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Comparative Studies on the Chemical Compositions of Cereal (Wheat and Corn) and Tubers (Water Yam and Bitter Yam) Flours

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ABSTRACT

The chemical components of four flour samples (wheat, corn, bitter yam and water yam) were determined. The proximate, vitamins and mineral contents were determined. Protein contents for the samples ranged from (6.11–11.62 %), fat (0.73–0.47 %), moisture content (7.57–10.47 %), Ash (0.41–30.33 %), fibre (1.68–3.33 %) and carbohydrate (73.76–80.38 %). Sodium (Na), potassium (K), iron (Fe), calcium (Ca) and magnesium (Mg) ranged from 2.68–4.01 mg/kg, 48.50-70.25 mg/kg, 0.70–7.50 mg/kg, 220–8.05 mg/kg and 6.50–9.50 mg/kg respectively. Bitter yam had higher vitamin A contents (23.00 mg/100g) and vitamin C (24.78 mg/100g) while vitamin E content was high in wheat. The chemical composition of the samples showed that the protein contents of the water and bitter yam flour were within the recommended range.

Keywords: Yam, Proximate, Mineral, Wheat, Corn

1.0 INTRODUCTION

Most tropical countries are faced with protein energy malnutrition as a result of increasing population. It is estimated that about 800 million malnourished people exist in some of the least developed countries mostly in sub-Saharan Africa (Meyers, 1997; FAO, 2010). In

countries such as Nigeria and most of the sub-Saharan countries, animal products representing high concentration and quality of protein are either too expensive or simply unaffordable. Flour is a fine powder made from cereals, roots and tuber crops and other starch based produce. Composite flour include yam, cassava, cocoyam, sweet potato, instant yam flour (Sanni *et al.*, 2006). Cereals grains are eaten in several ways and in most cases; they are milled into flour and utilized in preparing various items. Maize (*Zea mays*) is a cereal crop widely cultivated in Nigeria and the tropics

Wheat is the most important stable food crop for more than one third of the world population and it contributes more calories and proteins to the world diet than any other cereal crops (Kumar, *et al.,* 2011). It is nutritious, easy to store and transport and can be processed into various types of food. Wheat is considered as good source of protein, minerals, B-group vitamins and dietary fibre (Shewry, 2007) although the environmental conditions can affect nutritional composition of wheat grains with its essential coating of brain, vitamins and minerals; its an excellent health-building food. Wheat flour is used to prepare bread, produce biscuits, confectionary products, noodles and vital wheat gluten.

Root and tuber flour such as cassava flour, yam flour and potato flour are ranked next in importance to the cereal grains flour in providing the major part of the daily calories needs of people in the tropics. Yam (*Dioscorea spp.)* is a major food crop in West Africa particularly in Nigeria, Benni, Togo, Ghana and Cote d' lvore. This is a source of substantial income for farmers and traders. Traditionally, cultivated on subsistence basis, yam is now traded in large commercial quantities especially in the urban areas (Essotina and Etoudo, 2010). Its role in food security is justified by its potential energy, it insensitivity to climatic (Bricas, 1998) and its adoption as a staple in Africa well before the introduction of new crops of the new world such as

corn, cassava. Many species of yam are grown and are distinguished from each other by colour of the fresh tubers, the morphology of leaves and stems of flowers and sworn (Okigbo and Nwakammah, 2005). The production of yams in the world in general and West Africa in particular is constantly growing. The yam crops production according to Lawrence *et al.,* (2006) was 40 million tons. Excess production set subject to rot and slump because traditional conservation techniques are not effective (50% loss after 6 months of conservation) (Djeri, *et al.,* 2010). This study determined the chemical compositions of cereal (wheat and corn) and tubers (water yam and bitter yam) flours..

MATERIALS AND METHODS

PREPARATION OF THE SAMPLES

Yam tubers were washed and hand-peeled. The peeled tubers were then sliced, rinsed in clean potable water and soaked overnight for 12 hr. The soaked yam slices were mashed and sun dried. After drying, the yam chips were milled into flour using a disc attrition mill (mill machine, CS1R - FRI). A flour sifter (flour sifter, CSIR – FRI) with a 250 µm screen was used to remove fibres and larger particles to obtain fine flour with a uniform particle size. The flour was packaged in high density polyethylene (HDPE) bags, sealed and stored at 27 $\pm$ 3^0C before use. The wheat and maize grains were sorted to remove spoilt grains, stones and other foreign materials. The grains were then milled separately with a laboratory disc attrition mill and sifted in a 250µm sieve. The flours were packaged in High Density polyethylene (HDPE) bags, sealed and stored at 27 $\pm$ 3^0C before use

ANALYSES

The proximate analysis ere determined using AOAC (2006) methods. The mineral contents were evaluated using AOAC (2006) methods. Also the vitamin contents were determined. The Amino acid contents were investigated by chromatogram peaks

STATISTICAL ANALYSIS

All determinations were carried out in triplicate. Data were subjected to statistical analysis using SPSS 16.0 and means were separated using Duncan multiple Ranges Test (DMRT)

RESULTS AND DISCUSSION

The chemical composition of wheat, corn, water yam and bitter yam flours were presented in Table 1. Wheat flour had the highest value of protein of 11.62%, bitter yam, 7.33%, water yam 7.05% and corn flour 6.11% .water yam had lower protein content than wheat flour and bitter yam had slight higher value of protein than water yam. Corn flour had the lowest protein value. This result is in line with the report of Enriquez *et al.,* (2003) that water yam flour had lower protein content than wheat flour (10%), but higher than other *Dioscorea spp* such as *D. bulbfera* (1.2%), *D. cayanensis* (1.3%) and *D. rotundata* (1.8%) (Igyor, *et al.,* 2004).

All the flour samples had very low fat values ranging between 0.73 – 1.96%. Water and bitter yam flours are not a good source of fat. The fat values of all the yam flours were very low and are comparable to the values in other root and tuber crops like potato 0.4g/100 (Bradbury and Holloway, 1988) and Cassava 0.3g/100g (Richard and Coursey, 1981).

Moisture content of flour is very important for it shelf life, lower the flour moisture, the better it storage stability (Butt, *et al.,* 2004). The values for moisture content ranged between

7.68–10.55% for all the flour samples. This is in agreement with the result of Sobukola *et al.*, (2008) for potato flour. Butt *et al.* (2004) also reported low moisture in corn flour and wheat flour had less moisture as compared to bitter and water yam flours. Moisture content is affected significantly due to processing, treatments packaging and their interaction. The ash content of bitter yam flour was 2.46% and that of water yam flour was 3.33% which was in accordance with result of Baah (2009) and Adegunwa *et al.* (2011). There was a correlation between flour lightness and ash content. The ash content in wheat and corn flours decreased respectively (1.08% and 0.41%).

The crude fibre content of all the flour samples ranged from 1.68 and 2.82%. Water yam flour had the highest value with 3.33%. High fibre is one of the superiority of water yam tuber. It could be processed for rich foods or functional food (Schults, 2011). The carbohydrate content generally was high across all the flour samples and this account for high energy calories.

Table 1: Proximate composition of flours from grains (wheat and corn) and yams (water and bitter)

Sample	Protein (%)	Fat (%)	Moisture (%)	Ash (%)	Fiber (%)	Carbohydrate (%)
Wheat	11.62 ± 0.54^{a}	0.73 ± 0.01^{b}	7.57 ± 0.04^{b}	1.68 ± 0.03^{c}	1.68 ± 0.01^{c}	77.36 ± 0.48^{b}
Corn	6.11 ± 0.00^{b}	1.96 ± 0.03^{a}	8.32 ± 0.03^{b}	0.41 ± 0.01^{d}	2.82 ± 0.05^{b}	80.38 ± 0.1^{a}
Water yam	7.05 ± 0.15^{b}	1.95 ± 0.10^{a}	10.47 ± 0.10^{a}	3.33 ± 0.00^{a}	3.33 ± 0.00^{a}	73.76 ± 0.71^{b}
Bitter yam	7.33 ± 0.15^{b}	$1..96\pm0.00^{a}$	8.35 ± 0.00^{b}	2.46 ± 0.08^{b}	2.46 ± 0.07^{b}	74.92 ± 1.17^{b}

Means within columns with the same letter are not significantly different ($p< 0.05$)

Table 2 shows the mineral composition of flours from grains (wheat and corn) and yams (water and bitter). The values of mineral contents are dependent in the following factors season, species, soil types and cultural practices adopted during planting (Steven *et al.*, 1985). The most abundant mineral in the flours are potassium with the following values respectively for the flour samples (55.22 mg/kg/, 48.50 mg/kg, 52.50 mg/kg and 70.25 mg/kg) this observation is consistent with the reports of Olaofe and Sanni, (1988) and Oshodi *et al.*, (1999) that potassium is the most abundant mineral in Nigeria agricultural products. Potassium and sodium are required to maintain osmotic balance of body fluid, pH of the body, regulate muscle and nerve irritability, control glucose absorption and enhance normal retention of protein during growth, NRC, (1989), their presence in the diet is therefore desirable. The recommended daily allowance (RDA) of K, Na and P for and adult man is 2,500 mg/100g, 2,500 mg/100g and 800 mg100g respectively (NRC/NAS, 1980) assuming 100% absorption. There were no significant difference in the values of Ca and Mg in wheat, corn and water yam flours but the values of ca and mg in bitter yam had significant difference of ($P \leq 0.05$).

Table 2: Mineral content of flours from grains (wheat and corn) and yams (water and bitter) mg/kg

Sample	Na (mg/kg)	K (mg/kg)	Fe (mg/kg)	Ca (mg/kg)	Mg (mg/kg)
Wheat	3.56 ± 0.50^{a}	55.52 ± 7.78^{bc}	7.50 ± 0.71^{a}	2.75 ± 0.71^{b}	7.07 ± 0.38^{b}
Corn	2.68 ± 0.33^{b}	48.50 ± 3.54^{c}	6.70 ± 0.71^{a}	3.02 ± 0.68^{b}	6.75 ± 0.68^{b}
Water yam	3.50 ± 0.00^{a}	52.50 ± 2.12^{bc}	7.49 ± 0.73^{a}	2.20 ± 0.99^{b}	6.50 ± 0.71^{b}
Bitter yam	4.10 ± 0.14^{a}	70.25 ± 0.78^{a}	0.70 ± 0.14^{b}	8.05 ± 0.21^{a}	9.50 ± 0.71^{a}

Means within columns with the same letter are not significantly different ($p < 0.05$)

Table 3 presented the vitamin contents of flours from grains (wheat and corn) and yams (water and bitter) the vitamin A in water yam flour and bitter yam flour were significantly different to other flours, while vitamin A in wheat and corn flour are not significantly different. There were no significant differences ($p \geq 0.05$) in all the four flour samples for vitamin B. There were no significant differences ($p>0.05$) for samples of water yam and bitter yam flours for vitamin C and wheat and corn flours there were significant difference ($p \geq 0.05$). The observed results agreed with those of Lanauskas *et al.* (2006) and Liu *et al.* (2008). Ascorbic acid is important in the formation of intercellular substances of the body. Its deficiency leads to weakening of the endothelial wall of the capillaries due to reduction in the amount of intercellular substances (Hunt *et al.*, 1980). It is required for normal healing of wounds (Okwu, 2004).

Table 3: Vitamin contents of flours from grains (wheat and corn) and yams (water and bitter) mg/100g

Sample	Vit A (mg/100g)	Vit B (mg/100g)	Vit C (mg/100g)	Vit E (mg/100g)
Wheat	11.3 ± 1.56^{c}	0.45 ± 0.03^{a}	19.60 ± 0.57^{b}	10.41 ± 0.01^{a}
Corn	8.70 ± 0.42^{c}	0.43 ± 0.05^{a}	16.05 ± 1.48^{c}	0.06 ± 0.01^{c}
Water yam	17.70 ± 0.42^{b}	0.15 ± 0.12^{b}	23.75 ± 0.35^{a}	0.33 ± 0.01^{b}
Bitter yam	23.00 ± 1.41^{a}	0.07 ± 0.00^{b}	24.78 ± 0.31^{a}	0.37 ± 0.01^{b}

Means within columns with the same letter are not significantly different ($p< 0.05$)

Table 4 showed the essential amino acid of the flour samples. The predominant essential amino acids in wheat, corn, water and bitter flours were leucine, valine, phenylalanine and isoleucine with trytophen, methionine respectively. Amino acids are important components for healing and

protein synthesis processes: any deficiency in these essential components will hinder the recovery process (Zuraini et al. 2006).

The values obtained for the four flour samples were above the recommended 39 % considered to be adequate for ideal protein food for infants 26% for children and 11% for adults (FAO/WHO/UNU, 1985). These flours therefore compare favourable with some proteinous foods as reported by previous authors in beach pea isolate, subtropical red and green seaweeds and pigeon pea flour (Chavan et al., 2001). The sulphur containing amino acids (met+cys) in wheat was 2.45g/100g, corn (5.43g/100g) bitter yam (2.55g/100g) and water yam (2.56g/100g) were obtained. The aromatic essential amino acids were 7.03g/100g wheat, 8.07g/100g corn, 8.68g/100g bitter yam and 9.72g/100g water yam.

Table 4 Amino acid composition of grains (wheat and corn) and yams (water and bitter)

Essential Amino Acid	Wheat mg/100g	Corn mg/100g	Bitter yam mg/100g	Water yam mg/100g	FAO/WHO/UNU mg/100g
Threonine	3.25±0.28^{c}	3.25±0.33^{c}	2.38±0.18^{d}	3.50±0.01^{bc}	
Tyrosine	2.75±0.01^{d}	3.79±0.01^{c}	3.79±0.01^{c}	3.10±0.01^{c}	25
Methionine	1.75±0.71^{e}	4.28±0.28^{b}	1.40±0.01^{e}	1.19±0.13^{d}	10.4
Valine	4.75±0.70^{b}	4.75±0.71^{b}	4.56±0.66^{b}	4.53±0.66^{b}	26
Phenyl alanine	4.28±0.28^{b}	4.28±0.28^{b}	4.89±0.21^{b}	6.62±0.17^{a}	25
Isoleucine	3.08±0.7^{c}	3.02±0.17^{c}	3.04±0.06^{c}	3.65±0.07^{bc}	10
Leucine	6.27±0.35^{a}	8.87±1.08^{a}	7.03±0.18^{a}	6.15±0.21^{a}	14
Lysine	2.60±0.71^{d}	2.60±0.71^{d}	3.04±0.06^{c}	4.31±0.14^{b}	12
Cystine	1.70±0.12^{e}	1.15±0.17^{e}	1.15±0.13^{e}	1.37±0.12^{d}	4.1
Tryptophan	1.33±0.33^{f}	1.33±0.71^{e}	1.10±0.14^{e}	1.10±0.14^{d}	4.0
Total Ess A.A	32.48	37.32	33.01	35.52	
TSAA (Meth+cys)	2.45	5.43	2.55	2.56	
Ar. E.A.A (Phe + Try)	7.03	8.07	8.68	9.72	

Means within columns with the same letter are not significantly different ($p< 0.05$)

Conclusions

Wheat flour had the highest protein value and corn flour had the lowest value. The moisture content of wheat flour was the lowest and water yam flour had the highest due to the water content of the yam. Mineral compositions of the flours showed that potassium was abundant for the flour samples. The amino acid composition of the four samples showed that the values obtained for the samples were above the recommended 39% for infants, 26% for children, and 11% for adults.

REFERENCES

Adegunwa, M.O., Alamu, E.O. and Omitogun, L.A. (2011). Effect of Processing on the Nutritional Content of Yam and Cocoyam Tubers, *Journal of Application of Bioscience* 46: 3086 – 3087.

Alan, J.B., Changrun, L.M.S., Fergus, M., Clydesdale, F.A., and Decker, E.A. (2000). Potential of Wheat-based Break fast cereals as a source of Dietary antioxidants. *Journal of the American College of Nutrition*, 19(3); 3113.

AOAC (2000). Association of Official Analytical Chemists, Official Methods of Analysis, Anlington, Virginia, USA; 152 – 154.

AOAC, (2006). Official Methods of Analysis. International 18th edn. Association of Official Analytical Chemist Washington D C, USA.

Baah, D.F. (2009). Characterization of Water Yam (*Dioscorea alata*) for Existing and Potensial Food Products. Thesis, Faculty of Biosciences Kwame Nkrumah University, Nigeria.

Bancroft, R.D. (2000). Relieving Post-Harvest Constraints and Identifying Opportunities for Improving the Marketing of Fresh Yam in Ghana. 1st January – 31st March, 2000. Final Project Report No: R6505 Natural Resources Institute University of Greenwich, Chatham, Kent UK, 51 pp.

Beran, C.W. Broadbend, J.H., and Hirst, J. (1956). Nature 177:935

Bradbury, J.H and Holloway, W.D. (1988) Chemistry of Tropical Root Crops: Significance for Nutrition and Agriculture in the pacific. ACIAR Monograph No. 6, 180pp

Bricas , N. (1998) A Tuber in High Growth Potential Network Newsletter, December TPA,Pp 4-8

Butt, M.S., Nasir, M., Akhtar, S. and Sharif, K . (2014). Effect of Moisture and Packaging on te Shelf life of Wheat Flour. *Journal of Food Safety*, 5, 4.

Chavan, U.D., Mckenzie, D.B. and Shahidi, F. (2001). Functional Properties of Protein Islates from Beach Pea (*Lathyrus maritimus L.*) Food Chemistry 74: 177 – 187.

Corkill, N.L. (2008). The Poisonous Wild Cluster Yam, D. Dumetorum. Pax as a Framine Food in the Anglo-Egyptian Sudan. Annual Tropical Medical Parasit 42: 278 – 287.

Dattatreya, Y.C., Czuchajowsko, Z; Martin, C.R. and Lai, F.S. (2012). Determination of Corn Hardness by the Stenvert Hardness Tester, Cereal Chemistry 62(9): 108 – 110.

Djeri,B., Ameyapoh, Y., Karou, D.S.,Ananii, K.,Soncy,K., Adjah, Y. and Souza, C. 2010.Assessment of Microbiological Qualities of yam Chips Marketed in Toyo. Advance *Journal of Food Science and Technology* 2 (5): 236- 241.

Enriquez, N.M., Peltzer, A., Raimundi, V. and Pollio, M.L. (2003). Characterization of Wheat and Quinoa Flour. Blends in Relation to their Bread making Quality. *Journal Argen.* Chemic Soc., 91 (4): 47 – 52.

Essotina, K.K. and Etoudo,N. (2010) Baseline Survey Report on the Status of Yam Research in Togo. Togo Agricultural Research Institute. (ITRA) Togo.

FAO, (2010) . Prevention of Post Harvest Food Losses; Fruit Vegetable and Root Crops: and Training Manuals FAO, Code 17.J11;1-4.

FAO/WHO/UNU: (1985 and Protein Requirements, Report of a joint FAO/WHO/UNU Expect Consuitation. WHO T ECHNICAL Report Series 742. WHO Genera.

Hadjivassiliou, M., Grunewald, R.A., Sharrack, B., and Williamson, C. (2003), Gluten Ataxia in perspective: Epidemiology, Genetic susceptibility and Clinical characteristics. Brain, 126: 685 – 69D.

Henry, T.A. (2005). In the plant Alkaloids. 4th ed. Churchill, London p. 112.

Hunt, S., Groft, J.L. and Holbrook, J. (1980). Nutrition Principles and Chemical Practices. John Wiley and Sons. New York pp. 49 (52), 429.

Igyor, M.A., Ikyo,S.M. and Gernah, D.I.(2004) The Food Potential of Potata yam (*Dioscore bulbifera*) *Nigerian Food Journal* 22:209-210

Jamin, F.F. and Flories, R.A. (1998). Effect of Additional Separation and Grinding on the Chemical and Physical Properties of Selected Corn Dry Milled.

Johnson, D.B., McAloon, A.J., Moreau, R.A., Hicks, K.B. and Singh, R. (2005). Composition and Economic Comparison of Germ. Fractions Derived from Modified Corn Processing Technologies. *Journals of the American Oil Chemist's Society* 82, 603 – 605.

Keran, N.L., Paulsen, M.R. and Hills, L.D. (2009). Corn Quality Factors Affecting Dry milling Performance. *Journal of Agricultural Engineering Research* 31: 225 – 227.

Kumar, R K, Lazar, M E and Poland, G.J (2011). Moisture Sorption and Packaging Characteristics of Arabian dry Cereal Foods. *Journal of Food Science Technology* 37(3): 330 – 331.

Lanauskas, J., Uselis, N., Valiuskalte, A. and Viskelis, P. (2006). Effect of Foliar and Soil Applied Fertilizers on Strawberry Healthiness, Yield and Berry Quality. Agronomy Research, 4: 247 – 250.

Lawrence, K., Ponniah, A., and Cosmas,O.(2006) A Synthesis / Lesson- Learning Study on the Research Carried out on Root and Tuber Crops Commissioned through the DFID RNRRS Research Programes between 1995 and 2005.Pp:4

Liu, Z.H., Jiang, L.H., Hardter, R. and Zhang, W.J. (2008). Effect of Na and K Fertilizer on Yield and Quality of Green Vegetable Crops. Pedosphere, 18(4): 498.

Motoi, H. and Kodama, T. (2003) Isolation and Characterization of Angiotensin 1-Converting Enzyme Inhibitory Peptides from Wheat Gliadan Hydrolysate. Nahrung, 47: 345.

National Research Council (1989). Recommended Dietary Allowances 10th edition. National Academy Press. Washington D.C. USA

Neuhausen, S.L., Steele, L., Ryan, S., and Mousavi, M. (2008). Co-occurrence of Celiac Disease and other Autoimmune Disease in Celiac and their First Degree Relatives. *Journal of Autoimmunisy*, 31:165.

Norman, N.P. (1977). Food Science. The AVI Publishing Company Shahdafa India. Pp. 510–521.

Okigbo,R. And Nwakammah,P.(2005) Biodegradation of White yam (*Dioscorea rotundata*) and Water yam conditions. *Science Technological Journal* 3: 577-580

Okwu, D.E. (2004). The Phytochemicals and Vitamins Contents of Indigenous Spices of South Eastern, Nigeria. *Journal of Agriculture Environment* 6: 30 – 34

Olaofe,O. and Sanni, C.O.(1988) Mineral Contents of Agricultural Products. Food Chemistry 30: 73-74

Oselebe, H.O. and Okporie, E.O. (2005). Evaluation of Water Yam *(Dioscorea alata)* Hybrids within Abakaliki Agro-Ecological zone. In Proceedings of the 30th Annual National Conference of the Genetic Society of Nigeria, Nsukka, September 5 – 8; pp 110 – 113.

Oshodi, A.A., Ogungbenle, H.N. and Oladeji, M.C. (1999). Chemical Composition, Nutritionally Valuable Minerals and Functional Properties of Benni Seed (sesamum radiation), Pearl Millet (*Pennisetum typhoides*) and Quinoa (*Chenopodium quinoa*) flours. Inter, National. *Journal Food Science and Nutrition* 50: 325 – 331.

Otoo, E. and Asiedu, R. (2008), GGE Biplot Analysis of Dioscorea rohindata cultivar “Dente” in Ghana African. *Journal Agriculture Research* 3, 115 – 120.

Raemackers, R.H. (2001). Crop Production Tropical Africa Directorate General for International Cooperation (DGCC), Belgium

Richard, J.E. and Coursey, D.G. (1981). Cassava Storage Tropical Science, 23: 20.

Sanni, L.O., Adebowale, A.A. and Tafa, S.O. (2006). Proximate, Functional, Pasting and Sensory Qualities of Instant Yam Flour.A paper presented at the 14th ISTRC. Symposium Central Tuber Crops. Research Institute, Trivandrum, Kerala. State India.

Schultz, E. (2011). Dietary Fiber, Retrieved from; www.eltieschultz.coml files/pdf/dietary-fiber.pdf, (Accessed on: February 13th 2013).

Shanthakumari, S., Mohan, V.R. and Britto, J. (2008). Nutritional Evaluation and Elimination of Toxic Principles in Wild Yam (*Dioscorea spp*) Tropical Subtropical Agrosys 8, 319 – 322. Stream, Cereal Chemistry 75, 166 – 168.

Shewry, P.R. (2009). The Health grain program opens New opportunities for the Improving wheat for Nutrition and Health Nutrition Bulletin, 34(2); 225 – 230

Sobukola, O.P., Awonorin, S.O., Sanni, L.O. and Bamiro, F.O. (2008). Optimization of Blanching Condition Prior to Deep Fat Frying of Yam Slices. International *Journal Food Property.*, 11: 379 – 391.

Steven, B.J.H., Selvendran ,R.R.,Bayliss, C.E. and Turner, R. (1985) Degradation of Cell Wall Material of Apple and Wheat Bran by Faecal Bacteria In vitro. *Journal of Science Food and Agriculture*. 44:150-154

Topping, D. (2007). Cereal Complex Carbohydrates and their Contribution to Human Health. *Journal of Cereal Science,* 46:201

Tortoe, C., Nketia, S., Owusu, M., Akonr, P.T. and Otooe, E. (2014). Sensory Attributes and Consumer Preference of Precooked Vacuum – Packaged Yam from two cultivars of Ghanian Yam (*Dioscorea rotundata*) in the Accra Metropolitan Area Advances Research 2(1) 40 – 45.

Treche, S. and Guion, P. (2009). Etide des potentialite Nutritimnelle dequelques tubercules tropicant ad Cameroon, Agron Trop, Nogent, 34: 127 – 140.

Udensi, E.A., Arisa, N.U. and Maduka M. (2010). Effect of Processing Methods on he level of some Antinutritional Factors in Mucuna Flagelli-pcs *Nigerian Food Journal* 26(2): 53 – 55.

Vasil, L.K. (2007), Molecular Genetic Improvement of Cereals: Transgenic Wheat (*Triticum aestivum* L.). Plant Cell Report, 26: 1133 – 1152.

Watson, A.S. (1987). Structure and Composition In: Watson S.A., Ramstad, P.E. (eds). Corn Chemistry and Technology, st. Paul, MN: American Association of Cereal Chemists pp. 53 – 61.

Wende, L., Fang, S., Shanchang, S., Coke, H. and Beta, T. (2005). Free Radical Scavenging Properties and Phenolic content of Chinese Black grained Wheat. *Journal of Agricultural and Food Chemistry* 53:8534.

White, P.J., and Broadley, M.R. (2005). Biofortifying Crops with Essential Mineral Elements. Trend in Plant Science, 10: 586 – 590.

Yoshikawa, M., Takahashi, M., and Yang, S., (2003). Delta Opioid Peptides Defired from Plant Proteins. Current Pharmaceutical Design 9: 1325 – 1320.

Zuraini, A. Somchit, M.N., Solihih, M. and Zakarian, M.S. (2006). Fatty Acid and Amino Acid Composition of three local Malaysian Ghanna spp. Fish. Food Chemistry 4(97): 674 – 675.