

Effect of Enrichment of Trifoliolate Yam Flour with Pumpkin Seeds Flour on the Pasting Characteristics and the Acceptability of its Product

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Abstract

Trifoliolate yam (*Dioscorea dumentorum*) is an underutilized yam species which is highly nutritious, but cannot be stored for a long period like other yams because it hardens a few days to harvest. This makes it unavailable all year round. There is therefore the need for processing of the yam to stable flour. Trifoliolate yam flour was produced and enriched with pumpkin (*Telfaria occidentalis*) seed flour at three substitution levels (10%, 15% and 20%) and processed into chin-chin, this product was compared with the chin-chin made from Irish potato (*Solanum tuberosum*) flour. The flour was analysed for physico-chemical, functional and pasting properties. The product made from the flour (chin-chin) was tested for proximate composition and sensory evaluation to determine its acceptability. Results showed that enrichment of trifoliolate 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. Peak viscosity of the flour decreased from 344.17RVU (10% substitution) to 269.25 (20% 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 at the different substitution levels ($P > 0.05$).

Keywords: Trifoliolate yam flour; Pumpkin seed flour; Enrichment; Pasting properties; Acceptability

Introduction

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 Trifoliolate yam (*Dioscorea dumentorum*) [1] 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.

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 [2]. 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.

Trifoliolate 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 [3]. The proteins also, are more balanced than those of white yam [4]. Some works have been done on ways of minimizing the post-harvest problem associated with trifoliolate yam but no solution has been suggested yet but processing the yam tuber into a shelf-stable product offers an alternative to fresh storage.

The consumption of trifoliolate yam is restricted due to its bitter taste, inability to keep for longer time after harvesting and poor binding capacity of its flour [4,5,6].

Trifoliolate yam just like every other yam is also a good source of energy and carbohydrate when consumed. Inadequate intake of protein associated with carbohydrate results in a deficiency disease called kwashiorkor which is prevalent in yam growing areas [7]. As a result of this, a lot of research work has been carried out to improve the nutritional composition and qualities of yam and its products. For instance, the protein content of tubers has been increased by the addition of defatted, full fat soy flours or cowpea flour [8]. Processing of trifoliolate yam tubers into flour has been reported to be a means of adding longer term value to the tubers with a high nutritional potential [8]. Pumpkin seeds used for the enrichment of the trifoliolate yam are valuable both as oilseeds (54%) and also as protein source (27%) with a fairly well balanced amino acid composition [9,10].

Trifoliolate yam is a type of yam that hardens after harvesting if not processed immediately. Therefore, processing the yam into flour will go a long way in making it more useful and in extending its shelf life. Trifoliolate yam is an underutilized type of yam (due to its limitations) which needs to be modified. Therefore, enriching with a protein-rich seed will improve its nutritional composition making it a desired product.

The nutritional value of Irish potato along with its taste and ease of cooking has made it a popular vegetable in the tropical and subtropical world. This research was carried out to determine the effect of enriching

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Received September 23, 2013; Accepted November 25, 2013; Published December 04, 2013

Citation: Adelekan Aminat O, Arisa Ngozi U, Adediran A, Racheal OF (2013) Effect of Enrichment of Trifoliolate Yam Flour with Pumpkin Seeds Flour on the Pasting Characteristics and the Acceptability of its Product. J Food Process Technol 4: 283. doi:10.4172/2157-7110.1000283

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trifoliolate yam flour with pumpkin seeds (in different substitution levels) on the pasting properties and the acceptability of chin-chin made from the enriched yam flour in comparison with chin-chin made from Irish potato flour.

Materials and Methods

Fresh Trifoliolate 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 and Oja Ota, Ogun State.

Raw materials preparation

The production of Trifoliolate 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 65°C for duration of 11 h. 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.

The 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 65°C for duration of 9 h. The dried potato chips were thereafter hammer-milled into flour and sieved through a standard laboratory sieve of 500 micron meter.

The 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 60°C for duration of 30 h and thereafter milled into flour using first, a laboratory dry miller and secondly, a small size hammer mill.

Figure 1 shows the flow chart for the production of the enrichment Trifoliolate flour: The dried pumpkin seeds flour was added directly into the plain trifoliolate yam flour in different proportions of 10% (to 90% trifoliolate yam flour), 15% (to 75% trifoliolate yam flour and 20% (to 80%

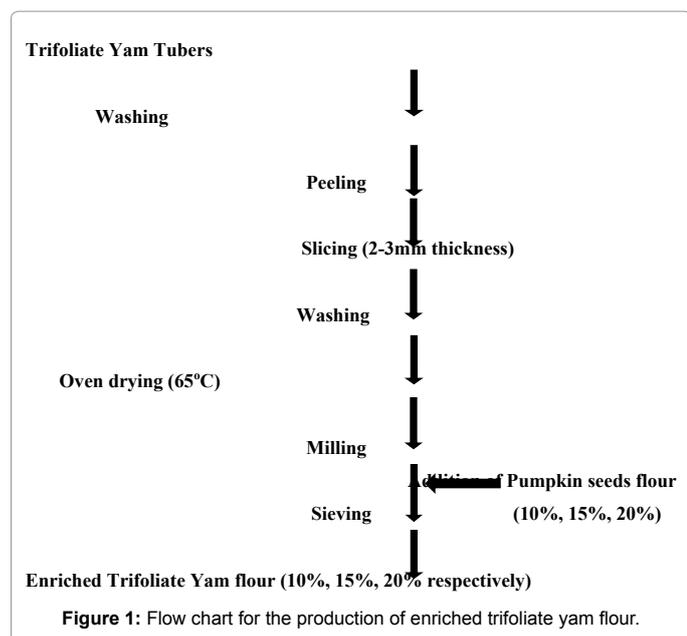


Figure 1: Flow chart for the production of enriched trifoliolate yam flour.

trifoliolate yam flour) and made to pass through a 500 micron meter aperture standard laboratory sieve to obtain the enriched trifoliolate yam flour.

The 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.

Proximate analyses

Moisture content, crude fibre and ash were determined according to AOAC[11], crude protein by Kjeldhal method, fat content by solvent extraction and carbohydrate content was by difference.

Determination of bulk density of flour samples: A known amount of the sample (5 g) was weighed into a 10ml measuring cylinder. The bottom of the cylinder was gently tapped for five minutes from a height of 5cm. The bulk density was taken as the mass per unit volume of the sample.

Calculation:

Bulk density (g/ml or g/cm³) = Weight of the sample / Volume of the sample after tapping

Determination of water absorption capacity of flour samples: One gram (1 g), of the flour sample was weighed into dry pre-weighed centrifuge tubes. This was followed by the addition of 10mls of distilled water and then stirred with a stirring glass rod to completely dissolve lumps. The solution was then centrifuged at 3500rpm for 15 minutes and the supernatant was discarded.

Calculation: Water Absorption Capacity (%) = [(Weight of Tube + wet sample) - (Weight of Tube + Dry sample)] x 100%

Determination of swelling power of flour samples

Flour sample (0.5g) was weighed, homogenized, heated (in a water bath at 100 degrees Celsius) for 15 minutes and gently stirred. The weight of the sediment was then recorded.

Calculation:

Swelling power = Weight of wet sediment / Weight of dry matter in gel.

Determination of pasting properties

Pasting properties were determined using the Rapid visco Analyzer (Newport scientific, Warri wood, Australia). Distilled water (2.5ml) was measured into the test canister followed by the addition of 3.5g of the sample on the water surface. The blade of the paddle was allowed to jog through the sample up and down several times in the canister and this was repeated to completely dissolve samples remaining on the water surface. The paddle and canister assembly were inserted firmly into the paddle coupling so that the paddle was properly centered. The following parameters (peak viscosity, trough, holding strength, breakdown, set back, final viscosity, peak time and pasting temperature) were obtained [12].

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. Data obtained were subjected to Analysis of Variance (ANOVA). Differences were considered significant if Probability is less than 5% ($P < 0.05$).

Results and Discussion

Table 1 shows the physical and functional properties of the flour samples. Irish potato flour had the highest pH (6.52) followed by the 20% enriched trifoliolate yam flour (6.03), the plain trifoliolate yam flour had the least value (5.82). The low pH of the plain trifoliolate yam flour is an indicator that it is acidic and the gradual increase in pH after enrichment means that the higher the enrichment, the less acidic the flour. Bulk density is usually affected by the particle size and density of the flour and it is very important in determining the packaging requirement, materials handling and application in wet processing in the food industry [13]. The bulk density of the Irish potato flour was the highest (0.83g/cm³). The trifoliolate yam flour and the enriched flour had a bulk density within the range of 0.62 to 0.68. The enrichment did not affect the bulk density of the trifoliolate yam flour samples. This means that all the trifoliolate yam flour samples can be packaged the same way and this is advantageous.

Water absorption capacity is the ability of flour particles to entrap large amounts of water, such that exudation is prevented [14]. It varies with size, shape, presence of proteins, carbohydrates and lipids, pH and salts. Previous processing such as heating, alkali processing, disulfide linking, may also influence water absorption [15]. Water absorption capacity may be an advantage in applications of the lesser known yam flours in such food systems as baby food formulations, fufu production and bread making where increase in water absorption of the flour will increase product yield [16]. Irish potato had the highest water

absorption capacity (167.75%), followed by the plain trifoliolate yam flour (152.95%) which is higher than the 131% and 137% reported by [17] for trifoliolate yam flours sieved through 40 and 80 mesh sizes respectively. From Table 1, the enrichment decreased the water absorption capacity of the trifoliolate yam flour samples (130.49%, 129.44% and 128.42%) respectively for 10%, 15%, and 20% substitution levels.

Swelling power is an indication of the absorption index of the granules during heating. Irish potato had the highest swelling power (766.19%), followed by the Trifoliolate yam flour (662.90%). According to [17] swelling power decreases as the particle size increases. This justifies the decrease in swelling power as level of substitution increased.

Table 2 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 [18]. 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 trifoliolate yam flour (16.53%) followed by the 15% enriched trifoliolate yam flour (15.32%). The 100% plain trifoliolate yam flour had 10.84%. 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 [19]. The control flour sample (Irish potato) had the lowest fat content of 2.87% followed by the plain trifoliolate yam flour (3.70), the fat content values increased with increase in level of enrichment. 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 [19].

Crude fibre helps with the peristaltic movement of food substances

Samples	pH	Bulk Density (g/ml)	Water Absorption Capacity (%)	Swelling Power (%)
IRP.FLOUR	6.52 ± 0.05	0.83 ± 0.00	167.75 ± 0.13	766.19 ± 0.90
100% TRIF.Y FLOUR	5.82 ± 0.10	0.68 ± 0.00	152.95 ± 0.48	662.90 ± 6.19
90% TRIF.Y+ 10% PPK FLOUR	5.95 ± 0.06	0.65 ± 0.02	130.49 ± 0.29	496.81 ± 3.52
85% TRIF.Y+ 15% PPK FLOUR	5.99 ± 0.06	0.62 ± 0.03	129.44 ± 0.08	473.07 ± 4.91
80% TRIF.Y+ 20% PPK FLOUR	6.03 ± 0.08	0.68 ± 0.01	128.42 ± 0.06	430.58 ± 4.04

Values represent means ± Standard Error of three determinations.

IRP. FLOUR = Irish Potato flour (Control) 100% TRIF.Y FLOUR = 100% Trifoliolate Yam Flour
 90% TRIF.Y+10% PPK FLOUR = 90% Trifoliolate Yam Flour Enriched with 10% Pumpkin seeds
 85% TRIF.Y+15% PPK FLOUR = 85% Trifoliolate Yam Flour Enriched with 15% Pumpkin seeds
 80% TRIF.Y+20% PPK FLOUR = 80% Trifoliolate Yam Flour Enriched with 20% Pumpkin seeds

Table 1: Effect of enrichment on the physical and functional properties of trifoliolate yam flour.

Samples	Moisture (%)	Protein (%)	Fat (%)	Carbohydrate (%)	Ash (%)	Crude Fibre (%)
IRP. FLOUR	7.30 ± 0.05	15.11 ± 0.43	2.87 ± 0.04	70.43 ± 0.49	4.29 ± 0.04	1.61 ± 0.06
100% TRIF.Y FLOUR	6.33 ± 0.08	10.84 ± 0.22	3.70 ± 0.08	76.77 ± 0.27	2.36 ± 0.04	2.43 ± 0.07
90% TRIF.Y+ 10% PPK FLOUR	6.12 ± 0.05	14.23 ± 0.05	9.55 ± 0.36	67.71 ± 0.01	2.40 ± 0.04	2.44 ± 0.06
85% TRIF.Y+ 15% PPK FLOUR	5.60 ± 0.03	15.32 ± 0.00	10.70 ± 0.04	65.97 ± 0.05	2.42 ± 0.02	3.20 ± 0.03
80% TRIF.Y+ 20% PPK FLOUR	5.38 ± 0.04	16.53 ± 0.22	12.44 ± 0.02	63.18 ± 0.22	2.47 ± 0.02	3.83 ± 0.03

Values are means ± Standard Error of three determinations

IRP. FLOUR = Irish Potato flour (Control)
 100% TRIF.Y FLOUR = 100% Trifoliolate Yam Flour
 90% TRIF.Y+10% PPK FLOUR = 90% Trifoliolate Yam Flour Enriched with 10% Pumpkin seeds
 85% TRIF.Y+15% PPK FLOUR = 85% Trifoliolate Yam Flour Enriched with 15% Pumpkin seeds
 80% TRIF.Y+20% PPK FLOUR = 80% Trifoliolate Yam Flour Enriched with 20% Pumpkin seeds

Table 2: Effect of enrichment on proximate composition of trifoliolate yam flour (%).

during digestion. The Irish potato had the lowest crude fibre content (1.61%). The fibre content of the flour increased with increase in enrichment levels. The plain trifoliolate yam flour had 2.43% crude fibre content. Ash content increased with increase in enrichment in flour samples. The enrichment decreased the carbohydrate content of the flours gradually.

Table 3 shows the pasting properties of the flour samples. The Irish potato flour had the highest peak viscosity (365.50 RVU). The 10% enriched trifoliolate yam flour had the next highest peak viscosity (344.17 RVU). The peak viscosity further decreased as the enrichment increased. Peak viscosity is the ability of starch to swell freely before their physical breakdown [20].

The high peak viscosity in the control sample is an indication that the sample forms a thick paste after cooking and has the ability to withstand heating and shear stress. In a research conducted by Okorie [17] trifoliolate yam starch paste was the most stable thus suggesting that this lesser known yam starch may be useful as a filler or binder in meat canning and other industries. Higher values for peak viscosity (445.3 RVU) have been obtained for other yam species such as *Dioscorea rotundata* flour [21]. Breakdown is a measure of susceptibility of cooked starch granules to disintegration and has been reported to affect the stability of the flour products. The control sample had the highest breakdown (118.17). Breakdown value increased as enrichment increased in the trifoliolate yam flour samples. Final viscosity of a sample indicates ability to form a firm, visco-elastic paste or gel after cooking and cooling owing to re-association of starch molecules (Newport Scientific) [22]. The 10% enriched trifoliolate yam flour had the highest final viscosity while the final viscosity decreased as enrichment increased. Setback value is an index of the tendency of the cooked flour to harden on cooling due to amylose retrogradation [23]. The 10% enriched trifoliolate yam flour had the highest setback value and pasting time while for the pasting temperature, the 20% enriched trifoliolate yam flour had the highest.

Table 4 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. The moisture content of the chin-chin made from all flour samples ranged from 2.81% to 4.9%. The protein content of all flour samples reduced after frying into chin-chin. On the other hand, frying significantly increased the fat content of chin-chin made from all the flour samples. However, the fat content increased because vegetable oil was used in frying the chin-chin.

Table 5 shows the mean score of the sensory attributes. 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 [24]. From the sensory evaluation, Irish potato chin-chin had the highest score of 6.95 for crust color while the 10% enriched trifoliolate yam chin-chin had the highest score of 6.85 for crumb color. For texture, Irish potato chin-chin had the highest score of 6.90. 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 trifoliolate 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 trifoliolate yam chin-chin (6.20), the 15% enriched trifoliolate yam chin-chin (5.90), and lastly the 20% enriched trifoliolate yam chin-chin and the plain trifoliolate 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 and Recommendation

The protein content of all enriched flour samples increased with increase in level of substitution. Frying significantly increased the fat content of chin-chin made from all the flour samples. This is as a result

SAMPLE	Peak Viscosity (RVU)	Trough (RVU)	Breakdown (RVU)	Final Viscosity (RVU)	Setback (RVU)	Peak Time (minutes)	Pasting Temperature (°C)
IRP. FLOUR	365.50	247.33	118.17	401.33	154.00	4.46	64.90
100% TRIF.Y FLOUR	321.92	254.92	67.00	377.67	122.75	4.66	64.45
90% TRIF.Y+ 10% PPK FLOUR	344.17	290.08	54.08	487.00	196.92	5.33	82.45
85% TRIF.Y+ 15% PPK FLOUR	329.58	259.42	70.17	399.67	140.25	4.53	64.95
80% TRIF.Y+ 20% PPK FLOUR	269.25	184.92	84.33	341.92	157.00	5.20	84.90

IRP. FLOUR = Irish Potato flour (Control)

100% TRIF.Y FLOUR = 100% Trifoliolate Yam Flour

90% TRIF.Y+10% PPK FLOUR = 90% Trifoliolate Yam Flour Enriched with 10% Pumpkin seeds

85% TRIF.Y+15% PPK FLOUR= 85% Trifoliolate Yam Flour Enriched with 15% Pumpkin seeds

80% TRIF.Y+20% PPK FLOUR= 80% Trifoliolate Yam Flour Enriched with 20% Pumpkin seeds

Table 3: Effect of enrichment on pasting properties of trifoliolate yam flour.

Samples	Moisture Content	Protein	Crude Fat	Carbohydrate	Ash Content	Crude Fibre
IRP. FLOUR Chin-Chin	3.18 ± 0.15	9.96 ± 0.11	23.58 ± 0.02	60.99 ± 0.14	2.30 ± 0.14	1.37 ± 0.02
100% TRIF.YChin-chin	3.09 ± 0.13	10.73 ± 0.22	20.93 ± 0.06	63.37 ± 0.01	1.89 ± 0.03	1.23 ± 0.01
90% TRIF.Y+ 10% PPK Chin-chin	2.81 ± 0.13	11.71 ± 0.11	19.92 ± 0.15	63.66 ± 0.16	1.91 ± 0.06	1.52 ± 0.03
85% TRIF.Y+ 15% PPK Chin-chin	2.67 ± 0.06	11.71 ± 0.11	22.79 ± 0.04	60.99 ± 0.15	1.84 ± 0.06	1.69 ± 0.02
80% TRIF.Y+ 20% PPK Chin-chin	4.90 ± 0.02	9.96 ± 0.11	20.81 ± 0.13	61.95 ± 0.13	2.38 ± 0.09	0.75 ± 0.01

Values are means ± Standard Error of two determinations

IRP. FLOUR = Irish Potato flour (Control)

100% TRIF.Y FLOUR = 100% Trifoliolate Yam Flour

90% TRIF.Y+10% PPK FLOUR = 90% Trifoliolate Yam Flour Enriched with 10% Pumpkin seeds

85% TRIF.Y+15% PPK FLOUR= 85% Trifoliolate Yam Flour Enriched with 15% Pumpkin seeds

80% TRIF.Y+20% PPK FLOUR= 80% Trifoliolate Yam Flour Enriched with 20% Pumpkin seeds

Table 4: Effect of frying on the trifoliolate yam flour dough (%).

Samples	Crust Color	Crumb Color	Texture	Flavor	Aroma	Taste	Overall Acceptability
IRP. Chin-chin	6.95 ± 0.36	6.50 ± 0.41	6.90 ± 0.33	6.50 ± 0.48	6.30 ± 0.44	6.65 ± 0.48	6.80 ± 0.49
100% TRIF.Y Chin-chin	6.25 ± 0.36	6.60 ± 0.30	6.35 ± 0.29	5.30 ± 0.41	6.15 ± 0.32	5.55 ± 0.41	5.70 ± 0.36
90% TRIF.Y+ 10% PPKChin-chin	6.70 ± 0.30	6.85 ± 0.38	6.75 ± 0.23	5.60 ± 0.34	6.40 ± 0.21	6.00 ± 0.39	6.20 ± 0.26
85% TRIF.Y+ 15% PPKChin-chin	6.75 ± 0.23	6.80 ± 0.17	6.60 ± 0.33	5.85 ± 0.28	6.45 ± 0.21	5.55 ± 0.37	5.90 ± 0.22
80% TRIF.Y+ 20% PPK Chin-chin	6.15 ± 0.31	6.25 ± 0.23	6.55 ± 0.36	5.55 ± 0.34	6.35 ± 0.28	5.30 ± 0.36	5.70 ± 0.28

Values are means ± Standard Error of twenty determinations

IRP. FLOUR = Irish Potato flour (Control)

100% TRIF.Y FLOUR = 100% Trifoliolate Yam Flour

90% TRIF.Y+10% PPK FLOUR = 90% Trifoliolate Yam Flour Enriched with 10% Pumpkin seeds

85% TRIF.Y+15% PPK FLOUR= 85% Trifoliolate Yam Flour Enriched with 15% Pumpkin seeds

80% TRIF.Y+20% PPK FLOUR= 80% Trifoliolate Yam Flour Enriched with 20% Pumpkin seeds

Table 5: Effect of enrichment on the acceptability of trifoliolate yam flour chin-chin.

of the vegetable oil used in frying 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.

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 trifoliolate yam flour can be used as industrial flour or made into dough (like 'Amala') because its bitter taste makes it not too acceptable as chin-chin.

The trifoliolate yam flour should undergo a heating process before consumption so as to reduce the anti-nutritional factors in it.

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Citation: Adelekan Aminat O, Arisa Ngozi U, Adediran A, Racheal OF (2013) Effect of Enrichment of Trifoliolate Yam Flour with Pumpkin Seeds Flour on the Pasting Characteristics and the Acceptability of its Product. J Food Process Technol 4: 283. doi:10.4172/2157-7110.1000283