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Effect of groundnut cake flours supplementation on proximate composition, functional and sensory properties of pearl millet flour based complementary food

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ABSTRACT— In this study, effect of groundnut cake flours supplementation on proximate composition, functional and sensory properties of pearl millet flour based complementary food was evaluated. Ground nut cake obtained from different oil extraction methods (hot water and hexane) and pearl millet were processed into flours. The ground cake flours were sieved and mixed with the millet flour in the ratio of 90:10, 80:20, 70:30, 60:40 and 50:50, respectively The proximate composition, functional properties (swelling power, bulk density, wettability, dispersability) and acceptability were determined. Data obtained were statistically analyzed using analysis of variance and where differences exited, means were separated using Duncan Multiple Range Test. Result indicated that, moisture content of the complementary food decreased from 12.16 to 6.21%) with increase in protein (9.37 to 19.14%), fat (3.18 to 9.02%), crude fibre (2.19 to 2.70%), ash (1.00 to 2.35%) and carbohydrate (62.85 to 74.28%) contents, while the Water absorption capacity ranged from 3.15 to 4.75%, wettability from 68.00 to 126.5 %, bulk density from 0.08 to 0.77 g/ml and dispersability from 47.5 to 60.00% and decreased with increase in rate of substitution. The complementary foods from formulations of MGhx 60:40 (60% Pearl millet flour and 40% ground nut cake flour from hexane oil extracted) and MGhx50:50 (50% Pearl millet flour and 50% ground nut cake flour of hexane oil extracted) were the best formulations in terms of consumer acceptability. It contains relatively low amount of moisture and high amount of protein and crude fiber compared with those supplemented with groundnut cake flour of hot water oil extracted. The addition of groundnut cake flour to pearl millet enhanced the nutritional value of the complementary food.

KEYWORDS: Complementary food, hot water extraction, hexane extraction, functional properties, sensory properties, proximate composition

1. INTRODUCTION

Complementary foods are nutrient containing foods or liquids other than breast milk given to young children during the period of complementary feeding (6-24 months) (WHO, 2001). The growth of an infant in the first two years is very rapid and breast feeding alone will not meet the child nutritional requirements. The ability of the breast milk to meet the requirements for macronutrient and micronutrient becomes limited with the increasing age of infants (Agostoni et al., 2008; Kamchan et al, 2004) However, the capacity of a complementary diet to meet the protein-energy requirement of infants depends on its nutritional quality (Kamchan et al., 2004). It is well known that high cost of fortified complementary foods in many parts of developing countries is beyond the reach of most families (Amankwah et.al. 2009; Muhimbula et al. 2011),

hence many families depend on inadequately processed and low quality traditional complementary foods for baby feeding. That is why protein-energy malnutrition is a major infant problem in the developing countries (WHO, 2001). Therefore, poor quality complementary food is a major cause for the high incidence of child malnutrition, morbidity, and mortality in many developing countries (Krebs and Westcott 2002). To reduce these problems, low cost indigenous and unexploited legumes which can be processed and when properly complemented with commonly available carbohydrate sources will provide relatively affordable complementary foods that will help to alleviate protein-energy malnutrition and improve infants nutrition (Amankwah etal., 2009; Mbataet al., 2009; Muhimbula et al., 2011).In developing countries millet and groundnut cake flour if properly formulated complement breast milk as complementary foods, because a well formulated and high nutrient and microbiologically safe food is necessary if complementary foods or foods other than breast milk are to be given to infants. During the processing of groundnut cake flour, hot water was used for the extraction of oil before grinding to obtained flour, while at industrial level, hexane was used for the same purpose. These two methods have different impact on the quality of groundnut cake flour. There was a need to also evaluate the industrial method of using hexane extraction on the outcome of the complementary foods as well as 80:20 and 90:10 used in the other formulations. This is especially necessary for bulk or mass production. Therefore, the objectives were to produce flour from groundnut cake produced through hot water and hexane extraction, and formulate different blend with millet as complementary foods using pearl millet and groundnut cake flour (from Hot water and hexane fat extraction) in the ratios of 90:10, 80:20, 70:30, 60:40, and 50:50. and to determine the proximate composition, functional properties and sensory qualities of the complementary foods.

2. MATERIALS AND METHOD

2.1 Source of Materials

Pearl millet cultivars and groundnut were obtained from the Lake Chad Research Institute, Maiduguri. Chemicals and reagents used were of analytical grade and purchased from recognized distributors were not available in the laboratory of Department of Food Science and Technology, Faculty of Agriculture and Agricultural Technology, Kano University of Science and Technology, Wudil, Kano, Nigeria where most of the analyses took place.

2.2 Preparations of pearl millet cultivars flours

The pearl millet (SOSAT C-88) was processed into pearl millet flour. The millet was soaked in tap water for about ten minutes to remove the green colour.

2.3 Preparation of groundnut cake flour

Groundnut paste which was later converted to groundnut cake flour (kulli-kulli). Due to the possibility of industrial production of the groundnut cake flour, the solvent extracted groundnut cake flour. The groundnut was made into groundnut cake (locally referred to as Kuli-kuli) before being ground into groundnut cake flour as indicated in figure 2. In case of the solvent extracted groundnut flour, there was no need to grind or mill the groundnut paste after hexane was added. This is because the meal left was almost dry and had to be put in the oven for the flour to be obtained (fig 3).

2.4 Experimental Design

A 5×2 factorial design was adopted to give a total of 10 experimental runs plus one control made of 100% Pearl millet (M)

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2.5 Formulating the Complementary Food

The processed pearl millet flour is mixed with either traditionally processed or solvent extracted. The groundnut cake flour in the ratio of 90:10, 80:20, 70:30, 60:40 and 50:50 (Table 1)

Table 1: Complementary food formulations of flour blends from pearl millet and ground nut cake of hot water and hexane oil extractions

Formulations	Millet	Solvent Extracted	Hot Water Extracted
M	100	-	-
MGhw	90	-	10
MGhx	90	10	-
MGhw	80	-	20
MGhx	80	20	-
MGhw	70	-	30
MGhx	70	30	-
MGhw	60	-	40
MGhx	60	40	-
MGhw	50	-	50
MGhx	50	50	-

MGhw; Groundnut Hot Water Extraction, MGhx; Groundnut Hexane Extraction, M; Pearl millet

2.6 Proximate Analysis of the Complementary Food Blends

Proximate analysis of the formulated complementary foods in-terms of moisture, crude fat, crude protein, ash, crude fibre and carbohydrate were determined using the AOAC (1984)

2.7 Moisture content

Moisture was determined by direct oven method (AOAC, 1984). About 5g each of the ground sample was weighed with weighing balance and put into petri dishes of known weights. It was then oven dried at 105°c for 3hrs; the dried samples were cooled in a desiccator for an hour and weighed. The moisture content was calculated as follows;

% moisture content (wb)=(W3-W2)100/W1 …… 1

Where W1 = weight of sample, W2 = weight of petri-dish plus dried sample and W3 = weight of petri-dish plus sample before oven drying.

2.8 Crude Fat Determination (Soxhlet Method)

Crude fat was determined by gravimetric estimate of fat from a dry powdered solid after a continuous extraction with light organic solvent e.g. petroleum ether. This was done by the soxhlet extraction method (AOAC, 1984). Two grams (2g) of the ground sample was weighed and transferred into a fat extraction thimble and stuffs with cotton wool to prevent particles from escaping during extraction. The soxhlet apparatus was properly assembled and extraction was allowed to continue for 3 hr at boiling temperature of petroleum either, after which the petroleum ether was removed from the unit or dried in an oven at 100°c for 1 hour. It was cooled in desicator for about 30minutes and weighed. The percentage fat was calculated as follows;

% Crude fat=(W3-W2)100/W1 …… 2

Where w1 = weight of sample, w2 = weight of empty flask and w3 = weight of flask plus fat

2.9 Crude protein determination

About one gram (1g) of the ground samples was weighed and introduced into the digestion tube. One kjeldal digestion table was added to the sample, followed by twenty milliliters (20ml) of concentrated sulphuric acid. The digestion tube was mounted on a digestion block where they were heated at a temperature of 350°c for about 5hours until a clear digest is obtained. The digested sample were allowed to cool and made up to 100ml with distilled water and poured into collection bottles. Five milliliter (5ml) of the digested sample was pipetted into the distillated unit. 20ml of 40% sodium hydroxide solution was added and the system washed down with distilled water meanwhile 5ml of 4% boric acid was pipetted into a conical flask and three to four drops of borocresol green and methyl red mixed indicator was added. This solution was placed at the receiving end of the distillation units. Steam was generated from the boiling water contained in a flask heated with the aid of kerosene stove. This distillate was collected as much as 50 to 75 ml. All the nitrogen in the sample, presumably held as ammonia in the boric acid indicator solution was titrated with 0.01N HCL to give a light pink color end point. Percentage crude protein was calculated by multiplying the percentage of nitrogen with 6.25 a nitrogen to protein conversation factor.

$$\% \text{ crude protein} = \frac{A \times C}{B \times D} \; X \; \frac{100}{1000} \; X \; \frac{1}{E} \times \frac{6.25}{1} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 3$$

where A = volume of acid, B = volume of the sample (digest) taken for distillation, C = volume of sample made after digestion, D = weight of the sample used for digestion and E = acid value

2.10 Ash content determination

Ash Content was determined by weighing two grams (2g) of ground sample transferred into a muffle furnace preheated to 5500C in a crucible of known weight and was allowed to incinerate for 5 hrs known as ash. The percentage ash was calculated as follows:

$$\% \text{ ash} = \frac{W3 - W2}{W1} \; X \; 100 \quad \ldots\ldots\ldots\ldots\ldots\ldots 4$$

where w_1 = weight of sample, w_2 = weight of empty crucible, w_3 = weight of crucible plus ash

2.11 Crude fibre

Two grammes of each sample was defatted. The defatted samples were boiled individually in a 500 ml flask containing 200 ml 1.25% H_2SO_4 solution under rflux for 30 minutes. After 30 minutes elapsed, the samples were washed with several portions of hot boiling water with a twofold muslin cloth to trap the residual

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particles. The residual particles were transferred to the flasks and 200 ml of 1.25% NaOH solution was added into each flask. The samples were boiled for 30 minutes and washed with hot water. They wrere transferred into a weighed and died in oven at 105℃ for 3 hours. The dried samples were then transferred into a dessicator and cooled for 20 minutes before weighing. After weighing the crucible dishes containing the samples were transferred into a muffle furnace set at 550℃for 2 hours until ashed. After ashing, the samples were cooled in a desiccator and weighed. The crude fibre content for each sample was calculated as follows:

$$\%\ \boldsymbol{Crude\ fibre} = \boldsymbol{(W2 - W3)100/W1} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ \mathbf{5}$$

Where W2 = Weight of crucible + sample after washing and drying in the oven, W3 = Weight of crucible + Sample as ash and W1 = Weight of the original sample

2.12 Total carbohydrate

Total carbohydrate was obtained by difference. The sum total of moisture, ash protein and tab in percentage substrate from one hundred gives the carbohydrate content of the sample.

$$\%\ \boldsymbol{Carbohydrate} = \mathbf{100} - \boldsymbol{Percentage}(\boldsymbol{Moisture + Crude\ Fat + Crude\ Protein + Ash + Crude\ Fibe})$$

$$\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ \mathbf{6}$$

Energy

Energy was evaluated using an Atwater formula as follows;

$$\boldsymbol{E = P\ x\ 4 + c\ x\ 4 + F\ x\ 9}\ \left(\frac{\boldsymbol{Kcal}}{\mathbf{100}}\boldsymbol{g}\right) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ \mathbf{7}$$

Where, E energy value, P protein content, C carbohydrate content and F fat content.

2.13 Functional Properties Determination

2.13.1 Bulk density determination

The method described by Onwuka (2005) was adopted. Ten (10ml) capacity graduated measuring cylinder was pre-weighted. The cylinder was filled gently with the sample. The cylinder was tapped gently several times on the laboratory bench until no further reduction of the sample level after filling to the 10ml mark. It was weighed, calculated as follows;

$$\textbf{Bulk Density}\ (\mathbf{g/ml}) = \frac{\boldsymbol{weight\ of\ sample\ (g)}}{\boldsymbol{volume\ of\ samples}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ \mathbf{8}$$

2.14 Determination of swelling power

This was determined by the method described by Leach et al. (1959) with modification for small samples. One gram (1g) of the samples was mixed with 10ml distilled water in a centrifuge tube and heated at 80OCfor 30mins with continuous shaking the tube during the heating period. After heating the suspension will be centrifuge at 1000 ×g for 15munites. The supernatant was decanted and the weight of the paste will be taken. The swelling power was calculated

$$\textbf{Swelling power} = \frac{\boldsymbol{weight\ of\ paste\ (g)}}{\boldsymbol{weight\ of\ dry\ flour\ (g)}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ \mathbf{9}$$

2.15 Determination of wettability of sample

The method described by Onwuka (2005) was adopted.One gram (1g) of the sample was added into a 25ml graduated cylinder, with a diameter of 1cm. invertedand clamp at a height of 10cm from the surface of a 600ml beaker containing 500ml of distilled water. Then removed and the time required for the sample to become completely wet was recorded as its wet ability.

2.16 Measurement of dispersability

The method described by Balami et al, (2004) was adopted. Fifty milliliter (50 ml) of distilled water was added to 3g of the sample and the mixture stirred for a minute at room temperature. The mixtures were filtered through dried cheese cloth of known weight then rinse in a beaker with 50 ml of distilled water and pour through the cheese cloth. The sieve and residue was dried in a hot air oven at 1000C for 10minutes. The dispersability was expressed as the percentage of the solids dissolved.

2.17 Determination of Water Absorption Capacity

Water absorption capacity was determined using the method described by Onwuka (2005). One gram (1g) of the sample was weighed in a graduated centrifuge tube. It was mixed thoroughly with 10 ml distilled water using a continous whirl mixer for 30seconds. The sample was allowed to stand for 30minutes at room temperature and then centrifuge at 5000 ×g for 30minutes. The volume of free water (supernatant) was read directly from the graduated centrifuged tube.

$$\boldsymbol{WAC}\ (\%) = \frac{\{(\boldsymbol{Amount\ of\ water\ added - Free\ water})\ \boldsymbol{x\ density\ of\ water\ x\ 100}\}}{\boldsymbol{Weight\ of\ sample}} \quad \ldots\ldots\ldots\ldots\ldots\ \mathbf{10}$$

2.18 Determination of viscosity

Viscosity was determined using Haake Roto Visco RVI equipped with concentric cylinders and viscosity measurement made at 300C. The apparent viscosity of the feed was measured over a range of shear rates (s-1) and the relative viscosity of the solution at a given shear rate was calculated as shown below. (Attia et al.,1979).

$$\textbf{Relative viscosity } (\eta r) = \frac{\eta g}{\eta s} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ \mathbf{11}$$

Where ŋg = apparent viscosity of solution, Ŋs = apparent viscosity of solvent

2.19 Sensory Evaluation

The sensory evaluation was conducted by a team of 15 panelists drawn from the Postnatal unit of the Aminu Kano Teaching Hospital. The samples were rated for taste, colour, texture and overall acceptability based on a nine-point Hedonic scale with 9 representing like extremely and 1 representing dislike extremely as described by Amerie et al., (1965).

2.20 Statistical analysis

Data generated was subjected to analysis of variance (Ihekoronye and Ngoddy 1985), and means and standard deviations were obtained with instant statistical software.

3. RESULTS AND DISCUSSION

3.1 Proximate Composition of the Complementary Foods

Table 2 shows the proximate compositions of the complementary foods. Moisture content ranged from 6.21 to 12.16%, the Protein from 9.37 to 19.14%, fat content from 3.18 to 9.02%, crude fibre ranged from 2.19 to 2.70%, ash from 1.00 to 2.35%, carbohydrate from 62.85 to 74.28% and the energy value ranged from 363.22 to 409.14Kcal. This showed that there was a significant difference ($p<0.05$) within the formulations. Protein is an essential component of diet needed for survival of animals and human beings, its basic function in nutrition is to supply adequate amount of required amino acids. The RDA for infants between 0-6 months is 9.1g/day of protein while RDA for older infants 7-12 months is 11g/day of protein (Food and Nutrition Board, 2005). The protein content of the formulated complementary blends ranged from 9.37 to 19.14%. This is line with the Indian Council of Medical Research (1981) recommendation. That the optimal protein requirement for weaning infants be 7.1% of the total mixed diet. All the formulations also seem to be able provide optimum protein levels as in RDA for protein of 10 to 12% recommended by WHO (1985). The protein content of the complementary foods with 50% legumes substitution of millet had more than 15% protein as compared to a commercially available complementary food. A higher amount of fat was attributed to sample Ghw 50/50 (Groundnut hot water extraction) of millet flour mixed with groundnut cake flour that was extracted with hot water.This is in line with FAO/WHO Food Standard Programme codex Alimentarius Commission (2004) suggests that vegetables oils should be included in the food meant for infant and children (Mariam, S., (2005). The carbohydrate content (by difference) of the samples principally differs from one another. Higher amount of fat content was attributed to MGhw 50/50 (Groundnut hot water extraction), which shows that there was a significant difference ($p<0.05$) between the samples. Formulation 50/50 MGhw and MGhx had the best result. The moisture content of foods gives an indication of its freshness and shelf life, and high moisture content subjects food items to increased microbial spoilage and short shelf life which can lead to its deterioration (Adepoju and Onasanya 2008).

3.2 Functional Properties of the Complementary Foods

Functional properties of the blends are shown in Table 3. The swelling power ranged from 4.87 to 7.13%, Dispersability 47.50 to 60.00%, Water absorption capacity ranged from 3.15 to 4.75%, Viscosity from 84.63 to 187.56m2/s, Bulk density from 0.53 to 0.77to 0.08 g/m3, Wettabilty ranged from 126.75 to 68.00%. Formulations MGhx and MGhw showed a significant difference ($p>0.05$) in swelling power. Suresh (2013) reported that swelling capacity of flours depend on the variety and particle size of the flour. According to WHO (2003), appropriate complementary diet is one which produced a gruel or porridge that is neither too thick (when it is too thick, it will be difficult for the infant to digest because of limited gastric capacity). The dispersibility of a mix in water indicates its reconstitution. The higher the dispersibility the better and more preferred.

Table 2 Effect of ground nut cake flours supplementation on the Proximate Composition of the Pearl millet based Complementary Food formulations

Formulation		Moisture(%)	Protein(%)	Fats(%)	Fibre(%)	Ash(%)	Carbohydrate (%)	Energy (Kcal)
M	100	12.16±0.08^{a}	9.37±0.63^{k}	3.18±0.02^{k}	2.19±0.03^{i}	1.00±0.10^{i}	74.28±0.43^{a}	363.22±0.12
MGhw	90:10	11.86±0.10^{b}	11.88±0.00^{i}	3.93±0.04^{g}	2.24±0.00^{h}	1.13±0.00^{j}	71.20±0.14^{c}	367.64±0.11
MGhx	90:10	11.47±0.07^{c}	11.41±0.47^{j}	3.36±0.03^{j}	2.54±0.10^{f}	1.39±0.01^{i}	72.37±0.44^{b}	365.36±0.05
MGhw	80:20	11.01±0.11^{d}	14.94±0.69^{g}	5.51±0.07^{d}	2.47±0.01^{d}	1.43±0.01^{h}	67.47±0.64^{h}	379.23±0.01

MGhx	80:20	10.87±0.03^{e}	13.69±0.56^{h}	3.45±0.51^{i}	2.55±0.05^{e}	1.55±0.00^{g}	70.45±0.51^{e}	367.61±0.01
MGhw	70:30	9.06±0.02^{f}	15.94±0.03^{e}	6.24±0.16^{c}	2.49±0.01^{g}	1.72±0.04^{e}	67.01±0.43^{i}	387.96±0.01
MGhx	70:30	8.68±0.03^{g}	15.63±0.00^{f}	3.59±0.02^{h}	2.58±0.04^{d}	1.70±0.00^{f}	70.40±0.01^{f}	376.43±2.12
MGhw	60:40	7.67±0.03^{h}	16.87±0.62^{c}	7.65±0.03 ^{b}	2.62±0.04^{c}	1.79±0.02^{d}	66.01±0.62^{j}	400.37±0.31
MGhx	60:40	7.02±0.02^{i}	16.25±0.00^{d}	4.06±0.10^{f}	2.64±0.04^{b}	1.98±0.00^{c}	70.69±0.13^{d}	384.3±0.02
MGhw	50:50	6.89±0.09^{j}	19.14±0.55^{a}	9.02±0.06^{a}	2.70±0.00^{a}	2.12±0.10^{b}	62.85±0.30^{k}	409.14±0.13
MGhx	50:50	6.21±0.20^{k}	18.04±0.55^{b}	4.46±0.02^{e}	2.70±0.22^{a}	2.35±0.10 ^{a}	68.98±0..23^{g}	388.22±0.22

Values are mean of three replicates ± Standard Deviation, number in the same column followed by the same letter are not significantly different at p>0.05. Key; M = Pearl millet, MGhw = Groundnut hot water extraction, MGhx = Groundnut hexane extraction. Higher water absorption capacity is attributed to high amount of starch and fiber in the complementary food. Formulation MGhx had the highest water absorption capacity with a value of 4.75%. According to Singh (2001), water absorption capacity is the ability of a product to associate with water under a condition where water is limited. The significance of a lower water absorption capacity in complementary diet is due to an increased in fat content in the food. The binding capacity which is desirable to making thick gruels with high caloric density per unit volume. This is in agreement with the findings of Elkahalita et al. (2005). The viscous foods have desirable characteristics in weaning foods known to facilitate chewing and swallowing (Waterlow and Payne, 1975). In addition, weaning foods must have an easy to swallow, since liquid consistency 1000 to 3000 Centipoise (Nout, 1990). The food which is of less density required limited space or area which was attributed to the control and formulations MGhw and MGhx when compared with all the sample tested for the analysis respectively.

3.3 Sensory Quality of Complementary Food

The sensory attributes of the complementary formulae produced are shown in Table 4. The aroma ranged from 5.30 to 8.85, colour from 5.50 to 7.00, and taste from 5.08 to 7.50, Texture from 5.07 to 6.60 and the overall acceptability ranged from 5.80 to 7.00. From the results it showed that there was a significant difference (p<0.05) in aroma. In terms of colour no significant different between formulations Mhx 50:50 and Mhw 50:50. In terms of taste and texture significant difference (p<0.05) existed within the formulations. The mean comparison scores of different attributes like colour, texture, aroma and overall acceptability were significant. It was found that based on the overall acceptability that formulations Mhx 60:40, MLEG 60:40 and Mhw 50:50 were overall accepted followed by Mhx 70:30 and Mhw 50: 50.all samples were accepted. This also showed that both the two method of extraction hot water and hexane shows a significant difference across the formulations based on the sensory attributes such as colour, aroma, taste, texture and overall acceptability.

TABLE 3. Effect of ground nut cake flours supplementation on the Functional Properties of Pearl millet based Complementary Food formulations

Formulation		Swelling power (%)	Dispersibility (%)	WAC (%)	Viscosity (m^2/s)	Bulk density (g/m^3)	Wettability (%)
M	100	7.13±0.00 ^{a}	60.00±0.00 ^{a}	4.75±0.50^{a}	187.56±0.69 ^{a}	0.08±0.00^{j}	68.00±2.00^{j}

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MGhw	90:10	6.41±0.01^{c}	58.00±0.00^{c}	4.45±0.50^{b}	169.12±0.91^{c}	0.77±0.00^{a}	76.50±0.50^{i}
MGhx	90:10	6.54±0.01^{b}	59.00±0.00^{b}	4.30±0.10^{c}	171.23±0.71^{b}	0.76±0.00^{b}	81.50±0.50^{h}
MGhw	80:20	6.02±0.07^{e}	57.70±0.50^{d}	4.00±0.00^{d}	153.61±0.62^{e}	0.75±0.00^{c}	89.00±1.00^{g}
MGhx	80:20	6.16±0.12^{d}	58.00±0.00^{c}	3.85±0.50^{e}	157.91±0.80^{d}	0.74±0.00^{d}	89.50±0.50^{g}
MGhw	70:30	5.84±0.12^{f}	55.50±0.50^{f}	3.80±0.00^{f}	130.89±1.78^{g}	0.73±0.00^{e}	95.50±0.50^{f}
MGhx	70:30	6.05±0.01^{e}	56.00±0.00^{e}	3.65±0.05^{g}	139.20±1.04^{f}	0.72±0.00^{f}	102.00±1.00^{e}
MGhw	60:40	5.31±0.06^{i}	52.50±0.50^{h}	3.55±0.05^{h}	109.59±1.07^{i}	0.71±0.00^{g}	106.00±1.00^{d}
MGhx	60:40	5.70±0.01^{g}	53.00±0.00^{g}	3.40±0.00^{i}	116.67±1.77^{h}	0.71±0.00^{g}	112.00±1.00^{c}
MGhw	50:50	4.87±0.04^{j}	47.50±0.50^{j}	3.30±0.00^{j}	84.63±1.64^{k}	0.69±0.00^{h}	120.00±1.00^{b}
MGhx	50:50	5.60±0.00^{h}	50.00±0.00^{i}	3.15±0.50^{k}	95.65±2.17^{j}	0.68±0.00^{i}	126.50±1.50^{a}

Values are mean of three replicates ± Standard Deviation, number in the same column followed by the same letter are not significantly different at p>0.05. Key; M = Millet, MGhw = Groundnut hot water extraction, MGhx = Groundnut hexane extraction.

Table 4. Effect of ground nut cake flours supplementation on the sensory quality of Pearl millet based Complementary Food formulations

Formulations		Aroma	Color	Taste	Texture	Acceptability	Acceptability Rate (%)
M	100	5.56±1.02^{d}	5.50±1.00^{g}	5.50±1.00^{d}	5.30±1.60^{f}	5.50±1.00^{g}	61.1
MGhw	90:10	5.45±1.61^{e}	6.90±1.03^{b}	5.30±1.42^{e}	5.45±0.90^{e}	6.00±1.00^{e}	66.6
MGhx	90:10	6.15±1.61^{b}	5.56±1,61^{g}	5.15±1.12^{f}	5.30±1.23^{f}	6.10±1.01^{es}	67.0
MGhw	80:20	5.80±1.32^{c}	5.65±1.24^{f}	5.55±1.54^{d}	5.35+1.62^{f}	6.30+1.12^{d}	70.0
MGhx	80:20	5.60±1.50^{d}	5.90±1.52^{e}	5.09±1.42^{g}	5.40+1.23^{e}	5.80+1.32^{f}	64.4
MGhw	70:30	5.30±1.20^{g}	5.50±1.24^{g}	5.08±1.57^{g}	5.07±1.49^{g}	6.30±1.12^{d}	70.0
MGhx	70:30	5.30±0.94^{g}	6.15±1.70^{d}	5.09±0.95^{g}	6.00±1.50^{c}	6.50±1.24^{c}	72.2
MGhw	60:40	8.85±1.31^{a}	6.20±1.46^{c}	6.35±1.57^{b}	6.60±1.68^{a}	6.95±1.08^{b}	77.2
MGhx	60:40	5.35±1.57^{f}	6.20±1.46^{c}	7.50±1.32^{a}	6.20±1.42^{b}	6.95±0.88^{b}	77.2
MGhw	50:50	5.35±1.10^{f}	7.00±1.05^{a}	6.00±0.94^{c}	5.80±0.80^{d}	7.00±1.07^{a}	77.7
MGhx	50:50	6.00±1.79^{b}	7.00±1.43^{a}	7.50±1.39^{a}	6.30±1.61^{ab}	6.45±1.24^{b}	71.6

Values are mean of three replicates ± Standard Deviation, number in the same column followed by the same letter are not significantly different at p>0.05. Key; M = Millet, MGhw = Groundnut hot water extraction, MGhx = Groundnut hexane extraction.

4. CONCLUSION

Complementary food formulation of 60:40 and 50:50 hexane extracted were the best formulations in terms of acceptability. It contains relatively low amount of moisture and high amount of protein and crude fiber when compared with the local extracted. Lower bacterial count and no detection of E. coli in the complementary

food render the food safe for consumption. Wholesome product of good quality was produced based on the acceptability of the complementary food. Lower level of aflatoxin shows that the complementary food is good for the infant children.

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