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Evaluation of the Quality of Composite Maize-Wheat Chinchin Enriched with *Rhynchophorous phoenicis*

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Abstract

The purpose of this research was to develop and evaluate a snack product (chin-chin) from composite maize-wheat flour blends enriched with edible palm weevil (*Rhyhnchophorus phoenicis*) paste. The maize-wheat chin-chin enriched with *R. phoenicis* were subjected to acceptability test using twenty member semi-trained panelist. The moisture, fat, protein and carbohydrate compositions of the snack samples had significant differences in their values. Sample 5M5R90W (containing 5% maize flour and *Rhyhnchophorus phoenicis* paste and 90% wheat flour) had the highest protein value of 19.05% while the least value 9.39% was obtained by sample 100M0R0W (100% maize flour alone). Sample 100M0R0W containing 100% maize flour also had the highest carbohydrate value of 75.24%. There was no significant difference in the ash and crude fiber contents of the chin-chin samples enriched with edible palm weevil paste. There were significant differences ($P \leq 0.05$) in the functional properties of maize-wheat composite flour blends. Their wettability values ranged from 46.67 – 200 while the swelling index, bulk density and oil absorption capacity showed no significant difference in their values. The result of the mineral analysis showed phosphorus, magnesium and sodium had significant differences in their values in the range of 317.55 – 376.75mg/100g; 5.60 -13.60mg/100g;59.0 – 70.3mg/100g, respectively. There were no significant differences in the sensory attributes of the chin-chin samples. The result showed that an acceptable chin-chin product can be processed with the inclusion of the larva of edible palm weevil with maize-wheat composite flour to enhance the nutritional quality of the product.

Keywords: maize, wheat, *Rhyhnchophorus phoenicis*, chin-chin

1. Introduction

Sustainable diets have been defined as diets with low environmental impacts which contribute to food and nutrition security and to healthy life for present and future generations. Sustainable diets are protective and respectful of biodiversity and ecosystems, culturally acceptable, accessible, affordable; nutritionally adequate, safe and healthy; while optimizing natural and human resources (FAO, 2012). Insects could be of great interest as a possible solution to food safety and environmental sustainability of food production due to their capability to serve as an important source of protein and other nutrients as well as have ecological and economic advantages (Belluco et al., 2013). Insects constitute quality food and feed, have high feed conversion ratios, and emit low levels of greenhouse gases (Huis, 2013). An upsurge of interest in the use of insects as sustainable diets should be encouraged as many of them are nutritionally, economically and ecologically important.

Entomophagy (human consumption of insects) has been practiced since mankind first made an appearance on planet earth. According to López and Shanley (2004), insects have played an important role in the history of human nutrition in Africa, Asia and Latin America. Hundreds of species are still eaten. Among the most importantorders of insects consumed in Nigeria are Coleoptera, Hymenoptera, Isoptera, Lepidoptera, Odonata, Orthoptera and they are highly priced (Fasoranti & Ajiboye, 1993). Notable examples ofthese are the palm weevil, *Rhynchophorus phoenicis*, termites, *Macrotermes nigeriense* (queen, king and reproductives), *Cirinaforda*, and variegated grasshopper, *Zonocerus variegatus* (Adedire & Aiyesanmi, 1999).

African insects are rich in protein and usually processed to tasty food products which are used as flavour intensifiers in soups and stews and also add protein to protein-poor diets. Ordinarily, insects are not used as emergency food sources during shortages, but are included as a planned part of the diet throughout the year or when seasonally available (Inyang & Iduh, 1996). Among the people living in south of the Sahara, the spectrum of hunger is endemic. This makes the insects unconventionally interesting to study because they remain under exploited and not recovered. However, the physical and chemical properties of their proteins in food systems during processing, storage, preparation and consumption is affected (Fennema, 1996).

People especially in areas where insects were not consumed for a long time prefer incorporating insects into the food in a way they are not visible, having accepted only the idea that the insects have a nutritional value. In practice, dried insects may be crushed or pulverized, and raw or boiled insects ground or mashed, making their insect form unrecognizable. They become masses of protein and lipids that can be mixed with other foodstuffs such as grain, ground meat and mashed potatoes to make a variety of dishes (Mitsuhashi, 2010). Some recipes of such dishes have been published (Borkovcová et al., 2009)

The larva of *Rhynchophorus phoeniciss*, a Coleoptera of Curculionidae family is used as traditional food in several countries. It is a delicious meal in many parts of Cameroon and other countries in Africa where it is found. The high cost of animal protein has directed interest towards several insects as potential sources of proteins for humans. Among the insects species, *R. phoénicis* larvae are considered the major sources of dietary lipids and proteins. They are consumed worldwide, especially in developing and under developed countries where consumption of animal protein may be limited because of economic, social, cultural or religious factors (Cerda et al., 1999). *Rhynchophorus* spp. are major pests of date palms, coconut palms, oil palms and sugarcane (Aldryhim & Al-Bukiri, 2003). *Rhynchophorus phoenicis* is rich in protein, inexpensive and underutilized by the industries, meanwhile it offers the same benefits as other meat products with less fat when deffated. They contain in this delipidated form over 80% of high quality protein with high content of essential amino acids (USDANAL, 2005) and can be useful in many food applications (Prinyawiwatkul et al., 1993). Though they are very destructive, their nutritional potentials have endeared them to man.

Chin-chin is a fried snack popular in West Africa. It is a sweet, hard, donut- like baked or fried dough of wheat flour, eggs and other customary baking items (Akubor, 2004). Chin-chin is easily one of the most favoured food item, a much relished African pastry which could serve as a dessert, snack and also as a popular street food. Chin-chin enjoys a very special place in the heart as well as stomachs of West African population (Mepba et al., 2007a). Chin-chin is one food item, that invites a great deal of flexibility in terms of the ingredient used and method of preparation involved; while some like to eat it hard and crunchy, others prefer a softer easier to chew version. This research was conducted to evaluate the nutrient composition of chin-chin from composite maize-wheat flour blends enriched with larva of edible palm weevil (*Rhynchophorus phoenicis)*.

2. Materials and Methods

2.1 Material Collection

Live larvae of edible palm weevil (*Rhynchophorus phoenicis)* were supplied from Orlu in Imo State. The method of Womeni et al. (2012) was used in processing *Rhynchophorus phoenicis* into paste for chin-chin production. The method described by Omueti et al. (2009) was used in processing yellow maize (*Zea mays*) into flour. The method of production of chin-chin described by Adegunwa et al. (2014) was used.

2.2 Nutrient Analysis of Chin-Chin Enriched with Rhynchophorus phoenicis

The chin-chin samples were analyzed for moisture, ash, protein and fat contents using the method described by AOAC (2000). The mineral components (phosphorus, magnesium, calcium, potassium and sodium) were analyzed using an Atomic Absorption Spectrophotometer (AAS, Model SP9, Pychicham UK).

2.3 Determination of Functional Properties of Composite Wheat-Maize Flour Blends

2.3.1 Bulk Density

Bulk density of flour samples were determined by weighing the sample (50g) into 100ml graduated cylinder, then tapping the bottom ten times against the palm of the hand and expressing the final volume as g/ml.

2.3.2 Wettability

The method of Onwuka (2005) was used. Into a 25ml graduated cylinder with a diameter of 1cm,1g of sample was added. A finger was placed over the open end of the cylinder which was invested and clamped at a height of 10cm from the surface of a 600ml beaker containing 500ml of distilled water. The finger was removed and the rest material allowed to be dumped. The wettability is the time required for the sample to become completely wet.

2.3.3 Oil Absorption Capacity

Two grams (2g) of sample was mixed with 20ml of oil in a blender at high speed for 30sec. Samples were then allowed to stand at 30^0C for 30 minutes then centrifuged at 1,000rpm for 30 minutes. The volume of supernatant in a graduated cylinder was noted. Density of water was taken to be 1g/ml and that of oil determined to be 0.93g/ml.

2.3.4 Swelling Index Determination

Three grams (3g) portions (dry basis) of each flour were transferred into clean, dry graduated (50ml) cylinders. Flour samples were gently leveled into it and the volumes noted. Distilled water (30ml) was added to each sample; the cylinder was swirled and allowed to stand for 60 minutes while the change in volume(swelling) was recorded every 15 minutes. The swelling power of each flour sample was calculated as a multiple of the original volume as done by Ukpabi and Ndumele (1990).

2.4 Sensory Evaluation

The sensory attributes - colour, taste, texture, flavour, aroma, appearance and general acceptability were evaluated by twenty member semi-trained panelist using a 9- point hedonic scale with 1 representing the least score (dislike extremely) and 9 the highest score (like extremely). Analysis of Variance (ANOVA) was performed on the data gathered to determine differences, while the least significant test was used to detect significant differences among the means (Iwe, 2002, 2007).

3. Results and Discussion

3.1 Nutritional Composition

The results of the proximate composition of maize-wheat composite chin-chin enriched with palm weevil are presented in Table 2. There was significant difference ($P \leq 0.05$) in the moisture content of the chin-chin enriched with edible palm weevil paste. The moisture content ranged from 4.35 – 5.34% with sample 20M5R75W (20%maize flour: 5% *Rhynchophorus phoneicis* paste: 75% wheat flour) having the highest value of 5.34% while sample 5M5R90W (5% maize four: 5% *Rhynchophorus phoneicis* paste: 90% wheat flour) had the lowest value of 4.35%. There was reduction in moisture contents as the rate of addition of wheat flour increased. Adegunwa et al. (2014) reported moisture content values of 3.98 – 5.04 in composite millet-wheat chin-chin. Sanni et al. (2006) reported that the lower the moisture content of a product to be stored the better the shelf stability of such products. Low moisture ensures higher shelf stability of dried product. The values obtained for moisture in Table 2 were minimal and may not have adverse effect on the quality attributes of the product (Kure et al., 1998). There was no significant difference in the ash content of the samples. It was observed that as the level of wheat flour substitution increased the ash content also increased. The ash content values were in the range of 1.85 – 3.21%. The ash content indicates a rough estimation of the mineral content of product (Adegunwa et al., 2014). There was also no significant difference in the crude fibre content of the chin chin. The values were in the range of 1.11 – 1.25%. Falola et al. (2014) reported similar values (0.77 – 2.15%) when they produced chin-chin from modified cocoyam starch.

Table 1. Blend formulation of chin-chin samples enriched with edible palm weevil (*Rhynchophorus phoenicis*)

Samples	**Maize flour**	***Rhynchophorus phoenicis paste***	**Wheat flour**
20M5R75W	20	5	75
15M5R80W	15	5	80
10M5R85W	10	5	85
5M5R90W	5	5	90
100M0R0W	100	0	0

Table 2. Nutrient composition of maize-wheat composite chin-chin enriched with *Rhynchophorus phoenicis*

SAMPLES PARAMETERS	**20M5R75W**	**15M5R80W**	**10M5R85W**	**5M5R90W**	**100M0R0W**	**LSD**
Moisture content	$5.34^{a}\pm0.16$	$4.97^{b}\pm0.13$	$4.38^{c}\pm0.02$	$4.35^{cd}\pm0.08$	$5.31^{a}\pm0.02$	0.18
Ash	$2.18^{a}\pm0.02$	$2.69^{a}\pm0.03$	$2.80^{a}\pm0.06$	$3.21^{a}\pm0.04$	$1.85^{a}\pm0.01$	-
Crude fibre	$1.15^{a}\pm0.01$	$1.13^{a}\pm0.01$	$1.11^{a}\pm0.01$	$1.10^{a}\pm0.02$	$1.25^{a}\pm0.03$	-
Fat	$9.93^{d}\pm1.05$	$10.28^{c}\pm0.31$	$11.39^{b}\pm0.08$	$15.82^{a}\pm0.06$	$6.97^{e}\pm0.17$	0.91
Protein content	$11.84^{d}\pm0.10$	$14.29^{c}\pm0.10$	$17.21^{b}\pm0.10$	$19.05^{a}\pm1.11$	$9.39^{e}\pm0.10$	0.93
Carbohydrate	$69.56^{b}\pm1.06$	$66.63^{c}\pm0.33$	$63.10^{d}\pm0.18$	$55.79^{c}\pm0.05$	$75.24^{a}\pm0.07$	0.91

**Means in the same row with the same superscript are not significantly different at P<0.05*
20M5R75W (20% maize flour : 5% Rhynchophorus phoenicis paste: 75% wheat flour)
15M5R80W (15% maize flour : 5% Rhynchophorus phoenicis paste: 80% wheat flour)
10M5R85W(10% maize flour : 5% Rhynchophorus phoenicis paste: 85% wheat flour)
5M5R90W (5% maize flour : 5% Rhynchophorus phoenicis paste: 90% wheat flour)
100M0R0W (100% maize flour : 0% Rhynchophorus phoenicis paste: 0% wheat flour)

There was significant difference (P<0.05) in the fat content of the samples. The samples had fat content values of 6.97 – 15.82%. The high fat content values especially the 15.82% recorded in sample 5M5R90W (5% maize flour: 5% *Rhynchophorus phoneicis* paste :90% wheat flour) could be due to the edible palm weevil added to the samples and the margarine used in the sample preparations. Opara et al. (2012) reported a high lipid content of 54.20% for larva of *R. phoenicis*. Kiin-Kabari and Ogbonda (2010) reported fat contents of 19.6 and 16.3% in *R. phoenicis* enriched fillers used for pies and sandwich production. Fasasi (2009) reported that low fat content in a dry product will help in increasing the shelf life of the sample by decreasing the chances of rancidity and also contribute to low energy value of the food product while high fat content product will have high energy value and promotes lipid oxidation. Edible insects contain good quality fatty acid especially long chain omega-3 fatty acids such as alpha-linoleic acid, eicosapentaenoic acid (Yang et al., 2006). The reason for insects containing long-chain PUFAs and different fatty acid compositions is linked with the diet and enzymatic activity in the insects (Mlcek et al., 2014). Lipids are necessary in food because they increase palatability and retain the flavor of food (Aiyesanmi & Oguntokun, 1996). They also play a structural and physiological role.

The protein content of the chin-chin samples ranged from 9.39 - 19.05%. The lowest mean protein content was recorded for Sample 100M0R0W 9.39%, while the highest mean protein content was recorded for Sample 5M5R90W (5% maize four: 5% *Rhynchophorus phoneicis* paste: 90% wheat flour) 19.05%. The high protein content in Sample 5M5R90W 19.05% maybe as a result of high wheat flour used in that sample; while the significant variation in the protein value of the samples could be attributed to the different proportions used in the formulation. The crude protein content of edible palm weevil has been reported to be very high, ranging from 28.42% (Banjo et al. 2006) to 71.63% (Braide & Nwaoguikpe, 2011). Idolo (2010) reported protein content of 9.96% in *R. phoenicis* on wet basis while he put that on dry basis at 25.16%. He also observed that the protein content of wheat buns enriched with larvae of *R. phoenicis* increased progressively in proportion to the percentage of larvae added. Kinyuru et al. (2009) in their study on the process development of wheat buns enriched with edible termites *(Marcrotermes subhylanus)* reported protein content of 15.63% in sample with 5% termite substitution with wheat flour compared to 10.60% protein in the wheat buns without termite paste addition. The larvae of *Rhychophorus phoenicis*have been reported to be a rich source of digestible proteins able to make up for the dietary imbalance as they form real sources of food for man and other animals (Fasoranti, 1997). Kiin-Kabari and Ogbonda (2013) reported that fillers enriched with *R. phoenics* paste for pies and sandwich had higher protein contents of 16.4 and 12.4% compared to the common meat pie and sandwich fillers which had protein contents of 11.2 and 9.9% respectively. Insects, a traditional food in many parts of the world, are highly nutritious and especially rich in proteins and thus represent a potential food and protein source. The high protein content is an indication that the insects can be of value in man and animal ration and can eventually replace higher animal protein usually absent in the diet of rural dwellers in developing countries (Banjo et al., 2006). Ekpo and Onigbinde (2005) have reported high level of leucine, lysine and threonine in the insect larva. Lysine and threonine are limiting amino acids in wheat, rice, cassava and maize based diets prevalent in the developing world (Ozimek et al., 1985). The inclusion of the larva into these staples would enhance the nutritional quality in these diets.

There were significant differences in the carbohydrate content of the chin-chin samples enriched with edible palm weevil. The values were in the range of 55.79 – 75.24%. Similar values have been reported for chin-chin produced from composite millet-wheat (Adegunwa et al., 2014) and in the use of modified cocoyam starch in composite for chin-chin production (Falola et al., 2014). Ekop et al. (2010) reported carbohydrate content of 22.70 dry weight for *R. phoenicis* (palm weevil).

There were no significant differences in the calcium and potassium contents of the chin-chin enriched with edible palm weevil paste (Table 3). But there were significance differences in the phosphorus, magnesium and sodium compositions of the samples. The calcium values were in the range of 25.39 – 30.91mg/100g while those of magnesium were in the range of 5.60 – 13.60mg/100g. Minerals are known to play important metabolic and physiologic roles in the living system. Magnesium helps maintain muscle and nerve functions, keeps heart rhythm steady and supports a healthy immune system and regulates blood sugar levels (Saris et al., 2000). It has been reported that edible palm weevil contains various minerals like: Calcium 39.58mg/100g; Phosphorus 126.4mg/100g; Magnesium 7.54mg/100g; Iron 12.24mg/100g (Banjo et al., 2006; Ekpo et al., 2006). Processing could also have affected the mineral values of the snack product.

Table 3. Mineral composition of maize-wheat chin-chin enriched with palm weevil

SAMPLES PARAMETERS (mg/100g)	**20M5R75W**	**15M5R80W**	**10M5R85W**	**5M5R90W**	**100M0R0W**	**LSD**
Phosphorus	332.96^{b}±0.16	331.17^{c}±0.49	323.85^{d}±1.03	317.55^{e}±0.80	376.75^{a}±0.33	1.19
Magnesium	8.80^{b} ±1.39	8.8^{b} ±1.39	11.20^{ab}±1.38	13.60^{a}±1.38	5.60^{a}±1.39	2.52
Calcium	29.39^{a}±2.31	29.39^{a}±2.31	26.72±2.32	25.39±2.32	30.91±2.48	-
Potassium	$97.73\ ^{a}$±0.61	76.8^{a}±0.40	75.2±0.80	74.80±40	116.27±0.12	-
Sodium	63.1^{b} ±0.95	63.63^{b} ±0.42	65.07^{b}±1.10	70.3^{b}±1.67	59.0^{c}±1.04	2.02

**Means in the same row with the same superscript are not significantly different at P<0.05*
20M5R75W (20% maize flour : 5% Rhynchophorus phoenicis paste: 75% wheat flour)
15M5R80W (15% maize flour : 5% Rhynchophorus phoenicis paste: 80% wheat flour)
10M5R85W(10% maize flour : 5% Rhynchophorus phoenicis paste: 85% wheat flour)
5M5R90W (5% maize flour : 5% Rhynchophorus phoenicis paste: 90% wheat flour)
100M0R0W (100% maize flour : 0% Rhynchophorus phoenicis paste: 0% wheat flour)

3.2 Functional Properties of Maize – Wheat Composite Flour

Table 4 presents the result of the functional properties of maize-wheat composite flour. There was significant difference in the wettability values of the maize –wheat composite flour blends. The values were in the range of 46.67 – 200. The values were decreasing as the rate of addition of maize flour reduced. The sample 100M0R0W (100% maize flour) had the highest value of 200 secs. Some of the samples high wettability values could be due to its low protein content. It has been reported that the lower the level of denatured protein present, the slower it takes to get wetted or imbibe water (Oti & Akobundu, 2008).There was no significant difference in the swelling index values of the samples. The values were in the range of 1.29 – 1.68. The swelling power of flour granule is an indication of the extent of associative forces within the granules (Moorthy & Ramanujan, 1986). Swelling capacity can also be related to the water absorption index of the starch-based flour during heating. There was no significant difference in the oil absorption capacity of the samples. The values were in the range of 1.04 – 1.45. The reason why the oil absorption capacity of Sample 100M0R0W (100% maize flour) is 1.45 and therefore greater than the ones of the other samples might be that the increase in oil absorption is associated with heat dissociation of the protein and denaturation which is expected to unmask the nonpolar residue from the interior of the protein molecule (Kinsella, 1976).

Table 4. Functional properties of maize- wheat composite flour blends

SAMPLES PARAMETERS	20M5R75W	15M5R80W	10M5R85W	5M5R90W	100M0R0W	LSD
Swelling index(v/v)	1.41±0.02	1.37±0.04	1.32±0.07	1.29±0.02	1.68±0.04	-
Oil absorption capacity(g/ml)	1.39±0.06	1.26±0.05	1.10±0.05	1.04±0.10	1.45±0.05	-
Bulk density(g/ml)	0.95±0.01	0.96±0.01	0.96±0.01	0.97±0.01	0.98±0.01	-
Wettability(secs)	181.67^{b}±6.51	90.67^{c}±7.23	72.67 ^{d}±3.51	46.67^{e}±1.15	200^{a}±7.21	10.31

**Means in the same row with the same superscript are not significantly different at P<0.05*
20M5R75W (20% maize flour : 5% Rhynchophorus phoenicis paste: 75% wheat flour)
15M5R80W (15% maize flour : 5% Rhynchophorus phoenicis paste: 80% wheat flour)
10M5R85W(10% maize flour : 5% Rhynchophorus phoenicis paste: 85% wheat flour)
5M5R90W (5% maize flour : 5% Rhynchophorus phoenicis paste: 90% wheat flour)
100M0R0W (100% maize flour : 0% Rhynchophorus phoenicis paste: 0% wheat flour)

The bulk density of the flour samples ranged from 0.95 in Sample 20M5R75W (20% maize flour : 5% *Rhynchophorus phoneicis* paste : 75% wheat flour) to 0.98 in Sample 100M0R0W (100% maize flour). Adengunwa et al. (2014) reported bulk density of 0.76 – 0.83 for millet-wheat composite flour blends while Etudaiye et al. (2015) reported bulk density values of 0.68 – 0.82 for sweet potato –wheat composite flour blends and 0.74 – 0.78 for sweet potato starch – wheat composite blends. The bulk density is generally affected by particle size and the density of flour or flour blend and it is very important in determining the packaging requirement, raw materials handling and application in wet processing in food industry (Ajanaku et al., 2012). It has been reported that bulk density of foods increases with increase in starch content (Bhattacharya & Prakash, 1994). Ojinnaka et al. (2009) in their work on the use of modified cocoyam *(Xanthosoma sagittifolium)* starch in cookie production reported packed bulk density of 0.67 and 0.62 for starch from native cultivars *Ede Uhie* and *Ede ocha* as well as loose bulk density of 0.49 and 0.47 for *Ede uhie* and *Ede ocha* respectively. High bulk density of protein material is also important in relation to its packaging (Onimawo et al., 1998). High bulk density of the flours and starches indicate that they would serve as good food thickners in food products (Adebowale et al., 2005) while the low bulk density of the flours and starch samples will be suitable for the formulation of high nutrient density weaning food (Mepba et al., 2007b).

3.3 Sensory Evaluation

Table 5 shows the results of the sensory evaluation of maize- wheat chin-chin enriched with palm weevil. There were no significant differences (P≤0.05) in all the organoleptic properties (appearance, flavor, taste, texture, general acceptability) measured. The values for appearance and texture attributes ranged from 7.39 – 7.76 and 6.83 – 7.50 respectively. The appearance was best for sample 20M5R75W (20% maize flour :5% *Rhynchophorus phoneicis* paste : 75% wheat flour) with value of 7.76. It was observed that the value in appearance decreased as the level of maize substitution reduced. The samples were well accepted by the members of the panel though sample 20M5R75W (20% maize flour :5% *Rhynchophorus phoneicis* paste : 75% wheat flour) and 15M5R80W (15% maize flour :5% *Rhynchophorus phoneicis* paste : 80% wheat flour) were most preferred. Idolo (2010) reported that wheat buns produced at 5%- 15% level of substitution with *R.phoenicis* were found to be acceptable but observed that with 5% substitution was most acceptable.

Table 5. Mean sensory scores of maize-wheat chinchin enriched with *Rhynchophorus phoenicis*

SAMPLES PARAMETERS	20M5R75W	15M5R80W	10M5R85W	5M5R90W	100M0R0W	LSD
Appearance	7.76±1.24	7.72±1.18	7.50±1.34	7.5±1.42	7.39±1.54	-
Flavour / Aroma	7.28±1.18	6.83±1.47	7.39±1.33	6.56±1.46	7.28±1.71	-
Taste	6.89±1.53	7.56±1.50	6.89±1.71	7.44±1.34	7.56±1.34	-
Texture	7.39±2.00	7.33±1.28	6.83±1.50	7.22±1.52	7.50±1.54	-
General Acceptability	7.78±1.17	7.72±1.07	7.39±1.02	7.39±1.38	7.56±1.46	-

**Means in the same row with the same superscript are not significantly different at P<0.05*
20M5R75W (20% maize flour : 5% Rhynchophorus phoenicis paste: 75% wheat flour)
15M5R80W (15% maize flour : 5% Rhynchophorus phoenicis paste: 80% wheat flour)
10M5R85W(10% maize flour : 5% Rhynchophorus phoenicis paste: 85% wheat flour)
5M5R90W (5% maize flour : 5% Rhynchophorus phoenicis paste: 90% wheat flour)
100M0R0W (100% maize flour : 0% Rhynchophorus phoenicis paste: 0% wheat flour)

4. Conclusion

The process developed for production of wheat-maize chin-chin enriched with edible palm weevil *(Rhynchophorous phoenicis)* paste at 5% level of substitution could easily be adopted due to its nutritional quality and sensory attributes. Results from the study showed that the chin-chin samples were nutritionally acceptable by the members of the panel. Edible insects can however be incorporated into different food formulations that will be palatable as well as nutritious to consumers especially those that find it difficult to consume edible insects in their forms. More studies can also be carried out on how best to incorporate these edible insects into different food products to create varieties so that their use as sustainable diets will be encouraged since they are nutritionally, economically and ecologically important.

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