2	-1	0	+1	+2
x_1	0.25	3.50	3.75	4.00	4.25	4.50
x_2	0.20	2.60	2.80	3.00	3.20	3.40

$$x_1=\frac{A}{B+C}=\frac{800g}{150+50g}=\frac{800}{200}=4 \quad (3)$$

$$x_2=\frac{B}{C}=\frac{150}{50}=3 \quad (4)$$

The coded level x_i ratios for each treatment as per experimental design were translated into working quantities of ingredients. The value for the snack ingredients were obtained by systematic algebraic solutions for A, B and C in terms of actual x_i ratios and a unit quantity of product. The equations used to convert to real values are as follows:

$$A=\frac{x_1}{1+x_1} \quad (5)$$

$$B=\frac{x_2(1-A)}{1+x_2}$$
(6)

$$C=1000-(A+B)$$
(7)

The values for dried lemon peel that are dependent were obtained from the difference between 1000 and the sum of wheat flour and edible caterpillar. The resulting weights of the ingredients in different treatments are given in Table 3.

2.2.2 Production of dried lemon peel powder

The method described by Sanchez-zapataet al. (2012) for preparation of pomace was adopted. The lemon fruits were sorted cleaned with water to remove dirts and were then peeled. The peel of the lemon was rewashed with water, drained and dried at 65 ^{o}C for 3 h before milling and sieving. Fig 1 shows the flow chart for the preparation of lemon peel powder from lemon.

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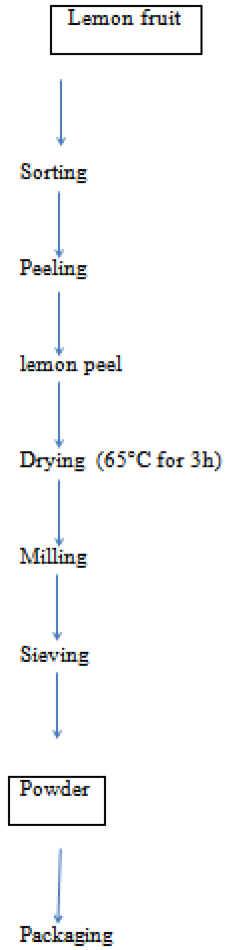

Fig 1: Flow chart for the production of lemon peel powder (Sanchez-Zapata et al., 2012)

Table 3: Weight of ingredients (g) obtained

Experimental run	Treatment coded level $x_1 x_2$ WF (A)	EC (B)	LP(C)	Composition (g)		
1	1		-1	809.52	140.37	50.11
2	1		1	809.52	145.14	45.34
3	-1		-1	789.47	155.11	55.42
4	-1		1	789.47	160.38	50.15
5	2		0	818.18	136.35	45.47
6	-2		0	777.78	166.65	55.57

7	0	-2	800.00	144.44	55.56
8	0	2	800.00	154.54	45.46
9	0	0	800.00	150.00	50.00
10	0	0	800.00	150.00	50.00
11	0	0	800.00	150.00	50.00

WF= Wheat flour, EC =Edible caterpillar, LP = Lemon peel

2.2.3 Production of edible caterpillar powder

The dried edible caterpillar was sorted to remove unwanted particles and milled into powder using an attrition mill. The edible caterpillar powder was sieved to remove the shaft that was present in the powder.

2.3 Analysis

2.3.1 Water Absorption Capacity of the Composite Flours

Water absorption capacity was determined according to the method described by Onwuka (2005).

2.3.2 Proximate composition of the Composite Flours

Moisture, protein, fat, crude fibre and ash carbohydrate contents were determined according to the method described by AOAC (2005)

2.3.4 Determination of anti-nutritional factors

The phytate content was determined according to the method described by Ajobieweet al. (2019) and tannin composition of the composite flour samples was determined according to the method described by AOAC (2005).

2.3.6 Determination of total phenolic

Total phenolic content of the composite flours was determined according to the method described by Siow and Hui (2013).

III. RESULTS AND DISCUSSION

Experimental Runs	Treatment Coded Level $x_1 x_2$		Composition- (g) WF	EC	LP	CP	CF	Moisture	Ash	WAC	Phytate	Tannins	Total phenolic
			(g)	(g)	(g)	(%)	(%)	(%)	(%)	g/cm^3	mg/100 g	mg/100g	mg/GAE
1	1	-1	809.52	140.37	50.11	17.20	4.21	10.12	2.01	169.49	296.37	232.00	0.44
2	1	1	809.52	145.14	45.34	16.63	3.40	8.21	1.97	139.58	296.64	182.00	0.46
3	-1	-1	789.47	155.11	55.42	17.53	3.61	8.22	2.00	169.49	295.02	190.00	0.45
4	-1	1	789.47	160.38	50.15	18.38	-	10.02	1.98	159.52	295.29	245.00	0.43
5	2	0	818.18	136.35	45.47	15.75	3.61	10.03	1.44	139.49	294.49	225.00	0.46
6	-2	0	777.78	166.65	55.57	18.39	5.80	10.02	1.83	179.46	298.49	240.00	0.49
7	0	-2	800.00	144.44	55.56	17.38	3.41	8.21	2.01	169.49	294.21	215.00	0.42
8	0	2	800.00	154.54	45.46	17.50	4.20	8.22	1.98	169.49	295.84	215.00	0.57
9	0	0	800.00	150.00	50.00	17.51	2.94	8.22	1.83	149.55	293.68	145.00	0.59
10	0	0	800.00	150.00	50.00	17.52	2.80	10.01	2.02	159.46	294.00	146.00	0.54
11	0	0	800.00	150.00	50.00	17.81	2.82	9.13	2.01	149.58	295.29	148.00	0.56

Table 4: Result of analysis on the composite flour formulations

Key: WF – Wheat flour, EC – Edible caterpillar, LP – Lemon peel, CP - Crude protein, CF – Crude fiber, M – Moisture, CA – Crude ash, WAC – Water Absorption Capacity, TP-Total phenolic

Proximate, Anti-nutritional and Total Phenols of the Composite Flours.

The result of the proximate composition, anti-nutritional components and total phenolic of the composite flours is presented in Table 4. The crude protein ranged from 15.75 to 18.39%. The highest protein content was recorded at runs 6 that contained 777.78 g wheat flour (WF), 166.65 g edible caterpillar (EC) and 55.57 g of lemon peel (LP). The highest protein content at coded point (-2, 0) was about 2.64% higher than the minimum value of 15.75%. It was observed that as edible caterpillar increased in the composite flour the protein content also increased. The protein content in pure wheat flour ranges between 11 and 13% (Olowe, 2004). The higher protein content of the composite flour could be attributed to the inclusion of edible caterpillar in the composite flour. Solomon and Prisca (2012) reported a protein content of 59.8% in edible caterpillar. The findings from this study agree with previous studies on the substitution of wheat flour with legumes such as production and acceptability of chinchinsnack made from wheat and tiger nut by Abiodunet al. (2017) that recorded a protein content that ranged between 11.1 and 14.9% at up to 30% substitution. Also, Adegunwaet al. (2014) reported a protein content that ranged from 12.63 to 19.99% in a composite millet- wheat chinchin at 30% millet substitutions.

The crude fibre content varied from 2.80 to 5.80 % with runs 6 that had 777.78 g WF, 166.65 g of EC and 55.57 g LP having the highest value while runs 10 consisting 800 WF, 150 EC and 50 LP had the lowest value. No definite trend was observed for the fibre content with the substitution of WF with EC and LP. This may be attributed to the dilution effect of wheat flour in the mixture. The source of fibre in the composite flour could be from EC and LP. EC and LP had been reported to contain 9.4% and10.6% fibre respectively (Braideet al., 2010). This result is in accordance with Adegunwaet al. (2014) that reported a fibre content range of 4.56- 5.23% in a composite millet- wheat chinchin at up to 30% millet substitutions. The ash content indicates a rough estimation of the mineral content of a product. The ash content of the composite flours has values that ranged from 1.44- 2.02%. The highest value was recorded at runs 10 that contain WF- 800 g, EC-150 g and LP-50 g while the lowest value was at coded point 2, 0 with 818.18 g WF, 136.35 g EC and 45.47 g LP. It was observed that the ash content was at its lowest when EC and LP have lower values. This may be attributed to the low content of lemon peel in the composite flour. This result is in agreement with Hawaet al. (2018) that reported ash content range of (1.25% - 2.4%) for cookies prepared from okara, red teff and wheat flour.

The moisture content estimates directly the water content and indirectly the dry matter of the samples. According to Hayma (2003), flours with moisture content less than 14% can resist microbial growth and hence better storage stability. Therefore the moisture content of the flour samples which falls between 8.21 and 10.12% indicates that the composite flours are within the range acceptable for effective flour storage for further processing without the risk of microorganism contamination. This result is similar with Adebowaleet al. (2012) who reported a moisture content range of 10.24 - 11.24% in wheat and sorghum composite flour.

Water Absorption Capacity (WAC) is the ability of a product to associate with water under a water limiting condition. The water absorption capacity (WAC) of flour has an important role in the food product preparation process, as it influences other functional and sensory properties. The WAC of the composite flours was found to be between 139 to 179 g/cm^3. The WAC was at its highest when the WF content is the lowest with the value 777.78 g at coded point (-2, 0) while the WAC has the lowest value when WF content is the highest with the value 818.18 g at coded point (2, 0). This could be indicative of the fact that addition of EC and LP to WF confers high water binding capacity to WF which in turn improves the textural properties of the dough obtainable from the composite flour (Adebowaleet al., 2012). High WAC is also attributed to loose structure of starch polymers while low values indicate the compactness of the structure (Oladipo and Nwokocha, 2011). A desirable characteristic of composite starches is the absorption of water during mixing to doughs (Doxastakiset al., 2002). Several authors have reported increased water absorption in composite flours compared to wheat flour alone (Lee et al., 2001; Morita et al., 2002; Adebowaleet al., 2012).

Anti-nutrients such as tannins, phytate and oxalate have been reported in edible insects and lemon peel in Nigeria (Ekpoet al., 2010; Ifie and Emeruwa, 2011; Anie and Abel, 2018). The anti-nutrients analysed in the composite flours were phytate and tannin, the result of the phytate content of the composite flour is between 293.68-298 mg/100g, the maximum phytate for the blends was recorded at coded points (-2, 0) which is 4.32 more than the minimum obtained at the coded points (0, 0).The highest phytate recorded at this point could be as a result of the high content of EC and LP in the blend. The tannin content has values that range between 145 mg/100g and 245 mg/100g, maximum value was obtained at coded point (-1, 1) while the minimum value obtained at centre point (0, 0). The high values of phytate and tannin in the composite flour could be attributed to EC and LP present in the composite flours. The result is in agreement with Abebeet al. (2018) that recorded phytate and tannin content of 245.36 mg/100g and 194.30 mg/100g respectively in composite of wheat anchote and soybean flour. Total phenolic content of the composite flours were shown on Table 4.1, the total phenolic ranged from 0.42 to 0.59 mg/GAE. The low total phenolic content in the composite flours may be attributed to the lower quantity of lemon peel flour in the composite flours. The values of the total phenolic are lower than the result of Tajamulet al. (2017) who reported a total phenolic content that range between 0.81 and 0.97 mg/GAE in bread supplemented with asparagus bean flour.

IV. CONCLUSION

The result of this study shows that ediblecaterpillar insect and lemon peel can be incorporated in to wheat flour for the production of snack that will be more nutritious to consumers than the conventional snacks predominantly produced from white wheat flour which has been reported to be deficient in some essential nutrients and lacking in bioactive substances. Also the use of composite flour will invariably reduce the pressure on wheat flour demand which is mostly imported to the country and improve the utilization of edible caterpillar as an alternative protein source. Furthermore, it has been established that lemon peel which has been assumed to be a waste by many is rich in antioxidants and can be useful in the production of snacks.

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