Physicochemical and Sensory Properties, and *In-Vitro* Digestibility of Biscuits Made from Blends of Tigernut (*Cyperus esculentus*) and Pigeon Pea (*Cajanus cajan*)

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ABSTRACT

Objective: The study explored the potential of tigernut and pigeon pea flour blends in the preparation of biscuits.
Materials and methods: Tigernut and Pigeon pea seeds were processed into flour and formulated into blends. The chemical composition of the flours and biscuits prepared from the flour blends as well as *in-vitro* (starch and protein) digestibility, physical and sensory properties of the biscuits were evaluated using standard methods.
Results: The chemical composition such as protein, moisture, fat, ash, crude fiber, ash, energy, iron, calcium, zinc and phosphorus contents of composite biscuits ranged from (11.64 to 17.81%), (4.11 to 6.03%), (12.80 to 18.40%), (2.43 to 3.63%), (3.81 to 4.95%), (437.84to 453.36kcal) , (3.18 to 3.81mg/100g), (60.15 to 87.69mg/100g), (0.50 to 1.27mg/100g) and (223.19 to 248.17mg/100g) respectively and were significantly ($p \leq 0.05$) higher than 100 % wheat biscuit. The composite biscuits had poor starch digestibility (25.43 to 44.18 %) than 100 % wheat flour biscuit (57.25 %) as well as high protein digestibility (60.20 to 71.57 %). Biscuits prepared from tigernut and pigeon pea flour blends were significantly ($p \leq 0.05$) higher in width and spread ratio than control samples while their break strength decreased with increase in pigeon pea flour addition. There were no significant ($p>0.05$) differences in appearance, flavour, crust colour and overall acceptability between composite biscuits and control.
Conclusion: This study reveals that tigernut and pigeon pea flour could be used in the production of nutritious biscuit and confirms their potential as a functional food especially for diabetic and obese patients due to their low starch and high protein digestibility.

Keywords: Chemical, in-vitro digestibility, mineral composition, physical and sensory properties

INTRODUCTION

Biscuits are a popular foodstuff consumed by a wide range of populations due to their varied taste, long shelf life and relatively low cost. Biscuit is a well-known product; it is categorized as a miscellaneous food product. It consists of three major components: flour, sugar, and fat, which compose biscuit dough and influence the quality of the final product (1).

Due to increased demand for functional products, attempts are being made to improve the nutritive value and functionality of biscuits by modifying their nutritive composition. This involves the use of non-wheat flour with attempt to increase the protein content and quality of biscuits (2, 3) and overcome the problems of high cost of wheat flour due to its importation in Nigeria and other countries whose climates are unfavourable for wheat cultivation. These limitations have prompted the search for available or underutilized crops with functional attributes to be incorporated as composite flours for the production of baked products.

Tigernut (*Cyperus esculentus*) is a tuber crop that belongs to the family *Cyperaceae* which is cultivated throughout the world and is widely found in the Northern parts of Nigeria. It has been found to contain appreciable quantities of the fatty acids; myristic acid, oleic acid, linoleic acid (4). Consumption of tigernuts helps in the prevention of heart attacks, thrombosis by enhancing blood circulation as well as assisting in reducing the risk of colon cancer (5). Tigernuts are rich in energy yielding nutrients (starch, fat, sugars and protein), mineral (phosphorus, potassium) and vitamins E and C (5). Tigernut is valued for its high dietary fiber content (6). The inclusion of flour rich in dietary fiber in biscuit dough is useful in manipulating the rate of starch degradation of biscuits during digestion, and may not necessarily affect the starch and protein matrix necessary for good biscuit quality (7). Consequently, tigernut flour has been considered by many researchers as a highly valuable ingredient with tremendous potential in designing functional food products (8,9). Pigeon pea (*Cajanus cajan*) is a widely cultivated legume in Nigeria and in other tropical countries (10). Pigeon pea contains 20-22 % proteins, 1.2 % fat, 65 % carbohydrate and 3.8 % ash (11). The mineral content and amino acid profile of pigeon pea compares closely with that of soybean except in methionine content (12, 13).

From literature review, there is scanty information about any attempt to produce fortified protein biscuits by using tigernut and pigeon pea flour blends. The objectives of the study were to evaluate the proximate composition of tigernut and pigeon pea flour blends as well as the physicochemical, physical, sensory properties and *in-vitro* digestibility of biscuits prepared from the blends.

MATERIALS AND METHODS

Source of raw material

Three kilograms each of fresh tigernut and pigeon pea seeds were purchased from Minna Central Market, Minna, Nigeria.

Preparation tigernut flour

Brown tigernut seeds were sorted, winnowed and washed using cold tap water, dried at 60 °C in an air-draft oven (Gallenkamp 300 plus series, England) and then ground into flour using attrition mill (Globe P 44, China). The flour samples were passed through a 0.45 mm mesh size sieve. It was then packaged in an air tight polyethylene bag and stored in a plastic container with lid and then stored in a freezer at -18 °C from where samples were taken for analysis.

Preparation of pigeon pea flour

Pigeon pea flour was prepared as described by Onwuka (10). Pigeon pea seeds (*Cajanus cajan*) were sorted to remove foreign matters. The clean seeds were steeped in tap water for 12hrs after which the seeds were washed and drained. The drained seeds were poured into water that was boiling at 100 °C, and cooked for 80 minutes. The cooked pigeon pea seeds were sun dried for 12 hours, dehulled, winnowed and ground into flour using attrition mill (Globe P 44, China). The flour samples were passed through a 0.45 mm mesh size sieve. It was then packaged in an air ti polyethylene bag and stored in a plastic contai with lid and then stored in a freezer at -18 °C fr where samples were taken for analysis.

Formulation of blends

Tigernut and pigeon pea flours were mixed different proportions (95: 5 %; 90 : 10 %; 85 : %; 80 : 20 % and 70 : 30%) where 100% wl flour served as control. A Kenwood mixer used for mixing samples at speed 6 for 3 minute achieve uniform mixing.

Chemical analysis

The AOAC methods (14) were used in determination of the following chemical conte moisture (by the oven drying method), protei macro kjeldahl method), fat (Soxhlet solv extraction method), crude fiber, ash, carbohyd (was estimated by difference), energy (calculated using Atwater factors of 9 × fat, protein and 4 × carbohydrate) and mineral (i zinc, iodine and calcium) of flour blends biscuit samples. The *in-vitro* protein digestibilit biscuit samples were determined using procedure described by Mertz et al and Abouba et al (15 and 16) while *in-vitro* starch digestibi was determined as described by Sheib *et al.* (Phytic acid was determined by the method Haugh and Lantzch (18).

Proportion of ingredients

The proportions of ingredients used in bis production were as described by Tyagi et al. (with slight modification in terms of liquid m This consist of 100 g flour, 53.0 g of sugar, 26 of margarine, 1.10 g of sodium bicarbonate, 0.5 sodium chloride, 7.5 ml of unsweete evaporated liquid milk (peak) and 12.0 m water.

Preparation of biscuit

Creaming technique for biscuit production adopted. The fat and sugar were first blended f min. This was followed by the addition of sod bicarbonate and salt which were dissolved in of the water to be used followed by the liquid n The flour blend was transferred into the ble and blended well adding the remaining w Mixing time was between 5 and 7 minutes. dough was rolled on a flat rolling board sprin with the same flour to a uniform thickness of cm using a wooden rolling pin and cut rectangular shapes using a moulding shell biscuit dough was placed on a greased baking tray and baked in an oven at 160 °C for 10 minutes. The biscuits were allowed to cool and packaged in low density polyethylene bags of thickness 0.5 mm and stored in air tight containers for futher analysis.

Determination of physical properties of biscuits

The AACC method 10-50D (20) with slight modifications was used to evaluate biscuit width, thickness, and spread ratio. The spread ratio of biscuit samples was determined as follows: three rows of well formed biscuits were made and the height measured. Also the same were arranged horizontally edge to edge and the sum diameter measured. The spread ratio was calculated as width / height of biscuits. The break strength of the biscuit was determined using Okaka and Isieh (21) method. Biscuit of known thickness was placed between two parallel wooden bars (cm apart). Weight was added on the biscuit until the biscuit snapped. The least weight that caused the breaking of the biscuit was regarded as the break strength of the biscuits.

Sensory evaluation

Sensory properties of biscuits were determined using a twenty-member panelist consisting of students and members of Food Science option, Department of Animal Production Federal University of Technology, Minna, Nigeria. Biscuit samples prepared from each flour blend were presented in coded white plastic plates. The order of presentation of samples to the panel was randomized. Tap water was provided to rinse the mouth between evaluations. The panelists were instructed to evaluate the coded samples for appearance, crust colour, texture, flavour and overall acceptability. Each sensory attribute was rated on a 9-point Hedonic scale (1=disliked extremely while 9=liked extremely).

Statistical analysis

Data were analyzed by analysis of variance (22). The mean values were separated by least significant difference (LSD) test at 5 % probability level.

RESULTS

The chemical composition of tigernut and pigeon pea flour is shown in Table 1. Tigernut flour had higher moisture, fat, ash and crude fiber contents than pigeon pea flour while pigeon pea flour had higher contents of protein, crude fiber, phytic, iron, calcium, zinc and phosphorus.

Table 1: Proximate composition of tigernut and pigeon pea flour

Composition (%)	Tigernut	Pigeon pea
Moisture (%)	10.2±0.51	9.1±0.73
Ash (%)	3.1±0.63	1.2±0.45
Protein (%)	10.1±0.77	22.5±0.81
Fat (%)	13.2±0.54	2.7±0.11
Crude fiber (%)	4.3±0.01	1.1±0.30
Carbohydrate (%)	59.0±1.14	63.5±0.12
Phytic acid (mg/100g)	8.92±0.05	40.52±0.63
Iron	0.76±0.10	3.14±0.47
Calcium (%)	132.81±0.97	164.01±1.20
Zinc (mg/100g)	0.04±0.01	0.07±0.00
Phosphorus (mg/100g)	119.50±1.03	137.42±1.86

Mean value and standard deviation of three determinations

The chemical composition of biscuits prepared from tigernut and pigeon pea flour blends is presented in Table 2. Addition of pigeon pea flour to tigernut flour increased the contents of protein (11.64 to 17.81 %), moisture (4.11 to 5.92 %), fat (12.80 to 18.40%), ash (2.43 to 3.63%), crude fiber (3.81 to 4.95%) and energy value (437.84 to 453.36 kcal) while carbohydrate content decreased (from 69.02 to 54.13%) in biscuits. However, protein, fat, carbohydrate and energy values of biscuits prepared from tigernut and pigeon pea flour blends were significantly ($p \leq 0.05$) higher than wheat flour biscuit.

The results of mineral composition, phytic acid an in-vitro (starch and protein) digestibility of biscuit are shown in Table 3. Mineral contents of tigernu pigeon pea biscuits such as iron, calcium, zinc ar phosphorus were significantly ($p \leq 0.05$) high than wheat biscuit. Addition of pigeon pea flour tigernut flour increased the contents of iron (3. to 3.81mg/100g), calcium (60.15 87.69mg/100g), zinc (0.50 to 1.27mg/100g) a phosphorus (223.19 to 248.17mg/10 respectively. The phytic acid contents of biscuits ranged from 1.94 to 2.37 mg/100 g. Th were no significant ($p \geq 0.05$) difference in ph acid content between 100% wheat flour biscuit composite biscuits. The in-vitro starch digestib of biscuit samples ranged from 25.43 to 57.2 with composite biscuits having low st digestibility value than 100 % wheat biscuit. T were significant ($p \leq 0.05$) differences in in-starch digestibility among biscuit samples. Th *vitro* protein digestibility of biscuit samples ra from 60.20 to 71.57%.

The physical properties of biscuits prepared from tigernut and pigeon pea flour blends as well as 100% wheat flour are shown in Table 4. The width, thickness and spread ratio of biscuits ranged from 19.63 to 22.70 cm, 0.41 to 0.51 cm and 38.49 to 53.37 respectively. Biscuits prepared from tigernut and pigeon pea flour blends were significantly ($p \leq 0.05$) higher in width and spread ratio than 100% wheat flour biscuit.

The break strength of biscuits varied between 1.28 and 3.30 kg. The break strength of 100% wheat flour biscuit was significantly ($p \leq 0.05$) higher than biscuits prepared from tigernut and pigeon pea flour blends However, the break strength of composite biscuits decreases with increasing level of pigeon pea flour addition.

Table 5 shows the sensory properties of biscuits prepared from tigernut and pigeon pea flour blends and 100% wheat biscuit. There was no significant ($p \geq 0.05$) difference in appearance, flavour, crust colour and overall acceptability between control sample and composite biscuits

DISCUSSION

The high protein content in pigeon pea flour was expected since legumes contain higher protein content than tubers. The variation in moisture content between tigernut and pigeon pea flour samples may be due to variation in drying time and oven temperature. The increase in protein values of composite biscuits may be attributed to addition effect caused by pigeon pea flour due to the complementation of tigernut flour with pigeon pea flour that contain higher amount of protein. Based on the results of the protein values of composite biscuits obtained in this study when compared to 100% wheat flour biscuit, it can be inferred that the composite biscuit samples are nutritious. This is because about 100 g of each product formulation would provide more than half of the recommended daily requirement for protein (25 to 30 g /day) and about one of six of the requirement for energy (1790 to 2500 kcal /day) as recommended by FAO/WHO (23) for children aged between 5 and 19 years. This fact suggests that biscuits prepared from flour blends comprising of tigernut and pigeon pea could usefully be included in school feeding programmes for children. The increase in moisture of biscuits prepared from tigernut and pigeon pea flour blends as a result of increase in addition of pigeon flour could be due to the presence of polar amino acids and the positive influence of increasing levels of protein on water-holding capacity, taking into consideration the higher hydration rate that is associated with higher protein content. The moisture values (4.05 to 5.92 %) of biscuits obtained in this study were below the maximum level (6.0 %) recommended by Nigerian Industrial Standard (NIS) requirement for biscuits by SON (24). The protein, ash, fat and energy values of biscuit samples obtained in this study is higher than the values of 9.21 to 11.00 % (protein), 1.80 to 1.91 % (ash), 2.05 to 2.70 % (crude fiber) reported by Hooda and Jood (25) for wheat-fenugreek flour biscuits and 5.00 to 14.19 % (protein) reported by Ayo *et al.* (2) for Acha-soybean biscuits.

The increase in mineral contents of composite biscuits as a result of pigeon pea flour addition to tigernut flour could be attributed to the relatively higher mineral contents of the former. From the results of the mineral composition of biscuits as shown in Table 3, it is evident that biscuits prepared from tigernut and pigeon pea flour blends are more nutritious than 100 % wheat flour biscuit. The mineral content of biscuits obtained in this study is in agreement with the values reported by Škrbic and Cvejanov (26) for wheat-sunflower-barley cookies.

The phytic contents in composite biscuits increased slightly with increasing level of pigeon pea flour addition. Manufacturing processes such as kneading, soaking and baking, play a key role on the reduction of phytic acid content of the final product and thus on the mineral bioavailability (27). The phytic acid levels (1.94 to 2.20 mg/100 g) of the composite biscuits obtained in this study were lower than the range (6.2 to 9.9 mg /100 g reported for wheat-pumpkin biscuit by (28) and 69.7 to 244 mg/100g reported by Hooda and Jood (25) for wheat-fenugreek biscuits.

The decrease in in-vitro starch digestibility of biscuits may be attributed to increase in crude fiber content in the blends which may have caused reduced starch digestibility by trapping starch granules within a viscous protein–fiber–starch network. The presence of non-starch carbohydrates (dietary fiber) has been reported to influence the starch digestibility due to the non specific adsorption of the enzyme molecules dietary fiber or entrapment of starch in the fibre matrix (29). Another possible reason may be limitation of water availability as a consequence of soluble non-starch polysaccharide hydration which can restrict gelatinization of starch and hence reduce hydrolysis by α-amylase (30). Apart from crude fiber, an increase in pigeon pea flour that caused an increase in protein and fat contents of composite biscuits (Table 2) may be responsible for the decrease in starch digestibility. The presence of protein bodies around starch granules may restrict granule swelling and starch gelatinization and hence, reduces the susceptibility to enzymatic attack (31). The poor starch digestibility of biscuits prepared from tigernut and pigeon pea flour blends indicates their potential as a functional food for use in nutrition therapy in the treatment of conditions such as obesity and diabetes.

In-vitro protein digestibility is an important criterion for evaluation of protein quality as well as an indicator for protein bioavailability in foods. The in-vitro protein digestibility of biscuits prepared from tigernut and pigeon pea flour blends were significantly ($p \leq 0.05$) higher than control sample up to 15 % level of pigeon pea flour addition, which implies that these composite biscuits have better nutritional value than 100% wheat biscuit. According to Ali *et al.* (32), a protein with high digestibility is potentially of a better nutritional value than the one of low digestibility because the former provides more amino acids on proteolysis. On the other hand, the decrease in *in-vitro* protein digestibility of composite biscuits as the level of pigeon pea addition increases could be attributed to interaction between anti-nutrients and proteins to form complexes which increases the degree of cross-linking thereby decreasing the solubility of protein and making protein complexes less susceptible to proteolytic attacks thereby affecting the protein digestibility. The *in-vitro* protein digestibility values of biscuits obtained in this study is in close range with the values of 37.2 to 70.8 % reported by Hooda and Jood (25) for wheat-fenugreek biscuits.
The width and spread ratio of composite biscuits increased with increasing level of pigeon pea flour in the blend while thickness and break strength decreased. The changes in width and height are reflected in spread ratio which depends on width and height of the biscuit. Biscuits having higher spread ratio are considered most desirable (33). Our results for spread factor and thickness were in close agreement to those reported by Ayo *et al.* (2) for biscuits prepared from acha-soybean flour blends. The break strength is a mechanical property that is important in determining the perception of the biscuit in the mouth and plays an important role in product acceptance. The reduction in break strength and thickness of the biscuit may be related to the dilution effect the fiber has on the starch-protein matrix of the biscuits since tigernut flour contained higher amount of crude fiber. This is likely to disrupt the formation of a homogeneous matrix and hence lead to a weakening in biscuit structure..

An important aspect in designing biscuits with improved nutritional quality is the maintenance of a product's sensory characteristics because consumers' acceptability remains the key factor which determines the successful application of a newly developed product. There was no significant ($p \geq 0.05$) difference in appearance, flavour, crust colour and overall acceptability between control sample and composite biscuits. Although, texture scores between the control sample and composite biscuits did not show any significant ($p \geq 0.05$) differences up to 20% pigeon pea flour addition, the scores decreased slightly with increase in pigeon pea flour addition. The texture scores were in good agreement with the results of the breaking strength of biscuits. In terms of overall acceptability, biscuit prepared from 80: 20 (tigernut: pigeon pea) flour blends had the highest score and considering other sensory attributes as judged by the panelist, this blend was rated high.

CONCLUSION

This study has revealed that an acceptable biscuit can be prepared using tigernut and pigeon pea flour blends. The width and spread ratio of composite biscuits increased with increasing level of pigeon pea flour in the blend while thickness and break strength decreased. The use of tigernut and pigeon pea flour in biscuit preparation resulted in significant improvement in protein, crude fiber, ash and energy values with decreased carbohydrate content in composite biscuits than 100% wheat biscuit. The composite biscuits had poor starch and high protein digestibility which confirms their potential as a functional food.

REFERENCES

1. O'Brienа CM, Chapmanb D, Neville DP, Keogh MK, Arendt EK., Effect of varying the micro-encapsulation process on the

functionality of hydrogenated vegetable fat in short dough biscuits. Fd. Res. Int. 2003; 36:215–21

2. Ayo JA, Nkama I. and Adewori R. Physicochemical, invitro digestibility and organoleptic evaluation of "acha"-wheat biscuit supplemented with soybean flour. Nig. Fd. J. 2007; 25(2):77-89

3. Akubor P I. Protein contents, physical and sensory properties of Nigerian snack Food (cake, Chin-chin and puff-puff) prepared from cowpea-wheat flour blends. Int. J. Fd. Sci. Tech. 2004; 39(4):419-424

4. Eteshola E. and Oraedu, ACI. Fatty acids composition of Tigernut tubers (*Cyperusesculentus L.*), baobab seeds (*Adansonia digitata L.*) and their mixtures. J. Am. Chem. Soc. 1996; 73: 255–267

5. Anonymous 2005. Tigernut and health. http://www.tigernut.com/salad.html [accessed 4th June 2009]

6. Umerie SC and Enebeli JN. Malt caramel from the nuts of *Cyperus esculentus*. J. Biores. Techn. 1997; 52: 215 – 216

7. Brennan CS and Samyue E. Evaluation of starch degradation and textural characteristics of dietary fibre enriched biscuits. Int. J. Fd. Prop.2004; 7:647–757

8. Chinma CE, Abu JO and Abubakar YA . Effect of tigernut (*Cyperus esculentus*) flour addition on the quality of wheat-based cake. Int. J. Fd. Sci. Techn. 2010; 45:1746-1752

9. Chinma CE, Adewuyi AO. and Abu JO. Effect of germination on the chemical, functional and pasting properties of flour from brown and yellow varieties of tigernut. Fd. Res. Int. 2009; 42 (8):1004-1009

10. Onwuka GI. Soaking, boiling, and antinutritional factors in Pigeon pea (*Cajanu cajan*) and Cowpea (*Vigna unguiculata*). J. Fd. Proces. Preserv. 2006; 30: 616- 630

11. FAO/WHO. Energy and protein requirements. Food and Agriculture Organization. Nutrition meeting report Series 52, Rome: World Health Organization Technical Report Series, 1973, 522

12. Apata DF. and Ologhobo AD. Biochemical evaluation of some Nigerian legumes seeds. Fd. Chem. 1994; 49: 333-338.

13. Osagie, AU. Antinutritional factors. In A. U. Osagie and O. U. Eka (Eds.) Nutritional quality of plant foods. Published by Post Harvest Research Unit, Department of Biochemistry University of Benin, Nigeria, 1998, Pp: 53-83.

14. AOAC. 'Official methods of Analysis'. Association of official analytical chemist. 17th edition, Washington DC.2000

15. Mertz E, Hassan MM, Cairuns-Whittem C, Wrleis AW, Tu L and Axtell, JD. Pepsin digestibility of proteins in sorghum and other major cereals. Proceedings of the National Academy of Science,1994; 22:85-93

16. Aboubacar A, Axiell JD, Huagng C and Hamaker D. A rapid protein digestibility assay for identifying highly digestible sorghum lines. Cereal Chem. 2001; 78(2):160-165

17. Sheib AL, Sanir ME and Abo-Bkr MT. Studies on amylase inhibitors in some Egyptian legume seeds. Plant Fds. Hum. Nutr. 1988; 38:325-352

18. Haug W and Lantzsch HJ. Sensitive method for the rapid determination of phytate in cereals and cereal products. J. Sci. Fd. Agric. 1983; 34:1423–1426

19. Tyagi, S. K., Manikantan, M. R., Harinder, S. Oberoi., and Kaur, Gurlen. Effect of mustard flour incorporation on nutritional, textural and organoleptic characteristics of biscuits. Journal of Food Engineering (2007), 80, 1043–1050.

20. AACC. Approved methods of the American Association of Cereal Chemists, method 10 91 (10th edn.) 2000. St. Paul, MN American Association of Cereal Chemists Inc.

21. Okaka JC and Isieh MI. Development and quality evaluation of cowpea-wheat biscuit. Nig. Fd. J. 1990; 5:56-60

22. Steel RDG. and Torrie JH. Principle and Procedures of Statistics. A Biometrical Approach. 2nd edn. McGraw Hill Co. New York, 1980, P. 623

23. FAO/WHO. Energy and protein requirements. Food and Agriculture Organization. Nutrition meeting report Series 72 Geneva, Switzerland: World Health Organization Technical Report Series; 1985, Pp 13-205

24. Standard Organization of Nigeria (SON). Nigerian Industrial standard for biscuits. ICS. 2007, 664.68, Pp 1-8.

25. Hooda S and Jood S. Organoleptic and nutritional evaluation of wheat biscuits supplemented with untreated and treated fenugreek flour. Fd. Chem. 2005; 90:427-435

26. Škrbic B and Cvejanov J . The enrichment of wheat cookies with high-oleic sunflower seed and hull-less barley flour: Impact on nutritional composition, content of heavy elements and physical properties. Fd. Chem. (in press, 2010)

27. Lopez HW, Coudray C., Levrat-Verny MA., Feillet-Coudray C, Demigne C. and Remesey C. Fructooligosaccharides enhance mineral apparent absorption and counteract the deleterious effects of phytic acid on mineral homeostasis in rats. J. Nutr. Biochem. 2000; 11: 500-508

28. Giami SY, Achinewhu SC, Ibaakee C. The quality and sensory attributes of cookies supplemented with fluted pumpkin seed flour. Int. J. Fd. Sci. Tech.2005; 40:613-620.

29. Altan A, Mccarthy K.L and Maskan, M. Effect of extrusion cooking on functional properties and *in vitro* starch digestibility of barley-based extrudates from fruit. J. Fd. Sci. 2009; 74 (2): E77-E86

30. Tester RF and Sommerville MD. The effects of non-starch polysaccharides on extent of gelatinization, swelling and α-amylase hydrolysis of maize and wheat starches. Fd. Hydrocoll. 2003; 17:41-54

31. Aarathi A, Urooj A, Puttaraj S. In vitro starch digestibility and nutritionally Important starch fractions in cereals and their mixtures. Starch/Starke, 2003; 55:94-99

32. Ali, MAM., El Tinay AH, Mallasy, LO and Yagoub AEA. Supplementation of pearl millet flour with soybean protein: effect of cooking on in vitro protein digestibility and essential amino acids composition. Int. J. Fd Sci. And Tech. 2010; 45:740-744

33. Kissel L. and Prentice M . Protein and fibre enrichment of cookie flour with brewer's spent grains. Cereal Chem. 1979; 50: 261−265