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Dietary Fibre Components of Four Common Nigerian *Dioscorea* Species

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Abstract: Four common *Dioscorea* species were analyzed for dietary fibre components viz, hemicellulose, cellulose and lignin as well as Neutral Detergent Fibre (NDF) and Acid Detergent Fibre (ADF) in the raw and cooked samples. The dietary fibre components in the raw and cooked samples in all the four yam species namely *Disocorea bulbifera*, *Dioscorea alata*, *Dioscorea cayenenis* and *Dioscorea rotundata* were found to be low ranging from 1.20-2.59% for NDF, 1.06-2.22% for ADF, 0.10-0.27% for hemicellulose, 0.07-1.13% for cellulose and 0.08-0.27% for lignin. There was no significant change ($p<0.05$) in the content of dietary fibre components of the yam samples upon cooking. In spite of the low levels of fibre in the yam species analyzed, yams may constitute a significant source of fibre for many in Nigeria and the tropics generally since they are a common staple and are widely consumed on a daily basis.

Key words: *Dioscorea*, fibre, hemicellulose, cellulose and lignin

INTRODUCTION

Dietary fibre is defined as the remnants of plant cell walls which are not hydrolyzed by alimentary enzymes (Baker, 1977; Kelsay, 1978; Kritchevsky, 1977; Van Soest, 1978; Adamson, 1985). Plant constituents usually considered as part of dietary fibre include cellulose, hemicellulose, lignin and pectins while additional minor components include cutin, gums, some proteins and oligosaccharides (Kelsay, 1978; Van Soest, 1978; Adamson, 1985).

Dietary fibre is classified into soluble and insoluble fibres which have very different but complimentary functions in the bowel. Soluble fibre includes such compounds as mucilage, beta-glucans and pectin. Soluble fibre provides valuable viscosity, bulk and lubrication in the stomach and small intestine but it is broken down in the large intestine or colon by the naturally occurring bacteria which are present in a healthy colon. On the other hand, insoluble fibre includes compounds such as cellulose, hemicellulose and lignin which maintain an open sponge-like structure that contributes valuable bulk and pore space, which evenly distributes pressure and pass out of the body largely unmodified. Additionally, lignin lowers the digestibility of other fibre components (Monro, 1989; Richard and Thompson, 1997; Eastwood and Kritchevsky, 2005; Suter, 2005).

Dietary fibre has long been considered an insignificant part of the human diet because it is believed to contribute little nutritionally (Burkit *et al*., 1974). However, there is current evidence, although primarily epidemiological, that dietary fibre may have direct effect upon some human biochemical and physiological processes (Kelsay, 1978; Kelsay *et al*., 1978). Consequently, root crops, cereals, fruits and vegetables are often promoted as important sources of dietary fibre for humans (Reistad and Frolich, 1984; Monro, 1989; Richard and Thompson, 1997).

Low dietary fibre intake is reportedly associated with several disorders of the human body including diverticulosis and cancer of the colon, constipation, ischaemic heart disease, diabetes and other diseases of the gastro-intestinal tract. These conditions are reported to be virtually non-existent in populations subsisting on high fibre diets (Burkit *et al*., 1972, 1974; Kelsay, 1978; Trowell, 1976, 1978; Tungland and Meyer, 2002).

Fibre increases the water holding capacity and bulk of the stool since hemicellulose and cellulose absorb water and swell. Fibre also lowers the blood Low Density Lipoprotein (LDL) cholesterol levels and improves the cholesterol ratio. Thus inclusion of fibrous substances in the diet is essential for normal bowel functioning, promoting regularity, softer stools and rapid transit times thereby reducing the risk of bowel cancer as well as heart disease (Kelsay, 1978; Eastwood and Robertson, 1978; Adamson, 1985; Monro, 1989; Richard and Thompson, 1997; Eastwood and Kritchevsky, 2005; Suter, 2005; Anderson *et al*., 2009).

Foods which contain significant amounts of fibre are generally lower in caloric content than similar foods with little or no fibre. Diets recommended for weight reduction usually encourage consumption of various foods recognized as excellent sources of dietary fibre such as fruits, raw vegetables, whole grain products, roots, tubers and leguminous seeds (Anonymous, 1979).

The sources of dietary fibre in the industrialized countries are mainly cereals and processed wheat bran

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while those of most developing countries especially Africa and the tropics are the root crops and tubers including yams (Adamson, 1985; Blanco-Metzler *et al*., 2004). Some edible yam species common in Nigeria and in tropical Africa include *Dioscorea rotundata* (white yam), *Dioscorea alata* (water yam), *Dioscorea cayenensis* (yellow yam) and *Dioscorea bulbifera* (aerial yam or air potato). Yams are major staple in Nigeria and in most of tropical Africa and may constitute a major source of dietary fibre for these populations.

However, there is very scanty information in the literature on the dietary fibre content of yams in Nigeria and Africa as a whole. Adamson (1985) reported the dietary fibre, non-cellulosic polysaccharide, cellulose and lignin content of yam to be 13.2%, 9.7%, 2.9% and 0.1% respectively. However, the yam specie that was used in the study was not specified. This study serves to provide data on the dietary fibre components of the four yam species adumbrated above and which are widely consumed in Nigeria and in tropical Africa.

MATERIALS AND METHODS

The most widely used method of analyzing fibre is the detergent system of fibre analysis (Van Soest and Wine, 1967; 1968) which was originally designed for the analysis of animal feeds. Several modifications of this method including the use of enzymes have been introduced by other workers. However, the original Van Soest method of analysis is still widely used and the method was employed in this study.

Collection of samples: Tubers of *Dioscorea bulbifera*, *Dioscorea alata*, *Dioscorea cayenensis* and *Dioscorea rotundata* were purchased from Akim, Ika Ika Oqua and Watt markets in Calabar the Capital of Cross River State of Nigeria. These markets host yams from Calabar environs, Northern Cross River State and as far as the middle belt of Nigeria.

Sampling: The tubers of each yam species were pooled together, peeled and a sample extracted for experimental work.

Preparation of samples

Raw sample: The tubers of each yam species were peeled, cut into small pieces and mixed. About 800 gm sample of each of the yam species from each pool were weighed out and dried in the oven at 40°C for twenty-four (24) hours and finally ground to powder and then stored in polythene bags.

Cooked sample: The cooked sample of each yam species was prepared in a manner similar to (I.) above except that it was boiled for about 30 min to cook.

Methods of analysis of dietary fibre components: The dietary fibre components in the raw and the cooked samples of the four *Dioscorea* species were analyzed using detergent system of fibre analysis (Goering and Van Soest, 1970).

Neutral detergent fibre: 1 gm of each sample was reflexed for one hour with 100 ml of neutral detergent solution prepared by mixing two solutions: one consisting of 93 g of disodium Ethylenediamine Tetra acetate Dihydrate (EDTA) and 34 g of sodium borate in distilled water to which 15 g of sodium lauryl sulphate and 10 ml of ethylene glycol were added and the other consisting of 22.8 g of anhydrous disodium hydrogen phosphate in distilled water. After reflux, each suspension was filtered hot through sintered glass crucible with the aid of suction pump and the residue washed with hot distilled water and acetone. The crucible was dried overnight at 100°C and the weight of neutral detergent fibre was calculated. The determination was carried out in triplicate.

Acid detergent fibre: The crucible containing the neutral detergent fibre of each sample was placed in a flask and reflexed for 60 min from onset of boiling (3-5 min) with 100 ml of acid detergent solution consisting of 56 ml of conc. sulphuric acid and 20 g of cetyltrimethyl ammonium bromide in 2 litres of distilled water. The contents of the flask was filtered with the aid of suction pump and the residue was washed with acetone. The crucible was dried overnight in an oven at 100°C and weighed hot. The determination was done in triplicate. The loss in weight of the neutral detergent residue was taken as the acid detergent fibre.

Hemicellulose: The hemicellulose content of each of the yam samples was determined by taking the difference between Neutral Detergent (NDF) and Acid Detergent Fibre (ADF) of each sample.

Lignin: The crucible containing the acid detergent residue of each sample was placed in enamel pan and treated for 90 min with a single 25 ml portion of 0.1N permanganate solution, the mixture being stirred with a glass rod to wet all the particles. The remaining permanganate was aspirated from the residue which was washed with hot distilled water, followed with ethanol and then with acetone. The crucible was dried overnight at 100°C in an oven and weighed hot. The loss in weight of the acid detergent residue was taken as the estimate of lignin. The determination was carried out in triplicate.

Cellulose: The crucible containing the residue from the permanganate treatment was placed in an enamel pan half filled with 72% sulphuric acid and the mixture stirred with a glass rod to wet all particles. The crucible was replenished with sulphuric acid at an hourly interval and after three hours the remaining sulphuric acid was removed by suction and the residue thoroughly washed with hot distilled water. The crucible was dried in an oven at 100°C overnight and weighed hot. The loss in weight of the permanganate residue was taken as the estimate of cellulose. The determination was carried out in triplicate.

Statistical analysis: The data obtained for the fibre components of the *Dioscorea* species were subjected to analysis of variance ($p<0.05$) among the yam species and between the cooked and raw samples for each yam specie.

RESULTS AND DISCUSSION

The results of the analyses of the raw and cooked samples of the four *Dioscorea* species for dietary fibre components are as shown on the (Table 1).

The results showed that the dietary fibre components namely cellulose, hemicellulose and lignin in the four yam species were low generally. The cellulose content in both the raw and cooked samples of the four yam species analyzed showed values that hovered around 1.0%. The raw samples showed values of cellulose content that ranged from 0.90% in *Dioscorea alata* to 1.13% in *Dioscorea bulbifera* while the cellulose content in the cooked samples ranged from 0.70% in *Dioscorea alata* to 1.09% in *Dioscorea cayenensis*.

When the data obtained for cellulose for each yam species for the raw and the cooked samples were subjected to analysis of variance, there was no significant difference ($p<0.05$) observed between the cooked and raw samples. Available literature is lacking in data for fibre in yams. Adamson (1985) reported a value of 2.9% of cellulose for yam but the specie was not specified. He also found a value of 2.5% of cellulose in cassava. The result obtained in this study for cellulose in the specified yam species cannot be compared with the result of Adamson as the specie used by him was unknown. However, the result showed the cellulose contents of yams are low and are comparable to those of cassava. Lund and Smoot (1982) reported the cellulose content of tropical fruits and vegetables to range from 0.1-0.9% while Lund *et al.* (1983) found values ranging from 0.2-3.8% on analysis of eleven tropical fruits and vegetables. The data obtained in this study for cellulose compared favourably with the results of these workers.

Hemicellulose values observed in both the raw and cooked samples of the yam species analyzed ranged from 0.16% in the raw *Dioscorea cayenensis* to 0.27% in the raw *Dioscorea bulbifera*. The cooked samples in each of the yam species showed hemicellulose content that ranged from 0.15% in *Dioscorea alata* to 0.28% in *Dioscorea bulbifera*. Upon analysis of variance, no significant difference ($p<0.05$) was observed in the raw and cooked samples in each yam species. However, the hemicellulose content of *Dioscorea bulbifera* was found to be significantly different ($p<0.05$) from the other three yam species studied upon analysis of variance. There are no data for hemicellulose content of yams in the available literature but data obtained in this study compared favourably with the range of values of 0.04-0.4% (Lund and Smoot, 1982) and 0.07-0.4% (Lund *et al.*, 1983) reported for vegetables.

The lignin content in the raw samples of the four yam species analyzed ranged from 0.09% in *Dioscorea rotundata* to 0.27% in *Dioscorea alata* while in the cooked samples, the lignin content ranged from 0.08% in *Dioscorea rotundata* to 0.26% in *Dioscorea alata*. Thus, *Dioscorea alata* showed the lowest lignin content and *Dioscorea rotundata* the highest for both the raw and cooked samples. Analysis of variance for lignin in the raw and cooked samples of each yam species showed no significant difference ($p<0.05$). Thus cooking of the samples had no effect upon the lignin content. However, the lignin content of *Dioscorea alata* was significantly different from the lignin content of the other three yam species studied. Adamson (1985) found the lignin content of an unspecified yam to be 0.1% and

Table 1: Dietary fibre components in four Nigerian *Dioscorea* species

Yam species	Neutral Detergent Fibre (NDF)[a]	Acid Detergent Fibre (ADF)[a]	Hemi-cellulosea	Lignina	Cellulosea
Dioscorea bulbifera					
Raw	2.57 ± 0.35^{b}	2.30 ± 0.05^{d}	0.27 ± 0.06^{g}	0.10 ± 0.03^{i}	1.13 ± 0.03^{k}
Cooked	2.59 ± 0.55^{b}	2.31 ± 0.04^{d}	0.28 ± 0.05^{g}	0.09 ± 0.01^{i}	0.97 ± 0.05^{k}
Dioscorea alata					
Raw	1.40 ± 0.15^{c}	1.20 ± 0.09^{e}	0.20 ± 0.10^{h}	0.27 ± 0.05^{j}	0.90 ± 0.05^{l}
Cooked	1.38 ± 0.16^{c}	1.25 ± 0.15^{e}	0.15 ± 0.05^{h}	0.26 ± 0.06^{j}	0.80 ± 0.03^{l}
Dioscorea cayenensis					
Raw	1.35 ± 0.15^{c}	1.19 ± 0.10^{e}	0.16 ± 0.05^{h}	0.10 ± 0.02^{i}	1.10 ± 0.02^{m}
Cooked	1.40 ± 0.10^{c}	1.20 ± 0.09^{e}	0.20 ± 0.06^{h}	0.09 ± 0.03^{i}	1.09 ± 0.01^{m}
Dioscorea rotundata					
Raw	1.34 ± 0.09^{c}	1.13 ± 0.03^{f}	0.21 ± 0.08^{h}	0.09 ± 0.01^{i}	0.98 ± 0.03^{m}
Cooked	1.38 ± 0.05^{c}	1.14 ± 0.06^{f}	0.22 ± 0.04^{h}	0.08 ± 0.02^{i}	1.00 ± 0.02^{m}

[a]Values represent mean±standard deviation of three replicates.

[b-m]Values in the same column bearing different superscripts are significantly different ($p<0.05$) on analysis of variance

cassava to be 0.2%. The results obtained in this study were about the same as reported by Adamson indicating that the lignin content of yams and cassava were comparable.

The values obtained for lignin in this study also compared favourably with those found in the literature which ranged from 0.025-0.17% (Lund and Smoot, 1982), 0.051-2.01% (Lund *et al*., 1983) for tropical fruits and vegetables and 0.057-0.18% (Lajide *et al*., 2008) for edible legume seedlings.

The neutral detergent fibre or residue (NDF or NDR) which is actually a combination of cellulose and lignin together with neutral detergent insoluble hemicellulose was found in the raw yam samples to range from 1.34% in *Dioscorea rotundata* to 2.57% in *Dioscorea bulbifera* while the values ranged from 1.38% in both *Dioscorea alata* and *Dioscorea rotundata* to 2.59% in *Dioscorea bulbifera* in the cooked samples. Lund and Smoot (1982) reported the Neutral Detergent Residue (NDR) to range from 0.9-1.2% in fruits and vegetables while Lund *et al*. (1983) found NDR in eleven tropical fruits and vegetables to range from 0.53-8.6%. The range of 1.34-2.57% NDF found in this study for raw yam samples and 1.38-2.59% in the cooked samples of yams are within the range reported by Lund *et al*. (1983) and indicate that yams are comparable sources of dietary fibre to fruits and vegetables. There was a significant difference ($p<0.05$) in the value of neutral detergent fibre found in *Dioscorea bulbifera* compared to the other three yam species namely *Dioscorea alata*, *Dioscorea cayenensis* and *Dioscorea rotundata*.

Acid detergent fibre is a combination of cellulose and lignin together with acid insoluble hemicellulose. For most practical purposes, the acid detergent fibre and neutral detergent fibre are roughly same except their content of hemicellulose which is significant in NDF and largely negligible in ADF. Acid detergent fibre data on yams except crude fibre are lacking in the available literature. The data from this study on acid detergent fibre ranged from 1.13% in *Dioscorea rotundata* to 2.30% *Dioscorea bulbifera* in the raw yam samples and from 1.14% in *Dioscorea rotundata* to 2.31% in *Dioscorea bulbifera*. Thus *Dioscorea rotundata* showed the lowest values of ADF in both the raw and cooked samples of the yams analyzed while *Dioscorea bulbifera* exhibited the highest values. When the data for acid detergent fibre obtained from both the raw and cooked yam samples were respectively subjected to analysis of variance, the samples were found to be significantly different ($p<0.05$) except *Dioscorea cayenensis* and *Dioscorea rotundata* which showed no difference from each other.

This study had shown that cooking of the yam samples had no effect on the dietary fibre components which agreed with finding of Reistad and Frolich (1984) who worked on Norwegian vegetables. Whatever variations that were observed between the results of this study and those of other workers might be due to species differences, stage of maturity and growing environment as dietary fibre depends on these factors.

Conclusion: The results obtained for dietary fibre components in this study have shown that these components are low in yam species generally. However, among the yam species analyzed in this study for dietary fibre components *Dioscorea bulbifera* showed the highest values for the components except in lignin content which was found to be highest in *Dioscorea alata* (0.27% for raw and 0.26% for cooked sample). The results of this study also showed that cooking of yam had no significant effect ($p<0.05$) on the dietary fibre components.

Although the findings of this study had shown the dietary fibre components in yams to be low, yams may still contribute significantly to the dietary fibre intakes of many in Nigeria and tropical Africa generally, since yams are a common staple and are widely consumed in these parts of the world on a daily basis.

REFERENCES

Adamson, I., 1985. Dietary fibre of yam and Cassava In: Advances in Food Research, (ed.) Osuji, pp: 321-340.

Anderson, J.W., P. Bair, R.H. Davis, S. Ferreri, M. Knudtson, A. Koraym, V. Waters and C.L. William, 2009. Health benefit of dietary fibre. Nutr. Rev., 67: 188-205.

Anonymous, 1979. Dietary fibre. Food Technol., 33: 35.

Baker, D., 1977s. Determining fibre in cereals. Cereal Chem., 54: 360.

Blanco-Metzler, A., J. Tovar and M. Fernandez-Piedra, 2004. Nutritional characterization of carbohydrates and proximal composition of cooked tropical roots and tubers produced in Costa Rica. Arch Latinoam Nutr., 54: 322-327.

Burkit, D.P., A.R.P. Walker and N.S. Painter, 1972. Effect of dietary fibre on stools and transit times and its role in the causation of disease. Lancet, 2: 1408.

Burkit, D.P., A.R.P. Walker and N.S. Painter, 1974. Dietary fibre and disease. J. Am. Med. Assoc., 229: 1068-1074.

Eastwood, M.A. and J.A. Robertson, 1978. The place of dietary fibre in diet. J. Human Nutr., 32: 53.

Eastwood, M. and D. Kritchevsky, 2005. Dietary fibre: How did we get there? Annu. Rev. Nutr., 25: 1-8.

Goering, H.K. and P.J. Van Soest, 1970. Forage fibre and analyses. Agric. Res. Serv., Department of Agriculture. Agric. Handbook No. 379, 1. Washington D.C.

Kelsay, J.L., 1978. A review of research on effects of fibre intake on man. Am. J. Clin. Nutr., 31: 142-159.

Kelsay, J.L., K.M. Behall and E.S. Prather, 1978. Effect of fibre from fruits and vegetables on metabolic responses of human subjects 1. Bowel transit time, number of defaecations, faecal weight, urinary excretions of energy and nitrogen and apparent digestibility of energy, nitrogen and fat. Am. J. Clin. Nutr., 31: 1149-1153.

Kritchevsky, D., 1977. Dietary fibre; what it is and what it does. Food Product Dev., 11: 111.

Lajide, L., M.O. Oseke and O.O. Olaoye, 2008. Vitamin C, fibre, lignin and mineral contents of some edible legume seedlings. J. Food Technol., 6: 237-241.

Lund, E.D. and J.M. Smoot, 1982. Dietary fibre content of some tropical fruits and vegetables. J. Agric. Food Chem., 30: 1123-1127.

Lund, E.D., J.M. Smoot and T.H. Nancy, 1983. Dietary fibre content of eleven tropical fruits and vegetables. J. Agric. Food Chem., 31: 1013-1016.

Monro, J.A., 1989. Dietary fibre in human nutrition. Proc 1989 Cereal Science Conf., pp: 76-79.

Richard, S.E. and L.U. Thompson, 1997. Health effects of flaxseed mucilage, lignans. Inform (J. Am. Oil Chem. Assn., 8: 860-865).

Reistad, R. and W. Frolich, 1984. Content and composition of dietary fibre in some fresh and cooked Norwegian vegetables. Food Chem., 13: 209-224.

Suter, P.M., 2005. Carbohydrates and dietary fibre. Handb Exp. Pharmacol., 170: 231-261.

Trowell, H., 1978. The development of the concept of dietary fibre in human nutrition. Am. J. Clin. Nutr., 31: 3S-11S.

Trowell, H., 1976. Definition of dietary fibre and hypotheses that it is protective factor in certain diseases. Am. J. Clin. Nutr., 29: 417-427.

Tungland, B.C. and D. Meyer, 2002. Non-digestible oligo- and polysaccharides (dietary fibre): Their physiology and role in human health and food. Comprehensive Rev. Food Sci. Food Safety, 1: 73-92.

Van Soest, P.J., 1978. Dietary fibre: Their definition and nutritional properties. Am. J. Clin. Nutr., 31: 12S-20S.

Van Soest, P.J. and R.H. Wine, 1967. Use of detergents in the analysis of fibrous feeds. 1V. Determination of plant cell-wall constituents. J. Assoc. Off. Anal. Chem., 50: 50-55.

Van Soest, P.J. and R.H. Wine, 1968. Determination of lignin and cellulose in acid detergent fibre with permanganate. J. Assoc. Off. Anal. Chem., 51: 780-785.