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Physico-chemical, Nutritional and Sensory Characteristics of Chin-Chin made from Trifolate Yam (*Dioscorea dumentorum*) Flour Enriched with Pumpkin Seeds (*Telfaria occidentalis*) Flour

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ABSTRACT

Trifoliate yam flour (Dioscorea dumentorum) was produced and enriched with pumpkin (Telfaria occidentalis) seed flour at three substitution levels (10%, 15% and 20%) and processed into chin-chin, the quality of this product was compared with the chin-chin made from Irish potato (Solanum tuberosum) flour. The flour was analysed for physico-chemical, mineral, vitamins and anti-nutritional factors using standard procedures. The product made from the flour (Chin-chin) was analyzed for proximate composition and sensory evaluation to determine its acceptability. Results showed that enrichment of trifoliate yam flour with pumpkin seed flour increased the pH of the flour from 5.95 at 10% substitution to 6.03 at 15% substitution level, while the protein content also increased from 14.23% (10% substitution) to 16.53% (20% substitution). There was also an increase in fat content at the same substitution level. Potassium and Phosphorous also showed an increase in their contents after enrichment. Tannin decreased from 5.34% at 10% substitution level to 3.86% at 15% substitution. The overall acceptability showed that 10% substitution level had the highest rating and there was no significant difference in the chin-chin made from the enriched flour (P>0.05).

Keywords: acceptability; enrichment; pumpkin seed flour; trifoliate yam flour

INTRODUCTION

The importance of yam in general has been communicated by various researchers. Manuel *et al*., (2005) reported yam to be one of the principal foods in Nigeria, also an economically, socially and traditionally valuable crop in many tropical countries predominantly in West African, South Asian and Caribbean continents. Yam has been reported to be rich in carbohydrate with many of its varieties widespread throughout the humid tropics. The most economically important species grown are: White yam (*Dioscorea rotundata*), Yellow yam (*Dioscorea cayenensis*), Water yam (*Dioscorea alata*), Chinese yam (*Dioscorea esculenta*), Aerial yam (Dioscorea bulbifera) and Trifoliate yam (*Dioscorea dumentorum*) (Ike and Inoni, 2006) but only a few species of yams are cultivated as food crops. To some extent, processing of yam has not reached a significant level commercially.

Predominantly, the use of yam has been limited to the preparation of local dishes such as pounded yam (yam dough) and porridges (Amani *et al*., 2002). The production of instant yam flour, yam flakes and starch has been explored but industrial scale production has been limited due to various constraints including high fresh market price (Onayemi and Potter, 1974; FAO, 2005). In other words, some yam varieties are widely known and overexploited for food while others are known and exploited as food only in a few rural communities in Nigeria and as a result underutilized. Over dependence on the common yam varieties for food and industrial use account for the high market price of yams and this incidentally limits industrial exploitation.

Trifoliate yam is a species of yam in which limited work has been done in terms of its production and utilization though it is high yielding compared to other yam species. In Nigeria, its local names include; Esuru (in Yoruba language), Ona (in Ibo language) and Kosanrogo (in Hausa language). Some of its other common names are three-leaved yam, bitter yam and cluster yam. It has starch grains that are smaller, more soluble and more digestible than those of other yam species (Treche and Guion, 1980). The proteins also, are more balanced than those of white yam (Mbome and Treche, 1994) and it is rich in vitamins and minerals. The consumption of trifoliate yam is restricted due to its bitter taste, inability to keep for longer time after harvesting and poor binding capacity of its flour (Martin *et al*.,1983;Mbome and Treche, 1994; Sefa-dedeh and Afoakwa, 2001). Some works have been done on ways of minimizing the post-harvest problem associated with trifoliate yam but no solution has been suggested yet but processing the yam tuber into a shelf –stable product offers an alternative to fresh storage.

Pumpkin seeds used for the enrichment of the trifoliate yam are valuable both as oilseeds (54%) and also as protein source (27%) with a fairly well balanced amino acid composition (Akwaowo *et al*., 2000; Hamed *et al*., 2008). Unfortunately, 78 to 91% of the fruits are wasted annually (Fagbemi *et al*., 2005). It has also been reported by Jun *et al*. (2006) that pumpkin is a good source of carotene, pectin, mineral salts, vitamins and other substances that are beneficial to health. These facts lead to the processing of pumpkin into various food products. In the quest for industrial progress, a contribution was made through this research using trifoliate yam, an underutilized yam species as a case study. The trifoliate yam was enriched with pumpkin seed another underutilized food crop and compared with Irish potato a commonly known and utilized food crop which served as the control sample.

This research was carried out to determine the effect of enriching trifoliate yam flour with pumpkin seeds (in three substitution levels) on the physico-chemical, nutritional and sensory qualities of its product (Chin chin).

MATERIALS AND METHODS

Source of materials

Fresh Trifoliate yam tubers and the fluted pumpkin fruit containing viable seeds were obtained from Lusada market, Ogun state. The raw Irish Potato tubers were obtained from Sango Ota market, Ogun State.

Raw Materials Preparation

Production of Trifoliate Yam Flour:
The tubers were washed with clean water, peeled with sharp kitchen knives and sliced to a thickness of between 2mm to 3mm and oven-dried at a temperature of 65ºC for duration of 11 hours. The dried yam slices were milled into flour using a hammer milling machine and sieved through a standard laboratory sieve of 500 micron meter aperture to produce uniform particle size flour as described by Eke Ejiofor and Kiin-Kabari, (2010).

Production of Irish Potato Flour:
The fresh raw Irish potatoes were washed, peeled, and sliced to a thickness of about 2 to 3 mm and treated to stop enzymatic browning by soaking in a 0.3% salt water solution for 10 minutes. The treated potatoes were thereafter drained and oven-dried at a temperature of 65ºCfor duration of 9 hours. The dried potato chips were thereafter hammer-milled into flour and sieved through a standard laboratory sieve of 500 micron meter essentially as described by Chukwuonso *et al*.,(2010).

Production of Pumpkin Seeds Flour:
The fresh seeds were removed from the gourds, washed and sun dried to reduce sliminess, and thereafter broken out of shells, size-reduced by chopping with a kitchen knife and oven-dried at a temperature of 60ºC for duration of 30 hours and thereafter milled into flour using first, a laboratory dry miller and secondly, a small size hammer mill as described by Eke Ejiofor and Kiin-Kabari, (2010).

Enrichment Formulation:
The dried pumpkin seeds flour was added directly into the plain trifoliate yam flour in different proportions of 10% (to 90% trifoliate yam flour), 15% (to 75% trifoliate yam flour and 20% (to 80% trifoliate yam flour) and made to pass through a 500 micron meter aperture standard laboratory sieve to obtain the enriched trifoliate yam flour.

Production of Chin-Chin:
The flour sample (250 g) was sifted and margarine (25g) was rubbed in with 1 and half eggs added. This was followed by the addition of sugar (80g) and nutmeg (10g). All these were mixed into fairly stiff dough, turned into a floured board, rolled out thinly and cut into strips which were then squared. The squares of dough were fried (King’s vegetable oil) in small batches and frequently turned until brown. These were thereafter drained, allowed to cool and packaged in an air-tight freezer bag.

Physico-chemical analysis

Determination of pH of flour samples
The pH meter was switched on and allowed to warm up for about 5 minutes and then standardized with pH buffer solutions to ensure the sensitivity and accuracy of the meter. This was done by dipping the electrode of the meter into each buffer solution with thorough rinsing with distilled water.

The pH values of samples (initially prepared by dissolving 10 grams of dry sample into 10mls of distilled water) were taken individually by dipping the pH meter electrode into the samples followed by thorough rinsing with distilled water after each dip. The pH values were consequently read out from the display unit of the meter.

Chemical Properties
The moisture, protein, crude fat, crude fiber, and ash contents of the “Trifoliate yam flour” were determined using the methods of AOAC (2000). Carbohydrate was determined by difference according to James (1995).

Mineral Content determination

The dry ashing procedure was used for mineral content determination. Five (5) grams of each of the samples were accurately weighed into porcelain crucibles and pre-ashed until the sample was completely charred on a hot plate. The pre-ashed samples were thereafter ashed in the muffle furnace at 500oC till the ash was white for about 2 hours. After ashing, the crucibles were transferred into the desiccator to cool and the reweighed. Each sample was quantitatively transferred into volumetric flasks by carefully washing the crucibles with 1ml nitric acid, then with portions of dilute nitric acid. All washings were transferred to individual volumetric flasks, repeating the washing procedure twice. The solutions were diluted to volume with deionized water and were used for individual mineral determination using the appropriate standards and blank. The content of the minerals; Calcium, Magnesium, Potassium, Sodium,

Manganese, Iron, Copper and Zinc were determined with the Atomic Absorption Spectrophotometer (Buck Scientific, Model 210).
Calculation: Mineral Element concentration (%) = Ppm / 1000
Where Parts per million (Ppm) of any element = Meter reading x Slope x Dilution factor

Phosphorus Content:
Phosphorus was determined using the Spectrophotometric method described by Ceirwyn (1998). The dry ash of each sample obtained was digested by adding 5mls of 2Molar Hydrochloric acid to the ash in the crucible and heated to dryness on a heating mantle. 5mls of the 2Molar Hydrochloric acid was added again, heated to boil and filtered through a Whatman No.1 filter paper into a 100ml volumetric flask. 10ml of the filtrate solution was pipetted into 50ml standard volumetric flask and 10ml of Vanadate – molybdate yellow was added and the flask was made up to mark with distilled water, stoppered and left for 10 minutes for full yellow development. The concentration of phosphorus was obtained by taking the absorbance of the solution on a Spectronic 21D (Milton Roy Model) Spectrophotometer at a wave length of 470nm.
Calculation:
Phosphorus (%) = (Absorbance x Slope x Dilution Factor) / 10000

Vitamin Content Determination

Vitamin A:
Each sample was weighed (2g) into a flat bottom reflux flask and 10ml of distilled water was added followed by careful shaking to form a paste. This was followed by the addition of 25mls of alcoholic Potassium Hydroxide solution and the attachment of a reflux condenser. The mixture was then heated in boiling water bath for 1 hour with frequent shaking and rapidly cooled with 30mls of distilled water added. The hydrolysate obtained was transferred into a separating funnel and the solution was extracted three times with 250ml quantities of chloroform. Two grams of Anhydrous Sodium tetraoxosulphate (Na_2SO_4) was thereafter added to the extract to remove any traces of water. The mixture was then filtered into a 100ml volumetric flask and made up to mark with chloroform. Standard solutions (within the range of 0 to 50 micron gram/ml) prepared were determined with reference to their absorbance from which average gradients were taken to calculate Vitamin A (Beta- Carotene in micron gram/100 gram).
Absorbance of each sample and standards was read on the Spectrophotometer (Spectronic 21D, Milton Roy Model) at a wavelength of 328nm.
Calculation:

$$\text{Vitamin A } (\mu g/100g) = \frac{Absorbance\ x\ Dilution\ factor}{weight\ of\ sample} \text{ x } 100$$

Vitamin C:
Equal weights of each of the samples and 3% metaphosphoric acid were individually mechanically blended and each portion mixed to obtain homogenous slurry. Five (5) grams of individual slurry was transferred using a pipette into a 100ml volumetric flask and made up to mark with 3% metaphosphoric acid. Each mixture was filtered, discarding the first portion of the filtrate and 10ml of the aliquot was pipetted into a 50ml volumetric flask and titrated immediately with the standard dye solution of 2, 6 – dichlorophenolindophenol to a faint pink colour which persisted for 15 seconds.
Calculation:

$$\text{Vitamin C (mg/100g)} = \frac{W1}{W2} x \frac{V1}{V2}\ x\ [100\ (V\ x\ F)]$$

Where: W1 = Weight of sample (grams), W2 = Weight of extracting acid (grams), W3 = Weight of slurry removed for analysis, V1 = Volume to which slurry sample in diluted (ml), V2 = Volume of filtrate taken for titration (ml), V= Volume of dye solution used for titration, F = Ascorbic acid Equivalent of dye in milligrams/milliliters.

Determination of Anti-nutritional Composition

Determination of Tannins:
One (1) gram of each sample was weighed into a beaker and individually soaked with a solvent mixture (made up of 80mls of acetone and 20mls of glacial acetic acid) for five hours to extract the tannin. Samples were thereafter filtered through a double layer filter paper to obtain filtrate. This was followed by the preparation of a set of standard Tannic acid solution ranging from 10ppm to 50ppm. The absorbance of the standard solution and that of the filtrates were read at 500nm on a Spectronic 21D (Milton Roy Model) Spectrophotometer.
Calculation:

$$\text{Tannin (\%)} = \frac{Absorbance\ x\ Average\ gradient\ x\ Dilution\ factor}{10{,}000}$$

Determination of Oxalate:
One (1) gram of each sample was weighed into 250mls conical flask and soaked with 100mls of distilled water to extract the oxalates. Soaked samples were allowed to stand for three (3) hours and each was filtered through a double layer of filter paper. 10ppm, 20ppm, 30ppm, 40ppm and 50ppm standard solution of oxalic acid were prepared and the absorbance of standard solution and that of the filtrates from each sample was read using a Spectronic 21D (Milton Roy Model) Spectrophotometer at 420nm.
Calculation:

$$\text{Oxalate (\%)} = \frac{(Absorbance\ x\ Average\ gradient\ from\ std\ curve\ x\ DF)}{10{,}000}$$

Determination of Phytates:
The method described by Inuwa *et al*., (2011) was used for phytate determination. Sample (2g) was weighed into 250mls conical flask. 100mls of 2% concentrated hydrochloric acid was used to soak each of the samples in conical flasks for 3 hours and then filtered through a double layer filter paper. Each of the sample filtrates (50mls) was placed in 250ml beakers and 107mls of distilled water was added to each of the samples to improve proper acidity. 10mls of 0.3% Ammonium Thiocyanate solution was added to each sample solution as indicator and titrated with standard iron (III) chloride solution which contained 0.00195 g iron per ml. The end

point was signified by brownish-yellow coloration that persisted for 5 minutes.
Calculation:

$$\text{Phytic acid (\%)} = \frac{(Titre\ value\ x\ 0.00195)x\ 1.19\ x\ 100)}{2}$$

Determination of Saponin:

Two (2) grams of each of the samples were weighed into 250ml beakers and 100ml of isobutyl alcohol (octanol) was added to each sample and left for 5 hours on a UDY shaker for uniform mixing so as to obtain a uniform solution .The mixtures were then filtered through a No 1 Whatman filter paper. The filterate was transferred to another 10ml beaker and saturated with magnesium carbonate solution. The mixture thereafter obtained was then filtered to obtain a clear colourless solution. Standard saponin solutions (0 ppm to 10ppm) were prepared from 1000ppm saponin stock standard solution and saturated with magnesium carbonate as done above followed by filtration. The absorbances of the saponin standard solution (0 to 10ppm) were read at 380nm to obtain the gradient of the plotted curve.

Calculation: Saponin (%) =

$$\frac{Abs\ Standard - Abs\ Sample}{Weight\ of\ Sample}\ x\ \frac{Dilution\ factor\ x\ Average\ gradient}{10{,}000}$$

Determination of Trypsin Inhibitor:

Samples (0.2g) were weighed into screw cap centrifuge tubes. Thereafter 10mls of 0.1 Molar phosphate buffers were added into each and contents were shaken at room temperature for 1hour on a UDY shaker. The suspension obtained was thereafter centrifuged at 500rpm for 5 minutes and filtered through Whatman No 42 filter paper. The volumes of each were adjusted to 2mls with phosphate buffer and the test tubes were placed in water bath maintained at 37degrees Celsius. 6mls of 5% TCA Solution was added to an empty tube to serve as the blank. 2mls of casein solution was added to each of the tubes initially placed in the water bath followed by incubation for 20 minutes. TCA solution (6mls) was added into the sample tubes 20 minutes after (so as to stop the reaction) and shaken. The reaction was allowed to proceed for 1 hour at room temperature and the mixture was filtered through Whatman No 42 filter paper. The absorbance of sample filtrates and trypsin standard solutions were then read at 280nm.

Calculation:

Trypsin inhibitor (mg/100g)

$$= \frac{Abs\ standard - Abs\ Sample}{0.19\ x\ Sample\ weight\ (g)}\ \text{x}\ \frac{Dilution\ factor}{1000\ x\ Sample\ size}$$

Determination of cyanogenic glycoside:

Five (5) grams of each sample was weighed into 250ml conical flasks and incubated for 16 hours at a temperature of 38°C. Extraction of the cyanogenic glycoside was followed by filtration using double layer of hardened filter paper. Distillation was done using Markham distillation apparatus and each extracted sample was transferred into two-necked 500ml flasks connected to a steam generator. The steam was distilled with saturated sodium bicarbonate solution contained in a 50ml conical flask for 60 minutes. 1ml of starch indicator was added to 20mls of each distillate and titrated with 0.2N of Iodine solution.

Calculation:

$$\text{Hydrogen cyanide (\%)} = \frac{Titre\ x\ 10\ x\ 0.27\ x\ 100}{1000\ x\ weight\ of\ sample}$$

Sensory evaluation

Quality parameters such as the crust color, crumb color, crispiness, taste, flavor, aroma, texture and overall acceptability of the chin-chin made from the various flour samples were evaluated with a Scoring difference test. A 9-point hedonic scale was used to determine the overall acceptability of flour products. A twenty-man (untrained) panel was used for the sensory test using a questionnaire that was provided, for scoring. All quality parameters were evaluated as:
Like extremely = 9. Like very much = 8, Like moderately = 7, Like slightly = 6,
Neither like nor dislike = 5, Dislike slightly = 4, Dislike moderately = 3, Dislike very much = 2
Dislike Extremely = 1
Data obtained were subjected to Analysis of Variance (ANOVA).

RESULTS AND DISCUSSION

Effect of enrichment on proximate composition of Trifoliate yam flour

Table 1 shows the proximate composition of the flour samples. The moisture content determines the shelf life of the product. The range of moisture content for all the flour samples was between 5.38% and 7.31% which is at the minimum limit of moisture content for flour (Adeleke and Odedeji, 2010). The moisture content of the chin-chin made from all flour samples ranged from 2.81% to 4.9%. Proteins are made up of amino acids which perform different functions in the body such as growth and repair of body cells and tissues, synthesis of hormones and antibodies (Anne and Allison, 2006). The flour with the highest protein content was the 20% enriched trifoliate yam flour (16.53%) followed by the 15% enriched trifoliate yam flour (15.32%). The 100% plain trifoliate yam flour had 10.84%. The protein content of all flour samples reduced after frying into chin-chin. Fats provide the most concentrated source of chemical energy and heat. They support certain body organs and help with the transportation and storage of fat-soluble vitamins A, D, E, and K (Anne and Allison, 2006). The control flour sample (Irish potato) had the lowest fat content of 2.84% followed by the plain trifoliate yam flour (3.71), the fat content values increased with increase in level of enrichment On the other hand, frying significantly increased the fat content of chin-chin made from all the flour samples. This suggests that for health related purposes, the flour could be processed into a baked product rather than being made into a fried product. Alternatively, low cholesterol oil such as olive oil may be used in frying in place of ground nut oil. Above all, vegetable fats are essentially unsaturated which makes them more health-friendly than animal fat (Anne and Allison, 2006). Crude fiber helps with the peristaltic movement of food substances during digestion. The Irish potato had the lowest crude fiber content (1.61%). The fibre content of the flour increased with increase in enrichment levels. The plain trifoliate yam flour had 2.43%. Ash content increased with increase in enrichment in flour samples. The enrichment decreased the carbohydrate content of the flours gradually.

Effect of enrichment on the vitamin composition of the Trifoliate yam flour

Table 2 shows the vitamin A and C composition of the flour samples. Vitamins are organic compounds necessary for good health and vitality. Vitamin A is a fat soluble vitamin essential for the building and growth of all cells and for maintenance of normal vision in dim light. Vitamin C is a water soluble vitamin which acts as an anti-oxidant. Although vitamins are required in minute quantities, the resulting vitamins after enrichment in this study were insignificantly different (at P ≤ 0.05 significance level). A loss in vitamin composition could have been as a result of the heat treatments.

Table 1: Effect of enrichment on proximate composition (%) of Trifoliate yam flour

Samples	**Moisture**	**Protein**	**Fat**	**Carbohydrate**	**Ash**	**Crude Fiber**
IRP. Flour	7.30^{e}	15.11^{c}	2.87^{a}	70.43^{d}	4.29^{c}	1.61^{a}
100% TRIF.Y Flour	6.30^{d}	10.84^{a}	3.70^{b}	76.77^{e}	2.36^{a}	2.43^{b}
90% TRIF.Y+ 10% PPK Flour	6.12^{c}	14.23^{b}	9.55^{c}	67.71^{c}	2.40^{b}	2.44^{b}
85% TRIF.Y+ 15% PPK Flour	5.60^{b}	15.32^{c}	10.70^{d}	65.97^{b}	2.42^{b}	3.20^{c}
80% TRIF.Y+ 20% PPK Flour	5.38^{a}	16.53^{d}	12.44^{e}	63.18^{a}	2.47^{b}	3.83^{d}

Values within the same column with different superscript letters are significantly different from each other
IRP. Flour = Irish Potato flour (Control)
100% TRIF.Y FLOUR = 100% Trifoliate Yam Flour
90% TRIF.Y+10% PPK FLOUR = 90% Trifoliate Yam Flour Enriched with 10% Pumpkin seeds
85% TRIF.Y+15% PPK FLOUR= 85% Trifoliate Yam Flour Enriched with 15% Pumpkin seeds
80% TRIF.Y+20% PPK FLOUR= 80% Trifoliate Yam Flour Enriched with 20% Pumpkin seeds

Table 2: Effect of enrichment on the vitamin composition of the Trifoliate yam flour

Samples	Vitamin A (%)	Vitamin C (%)
IRP. Flour	0.03^{c}	0.71^{c}
100% TRIF.Y FLOUR	0.02^{b}	0.59^{a}
90% TRIF.Y+ 10% PPK FLOUR	0.02^{b}	0.75^{c}
85% TRIF.Y+ 15% PPK FLOUR	0.01^{a}	0.81^{d}
80% TRIF.Y+ 20% PPK FLOUR	0.02^{b}	0.65^{b}

Values within the same column with different superscript letters are significantly different from each other. IRP. Flour = Irish Potato flour (Control).
100% TRIF.Y FLOUR = 100% Trifoliate Yam Flour
90% TRIF.Y+10% PPK FLOUR = 90% Trifoliate Yam Flour Enriched with 10% Pumpkin seeds
85% TRIF.Y+15% PPK FLOUR= 85% Trifoliate Yam Flour Enriched with 15% Pumpkin seeds
80% TRIF.Y+20% PPK FLOUR= 80% Trifoliate Yam Flour Enriched with 20% Pumpkin seeds

Table 3: Effect of enrichment on the mineral composition of Trifoliate yam flour.

Samples	P	Mg	Fe	Cu	K	Mn	Ca	Na	Zn
IRP. Flour	2.50^{a}	93.48^{d}	2.90^{b}	0.44^{a}	325.35^{a}	0.73^{d}	3.20^{a}	372.15^{e}	1.26^{a}
100% TRIF.Y Flour	3.00^{c}	83.10^{a}	3.45^{c}	0.54^{b}	827.62^{b}	0.48^{a}	9.98^{c}	366.82^{d}	1.72^{b}
90% TRIF.Y+ 10% PPK Flour	3.13^{c}	100.38^{e}	4.53^{e}	0.82^{d}	781.38^{c}	1.08^{e}	10.75^{d}	41.88^{b}	2.46^{d}
85% TRIF.Y+ 15% PPK Flour	2.75^{b}	86.93^{b}	2.75^{a}	0.80^{d}	827.92^{d}	0.63^{c}	8.92^{b}	86.93^{c}	2.06^{c}
80% TRIF.Y+ 20% PPK Flour	3.22^{c}	88.88^{c}	3.98^{d}	0.60^{c}	845.40^{e}	0.58^{b}	8.50^{b}	40.25^{a}	2.24^{d}

Values within the same column with different superscript letters are significantly different from each other
IRP. Flour = Irish Potato flour (Control)
100% TRIF.Y FLOUR = 100% Trifoliate Yam Flour
90% TRIF.Y+10% PPK FLOUR = 90% Trifoliate Yam Flour Enriched with 10% Pumpkin seeds
85% TRIF.Y+15% PPK FLOUR= 85% Trifoliate Yam Flour Enriched with 15% Pumpkin seeds
80% TRIF.Y+20% PPK FLOUR= 80% Trifoliate Yam Flour Enriched with 20% Pumpkin seeds

Effect of enrichment on the mineral composition of Trifoliate yam flour

Table 3 shows the mineral composition of flour samples. Minerals are inorganic substances necessary for maintaining good health. Water balance, regulation of fluids and the acid base balance in the body depend to a great extent on certain mineral balance in the body. Phosphorus plays an important role in the calcification of bones and plays an essential part in carbohydrate metabolism (Raheena, 2007). Magnesium plays an important role in normal calcium and phosphorus metabolism in man. Iron forms a constituent of haemoglobin which takes part in the transportation of oxygen from the lungs to the tissues. Copper stimulates the absorption of iron and it is a constituent of the elastic connective tissue protein elastin. Potassium is an important constituent of cells and it helps with muscular function (Raheena, 2007). Manganese functions in many enzyme and it activates certain enzymes which take part in the digestion and metabolism of carbohydrates, proteins and lipids. Calcium is necessary for the ossification of bones and for normal nerve impulse transmission. Sodium is essential for normal functioning of the body and it also plays a role in the regulation of acid base balance and water metabolism in the body. Zinc plays an essential role in enzymatic action and aids in the healing of burns and wounds (Raheena, 2007).

Majority of the trifoliate yam flour samples had mineral composition higher than that of the Irish potato flour. Phosphorus and Potassium were highest in the 20% enriched trifoliate yam flour. Magnesium, Iron, Copper, Manganese, Calcium and Zinc were highest in the 10% enriched trifoliate yam flour while sodium was highest in the Irish potato flour.

Effect of enrichment on the anti-nutritional composition of Trifoliate yam flour

Table 4 shows the anti-nutritional composition of the flour samples. Tannins cause decreased feed consumption in animals, bind dietary protein and digestive enzymes to form complexes that are not readily digestible (Aletor, 1993).Tannins can also interact with dietary iron by preventing its absorption and they have the capability of decreasing the digestibility and palatability of proteins because they form insoluble complexes with proteins (Osagie *et al*., 1996). Irish potato flour had the highest Tannin content. Too much of soluble oxalates in the body prevent the absorption of soluble calcium ions as the oxalate binds the calcium ions to form insoluble calcium oxalate complexes. As a result of this, people with the tendency to form kidney stones are advised to avoid oxalate-rich foods (Adeniyi *et al*., 2009). The bioavailability of the essential nutrients in plant foods could be reduced by the presence of anti-nutritional factors such as oxalates (Akindahunsi and Salawu, 2005).The 20% enriched trifoliate yam flour had the highest oxalate content.

Table 4: Effect of enrichment on the anti-nutritional composition of trifoliate yam flour.

Samples	Tannins (%)	Oxalates (%)	Phytic Acid (%)	Saponins (%)	Trypsin Inhibitors (%)	Cyanogenic glycoside (%)
IRP. Flour	5.89^{d}	1.98^{a}	6.15^{a}	2.51^{a}	1.31^{d}	0.17^{a}
100% TRIF.Y Flour	4.75^{b}	3.05^{c}	8.25^{c}	2.95^{b}	1.14^{c}	0.85^{b}
90% TRIF.Y+ 10% PPK Flour	5.34^{c}	3.14^{c}	8.25^{c}	3.88^{c}	0.95^{a}	0.87^{b}
85% TRIF.Y+ 15% PPK Flour	3.86^{a}	2.08^{b}	7.14^{b}	4.31^{d}	1.02^{b}	0.95^{c}
80% TRIF.Y+ 20% PPK Flour	4.15^{b}	3.66^{d}	8.39^{d}	4.26^{d}	0.88^{a}	0.92^{c}

Values within the same column with different superscript letters are significantly different from each other
IRP. Flour = Irish Potato flour (Control)
100% TRIF.Y FLOUR = 100% Trifoliate Yam Flour
90% TRIF.Y+10% PPK FLOUR = 90% Trifoliate Yam Flour Enriched with 10% Pumpkin seeds
85% TRIF.Y+15% PPK FLOUR= 85% Trifoliate Yam Flour Enriched with 15% Pumpkin seeds
80% TRIF.Y+20% PPK FLOUR= 80% Trifoliate Yam Flour Enriched with 20% Pumpkin seeds

Table 5: Effect of frying on the proximate composition (%) of trifoliate yam flour dough.

Samples	Moisture	Crude Protein	Crude Fat	Carbohydrate	Ash	Crude Fiber
IRP. Flour	3.18^{c}	9.96^{a}	23.58^{d}	60.99^{a}	2.30^{c}	1.37^{c}
100% TRIF.Y Flour	3.09^{c}	10.73^{b}	20.93^{b}	63.37^{c}	1.89^{a}	1.23^{b}
90% TRIF.Y+ 10% PPK Flour	2.81^{b}	11.71^{c}	19.92^{a}	63.66^{c}	1.91^{a}	1.52^{d}
85% TRIF.Y+ 15% PPK Flour	2.67^{a}	11.71^{c}	22.79^{c}	60.99^{a}	1.84^{a}	1.69^{e}
80% TRIF.Y+ 20% PPK Flour	4.90^{d}	9.96^{a}	20.81^{b}	61.95^{b}	2.38^{d}	0.75^{a}

Values within the same column with different superscript letters are significantly different from each other
IRP. Flour = Irish Potato flour (Control)
100% TRIF.Y FLOUR = 100% Trifoliate Yam Flour
90% TRIF.Y+10% PPK FLOUR = 90% Trifoliate Yam Flour Enriched with 10% Pumpkin seeds
85% TRIF.Y+15% PPK FLOUR= 85% Trifoliate Yam Flour Enriched with 15% Pumpkin seeds
80% TRIF.Y+20% PPK FLOUR= 80% Trifoliate Yam Flour Enriched with 20% Pumpkin seeds

Phytates have twelve replaceable hydrogen atoms and therefore could form insoluble salts with many metals like calcium, iron, zinc, magnesium and phosphorus thereby preventing the proper utilization of these minerals and making them unavailable (Jack *et al*., 1985). The 20% enriched trifoliate yam flour also had the highest phytic acid content.

Saponins characterized by their bitter taste bind cholesterol, making it unavailable for absorption and they also cause haemolysis of red blood cells and are toxic to rats (Johnson *et al*., 1986). Humans generally, do not suffer severe poisoning from saponins. Some types of saponins are health friendly. They inhibit growth of cancer cells and help to lower blood cholesterol hence useful in the treatment of cardiovascular diseases and other health problems (Del-Rio *et al*., 1997). The 15% and 20% enriched flours had the highest saponin contents.

These are anti-nutrients for monogastric animals but they do not exert adverse effects in ruminants because they are degraded in the rumen (Cheeke and Shull, 1985). Trypsin (protease inhibitor) causes pancreatic enlargement and growth depression (Aletor and Fetuga, 1987). The Irish potato flour had the highest content of trypsin inhibitors. Cyanogenic glycosides on hydrolysis yield toxic hydrocyanic acid (HCN). The cyanide ions inhibit several enzyme systems; depress growth through interference with certain essential amino acids and utilization of associated nutrients (Akindahunsi and Salawu, 2005). They also cause acute toxicity, neuropathy and death (Fernando, 1987). The cyanogenic glycoside content was highest in the 15% and 20% enriched flour samples.

Effect of frying on the proximate composition of trifoliate yam flour dough

Table 5 shows the proximate composition of the Chin-chin. The chin- chin samples generally had a decrease in most of their proximate composition compared to that of the flour samples they were made from. Although, the fat content increased because oil was used in producing the Chin-chin.

Effect of enrichment on the acceptability of trifoliate yam flour chin-chin

Sensory quality is considered a key factor in food acceptance because consumers look out for food with specific sensory characteristics. The acceptance of a food will depend on whether it responds to consumer needs, and on the degree of satisfaction that it is able to provide (Heldman, 2004). Irish potato chin-chin had the highest score of 6.95 for crust color while the 10% enriched trifoliate yam chin-chin had the highest score of 6.85 for crumb color (Table 6). Irish potato chin-chin had the highest score of 6.90 for texture. Irish potato also had the highest score of 6.5 for flavor. The sample with the highest score (6.45) for aroma was the 15% enriched trifoliate yam while for taste Irish potato chin-chin had the highest (6.65). For overall acceptability, the Irish potato chin-chin was the most acceptable (6.80), followed by the 10% enriched trifoliate yam chin-chin (6.20), the 15% enriched trifoliate yam chin-chin (5.90), and lastly the 20% enriched trifoliate yam chin-chin and the plain trifoliate yam chin-chin which both had the same score of 5.70. These values, being above average on a 9 point hedonic scale, indicate to some extent that all samples were moderately acceptable to consumers.

CONCLUSION

It can be concluded that pumpkin seeds can be used to improve the nutritional composition (especially the protein content) of foods high in carbohydrate and low in other nutrients. Pumpkin seed can be used as a substitute for soya bean and other protein rich seeds. The enriched trifoliate yam flour can be used as an industrial flour or made into dough (like 'Amala') because of its bitter taste, which makes it not too acceptable as chin-chin. The trifoliate yam flour should undergo a heating process before consumption so as to reduce the intake of anti-nutrients.

Table 6: Effect of enrichment on the acceptability of trifoliate yam flour chin-chin.

Samples	Crust Color	Crumb Color	Texture	Flavor	Aroma	Taste	Overall Acceptability
IRP. Flour	6.95^{d}	6.50^{b}	6.90^{e}	6.50^{e}	6.30^{b}	6.65^{d}	6.80^{d}
100% TRIF.Y Flour	6.25^{b}	6.60^{c}	6.35^{a}	5.30^{a}	6.15^{a}	5.55^{b}	5.70^{a}
90% TRIF.Y+ 10% PPK Flour	6.70^{c}	6.85^{d}	6.75^{d}	5.60^{c}	6.40^{c}	6.00^{c}	6.20^{c}
85% TRIF.Y+ 15% PPK Flour	6.75^{c}	6.80^{d}	6.60^{c}	5.85^{d}	6.45^{d}	5.55^{b}	5.90^{b}
80% TRIF.Y+ 20% PPK Flour	6.15^{a}	6.25^{a}	6.55^{b}	5.55^{b}	6.35^{b}	5.30^{a}	5.70^{a}

Values within the same column with different superscript letters are significantly different from each other
IRP. Flour = Irish Potato flour (Control)
100% TRIF.Y FLOUR = 100% Trifoliate Yam Flour
90% TRIF.Y+10% PPK FLOUR = 90% Trifoliate Yam Flour Enriched with 10% Pumpkin seeds
85% TRIF.Y+15% PPK FLOUR= 85% Trifoliate Yam Flour Enriched with 15% Pumpkin seeds
80% TRIF.Y+20% PPK FLOUR= 80% Trifoliate Yam Flour Enriched with 20% Pumpkin seeds

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