

Comparative Studies on the Effect of Open Air and Oven Drying on the Antinutrient Content of Some Leafy Vegetables of Eastern Nigeria

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Abstract

Five leafy vegetables; *Pterocarpus mildbreadii* (Oha); *Talinium triangulare* (water leaf), *Telfaria occidentalis* (fluted pumpkin), *Cucurbita maxima* (Bread pumpkin), and *Vitex doniana* (uchakiri) were selected for the study of the effect of open air (sun), and oven drying on the antinutrient content. Each sample was shared into four equal parts representing, fresh/wet, sun drying, oven drying at 70°C, and 100°C respectively. The portions for sun, and oven drying were dried to constant weight before grinding into fine powder form. This was sieved and stored in a polythene bag at room temperature, and used for all the analysis. The result shows that tannins levels ranged from 1.89 ± 0.03 mg/100g in *T. triangulare* to 3.17 ± 0.01 mg/100g in *P. mildbreadii*, Phytic acid from 19.96 ± 0.01 mg/100g in *V. doniana* to 22.27 ± 0.01 mg/100g in *C. maxima*, Oxalates from 2.34 ± 0.08 mg/100g in *T. triangulare* to 3.50 ± 0.01 mg/100g in *P. mildbreadii*; Alkaloids from 0.48 ± 0.06 mg/100g in *V. doniana* to 4.15 ± 0.02 mg/100g in *C. maxima*, and Saponins from 4.85 ± 0.02 mg/100g in *V. doniana* to 9.76 ± 0.1 mg/100g in *C. maxima*. The levels of flavonoids and cyanogenic glycosides were relatively low in all the samples compared to other antinutrient factors determined. Sun drying increased the levels of tannins, phytic acid, oxalates, and saponins, while the levels of alkaloids, flavonoids and cyanogenic glycosides decreased as compared with the result of wet samples. Similar result was obtained when oven dried at 70°C and 100°C. However, the level of cyanogenic glycosides increased when oven dried at 100°C as compared to both sun, and oven drying at 70°C.

Keywords: Antinutrient, Drying, Vegetables

Introduction

Vegetables can be defined as plant parts usually herbaceous that contain edible portion which is suitably served with the main course of a meal (Tindall, 1975). Although, the line between vegetables and fruits is sometime vague, the stipulation that plant part be herbaceous in case of vegetables has helped to clarify the definition. The nutritional contribution of vegetables cannot be over emphasized particularly in the Eastern part of Nigeria. Most vegetables are low in calories and protein; however, they still contribute to the energy and protein content of the diet especially when accompanied or supplemented with animal protein (Eka, 1977). Vegetables in general are excellent source of micronutrients (vitamins and minerals). Calcium, iron, magnesium, sodium, potassium, and copper are among the minerals found in appreciable amount in leafy vegetables (Fox, and Cameron, 1984; Ihekoronye and Ngoddy, 1985; Oguntona, 1998). Vitamins C, E and A are also found in high quantity in many vegetables.

It has been pointed out that it is not enough that a particular food is rich in nutrient, such nutrient must be biologically available (Nwachukwu, 2002). Most of the antinutrient factors form complexes with minerals, vitamins and even proteins, and thus make them unavailable for their biochemical roles. In severe cases, manifest symptoms of the nutrient deficiency may result. Oxalate is known to form complex with calcium (Fox and Cameron, 1984) while phytic acid also chelates

a number of divalent elements like magnesium, iron, calcium, etc. Saponins, on the other hand complex with protein, hindering digestion or enzyme activity. (Onwuka, 1992). Antinutrient content of some seeds, roots, shoots, and vegetables of some plant species have been studied (Nwokolo and Bragg, 1977; Charkraborty and Eka, 1978; Ihekoronye and Ngoddy, 1985; Okolie and Ugochukwu, 1989; Onwuka, 1992; Oguntona, 1998). Studies on the effect of drying are few and in most cases limited to a single plant specie or to a particular antinutrient content.

In this study therefore we investigated the comparative effect of open air and oven drying on the antinutrient content of some leafy vegetables commonly found in Eastern Nigeria

Materials and Methods

Materials: Four of the vegetables; *Pterocarpus mildbreadii*, (Oha), *Talinium triangulare* (water leaf), *Telfaria occidentalis* (fluted pumpkin) and *Cucurbita maxima* (bread pumpkin) were purchased from Nsukka central market Enugu State. *Vitex doniana* (Uchakiri) was collected from Asusu farmland in Orumba south L.G.A. of Anambra state. All the samples were scientifically identified by Taxonomist from Department of Botany University of Nigeria, Nsukka.

Processing of the samples: The samples were sorted to select the good ones. Each sample was then shared into four equal parts representing,

fresh/wet, open air/sun, drying, and oven drying at 70°C, and 100°C respectively.

The portions for drying were dried to constant weight before grinding with Author Thomas milling machine. The powdered form was sieved using 1 mm sieve. It was then stored at room temperature, and used for all the analysis. The portion for wet analysis was ground with a mortar into a paste and used immediately for the analysis.

Determination of antinutrients: Tannins were determined by the method of Desphandes *et al.* (1986). Phytic acid was determined by the method of Marfor *et al.* (1990), oxalate according to the method of Oke (1969). The method of Cheeke (1989) was used to determine, alkaloids, saponins, and cyanogenic glycoside, while the method of Ozo and Caygill (1986) was used to determine flavonoids.

Results

Table 1 shows the antinutrient content of the wet sample analysis. Flavonoids and Cyanogen glycosides levels were the least of all the antinutrient factors determined in the samples. Tannins level ranged from 1.89 ± 0.3 mg/100g in *T. triangulare* to 3.17 ± 0.02 mg/100g in *P. mildbreadii*. phytic acid from 19.96 ± 0.01 mg/100g in *V. doniana* to 22.27 ± 0.01 mg/100g in *C. maxima*; oxalates from 2.34 ± 0.01 mg/100g in *V. doniana* to 3.5 ± 0.01 mg/100g in *T. occidentalis* and *P. mildbreadii* respectively, alkaloids from 2.48±0.06 mg/100g in *V. doniana* to 4.15 ± 0.02 mg/100g in *C. maxima*, and saponins from 4.85 ± 0.02 mg/100g in *V. doniana* to 9.76 ± 0.11 mg/100g in *C. maxima*. It appears that *V. doniana*, and *C. maxima* were the samples with the least and highest level of all the antinutrient factors determined.

In table 2, the result shows that open air (sun) drying generally increased the levels of all the antinutrient except for the values of Flavonoids and Cyanogen glycosides which rather decreased.

In table 3, the levels of tannins, phytic acid, oxalates, Cyanogen glycoside and saponins were increased by oven drying at 70°C. However, the levels of alkaloids, flavonoids decreased except again in *V. doniana* where the values increased as compared with the result of wet analysis. Saponins levels increased except for the level in *T. triangulare* which decreased as compared with the result of wet analysis. In table 4, similar result was obtained when the samples were dried in the oven at 100°C. However, the levels of Cyanogen glycosides increased as compared with the result of -wet analysis.

Discussion

The result shows that the level of tannins in the wet samples (Table 1) ranged from 1.89 ± 0.03 mg/100g in *T. triangulare* to 3.17 ± 0.02 mg/100g in *P. mildbreadii*. Both open air-drying and oven drying at 70°C and 100°C (Tables 2, 3 and 4) increased the levels as compared with the result of wet analysis. Tannins are found relatively high in may

plant species. Similar result had been reported by Okoh *et al.* (1982) on the tannin index of ten (10) varieties of sweet potatoes. Tannins are known to reduce protein digestibility by forming strong interaction with dietary protein leading to complexes that are not easily digested. Protein energy malnutrition and loss of weight may result. Damage to gastrointestinal tracts can also occur (Ihekoronye and Ngoddy, 1985). Tannins can also interact with dietary iron and prevent the absorption. The increase in the levels when dried could have been due to conversion of hydrolysable tannins to condensed ones. Again tannins are not easily destroyed by heat due to the high molecular weight (Osagie *et al.*, 1996). Phytic acid level in the wet samples (Table 1) ranged from 19.96 ± 0.01 mg/100g in *V. doniana* to 22.27 ± 0.07 mg/100g in *C. maxima*. Drying in the sun, and in the oven at 70°C and 100°C (Tables 2, 3, and 4) increased the level as compared with the result of wet analysis. The phytic acid content of food and food stuffs commonly consumed in Nigeria had been reported by Eka (1977). He concluded that the quantity of phytate and oxalates in traditional food in Nigeria were below toxic level, though their role in preventing the proper utilization of calcium and phosphorus could be considerable. Phytic acid has twelve (12) replaceable hydrogen atoms, and therefore could form insoluble salt with many metals like calcium, iron, zinc, magnesium (Guthrie and Picciano, 1995). The formation of these insoluble salts renders the minerals unavailable for absorption into the system. Nwokolo and Bragg (1977), showed that in chicken, there is significant inverse relationship between phytic acid and the availability of calcium, magnesium, zinc and phosphorus in food stuffs like soybean, palm kernel seed, rapeseed and cotton seed meals. Oke (1965) reported that phytate is not easily destroyed by processing temperatures. The increase in the level after drying could be due to the concentrating effect of the phytic acid after the loss of moisture. Also phytic acid occurs as the storage form of phosphorus in plants in association with proteins. The Protein component may have been denatured by heat leading to further concentration of pure phytic acid.

Beneficial effects of phytic acid have been suggested. *In vitro* studies indicate that there are interactions between phytic acid and heavy metals such as lead and cadmium (Nolar *et al.*, 1987). It has been reported that lowest lead accumulation was achieved when calcium and phytic acid were given simultaneously (Wise, 1981), and that phytate was responsible for a considerable decrease in the intestinal absorption of cadmium (Jack *et al.*, 1985). Phytic acid has also been known as to have antioxidant functions. The dietary protective effect of phytic acid was observed in azoxy methane dimethyl hydrazine induced carcinogenesis (Nelson *et al.*, 1989). The mechanism of the protective effect is explained by the inhibition of the iron- induced radical generation (Nelson *et al.*, 1989).

Oxalate level in wet analysis (Table 1) ranged from 2.34 ± 0.01 mg/100g in *V. doniana* to 3.50 ± 0.01 mg/100g in *T. occidentalis* and *P. mildbreadii* respectively.

Table 1: Antinutrient content of wet samples (mg/100g)

Samples	Antinutrient Factors						
	Tannins	Phytic acid	Oxalate	Alkaloids	Flavonoids	C. glycosides	Saponins
<i>P. mildbreadii</i>	3.17 ± 0.02	22.25 ± 0.02	3.50 ± 0.01	2.91 ± 0.01	1.01 ± 0.01	1.88 ± 0.02	7.66 ± 0.16
<i>T. triangulare</i>	1.89 ± 0.03	21.45 ± 0.06	2.34 ± 0.08	2.33 ± 0.16	1.05 ± 0.02	1.73 ± 0.12	8.60 ± 0.02
<i>T. occidentalis</i>	2.28 ± 0.01	21.37 ± 0.01	3.50 ± 0.01	2.59 ± 0.06	1.00 ± 0.12	1.45 ± 0.32	6.67 ± 0.12
<i>C. maxima</i>	2.64 ± 0.02	22.27 ± 0.01	2.34 ± 0.20	4.15 ± 0.02	1.20 ± 0.03	2.93 ± 0.01	9.76 ± 0.11
<i>V. doniana</i>	2.01 ± 0.10	19.96 ± 0.01	2.34 ± 0.01	0.48 ± 0.06	0.32 ± 0.02	0.28 ± 0.02	4.85 ± 0.02

Table 2: Effect of sun drying on the antinutrient content of the samples (mg/100g)

Samples	Antinutrient Factors						
	Tannins	Phytic acid	Oxalate	Alkaloids	flavonoids	C. glycosides	Saponins
<i>P. mildbreadii</i>	4.69 ± 0.20	24.28 ± 0.92	15.18 ± 0.13	1.77 ± 0.02	0.62 ± 0.06	1.67 ± 0.16	5.00 ± 0.17
<i>T. triangulare</i>	3.55 ± 0.02	24.23 ± 0.05	7.00 ± 0.06	1.88 ± 0.03	0.81 ± 0.02	1.74 ± 0.02	8.34 ± 0.23
<i>T. occidentalis</i>	3.65 ± 0.13	26.09 ± 0.23	6.54 ± 0.05	0.89 ± 0.02	0.61 ± 0.07	1.03 ± 0.06	8.81 ± 0.11
<i>C. maxima</i>	3.90 ± 0.02	26.49 ± 0.28	4.68 ± 0.02	1.61 ± 0.16	0.69 ± 0.02	1.74 ± 0.09	11.80 ± 0.19
<i>V. doniana</i>	7.15 ± 0.06	28.29 ± 0.09	23.35 ± 0.02	3.72 ± 0.19	0.94 ± 0.01	3.85 ± 0.15	12.27 ± 0.21

Table 3: Effect of oven at 70°C on the antinutrient content of the samples (mg/100g)

Samples	Antinutrient factors						
	Tannins	Phytic acid	Oxalate	Alkaloids	Flavonoids	C. glycosides	Saponins
<i>P. mildbreadii</i>	3.89 ± 0.12	23.50 ± 0.28	7.00 ± 0.07	1.29 ± 0.02	0.95 ± 0.02	0.74 ± 0.01	5.84 ± 0.16
<i>T. triangulare</i>	2.00 ± 0.06	23.80 ± 0.19	18.68 ± 0.16	1.21 ± 0.18	0.74 ± 0.01	1.78 ± 0.01	7.56 ± 0.11
<i>T. occidentalis</i>	4.92 ± 0.09	26.90 ± 0.15	10.51 ± 0.06	2.41 ± 0.10	1.20 ± 0.12	1.78 ± 0.16	11.25 ± 0.18
<i>C. maxima</i>	4.98 ± 0.01	25.73 ± 0.21	7.01 ± 0.02	2.25 ± 0.02	1.93 ± 0.02	1.63 ± 0.02	12.34 ± 0.04
<i>V. doniana</i>	3.62 ± 0.05	26.71 ± 0.23	7.24 ± 0.01	1.04 ± 0.09	0.74 ± 0.01	0.67 ± 0.07	7.74 ± 0.01

Table 4: Effect of oven drying at 100°C on the antinutrient content of the samples (mg/100g)

Samples	Antinutrient Factors						
	Tannins	Phytic acid	Oxalate	Alkaloids	Flavonoids	C. glycosides	Saponins
<i>P. mildbreadii</i>	4.02 ± 0.17	26.49 ± 0.19	8.17 ± 0.06	1.03 ± 0.06	0.77 ± 0.01	2.63 ± 0.16	9.33 ± 0.19
<i>T. triangulare</i>	3.55 ± 0.08	27.50 ± 0.22	17.51 ± 0.12	1.52 ± 0.01	0.76 ± 0.01	1.78 ± 0.12	11.82 ± 0.21
<i>T. occidentalis</i>	4.93 ± 0.04	26.80 ± 0.15	8.17 ± 0.02	3.03 ± 0.01	0.96 ± 0.01	2.45 ± 0.11	12.34 ± 0.26
<i>C. maxima</i>	0.08 ± 0.01	27.86 ± 0.20	7.01 ± 0.05	1.89 ± 0.06	0.84 ± 0.02	1.17 ± 0.01	13.60 ± 0.25
<i>V. doniana</i>	3.64 ± 0.04	30.77 ± 0.25	14.01 ± 0.01	1.58 ± 0.02	1.17 ± 0.02	1.17 ± 0.02	7.75 ± 0.01

The levels were also increased by open air-drying and oven drying at 70°C and 100°C respectively. This could be due to the crystal form of oxalate in plant species which is not easily destroyed by heat.

According to Munro and Bassir (1989), the possibility of oxalate poisoning in Nigeria from the consumption of fruits and vegetables is as remote as it is in other part of the world. The level found in this study is relatively high but may not be a hazard considering the various processing methods the vegetables may undergo before eating. Oxalic acid as an antinutrient interferes with mineral availability particularly calcium. It binds with calcium and forms insoluble calcium oxalate which cannot be absorbed in the body. This may lead to death due to hypocalcemia in the renal tubules. (Murray *et al.*, 2003).

The levels of alkaloids in the wet analysis (Tables 1) were relatively low and ranged from 0.48 ± 0.06 mg/10g in *V. doniana* to 4.15 ± 0.02 mg/100g in *C. maxima*. The levels were generally reduced by open air drying and oven drying at 70°C and 100°C respectively as compared to the result of wet samples.

Alkaloids are not strictly regarded as antinutrient, rather are grouped within natural food toxicants. Secondly, most alkaloids are known for their pharmacological effect rather than for their

toxicity. However, when alkaloids occur in foods they cause gastrointestinal upsets and neurological disorders. For instance pyrrolizidines are known to be mutagenic (Okaka *et al.*, 1992). Alkaloids generally act as stimulants by prolonging the action of several hormones. The mechanism is believed to be by prolonging or intensifying the action of cAMP and hence the action of the hormones dependent on the cAMP. Flavonoids and Cyanogen glycoside levels were the least in all the samples in the wet samples. Both open air, and oven drying at 70°C and 100°C generally reduced the levels except in *V. doniana*. According to McWilliam (1979), flavonoids are destroyed by increased drying temperature. Flavonoids are currently regarded as essential nutrients rather than antinutrient. Some flavonoids like rutin, antocyanidins are known to strengthen the blood capillary and other connective tissues (Bourne, 1990) while others like quercetin has been reported to block the sorbitol pathway that is linked with many health complications associated with diabetes (Alais and Guy, 1991).

Others such as naringenin and isoflavones are known as to be anticarcinogenic due to the antioxidant properties (Wink, 1993). Cyanogen glycosides on the other hand are precursors of hydrogen cyanide, a well known natural toxicant in foods. However, the low levels in these samples and the fact that drying decreased the levels

suggest that there is no hazard associated with their presence in these vegetables.

Saponin levels generally increased when sun dried except for the levels in *P. mildbreadii* and *T. triangulare* which decreased (Table 2). Oven drying at 70°C increased the levels except for the values in *T. triangulare* which decreased (Table 3). When oven dried at 100°C, the levels increased in all the samples (Table 4). Saponin is another antinutrient factor that supposed toxicological effect should be balanced with the benefits. For instance, saponins have been shown to possess hypocholesterolemic effect as well as cytotoxic permeabilization of the intestine, though the biological activities depend on the structure (Price et al, 1987). Saponins also have hemolytic effect on red blood cells (Ihekoronye and Ngoddy, 1985). According to Onwuka (1992), though saponin can be highly toxic under experimental conditions, acute saponin poisoning is relatively rare in both man and animals.

This study has shown the presence of the antinutrients determined in all the samples. Tannins, phytic acid, oxalate, alkaloids and saponins levels were relatively high. Another important aspect of this result is the increase in the levels of some of the antinutrients by drying. However, the high levels may not necessarily translate into hazard because of the various processing methods like washing, soaking, drying and cooking which are known to reduce the levels. Again these vegetables are often eaten in little quantity and in combination with staple foods. It will then be difficult for any of these antinutrients to build up in concentration to hazard level.

References

- Alais, C. and Guy, L. (1991). Food Biochemistry, (First Ed) Aspen Publ, London.
- Bourne, A. O. (1990). Toxicity of Plant Foods (2nd Ed). Avi. Publ. Comp. Toronto, Canada.
- Chakraborty, R. E, and Eka, O. U. (1978) Studies on hydrocyanic, oxalic, and phytic acid content of food stuffs. West African Journal of Biol. and App. Chem.. 21; 50-59.
- Cheeke, P. R, (1989). Toxicants of Plant Origin. Boca Raton, USA.
- Desphandes, S. S, Cheryan, M, and Salunkhe, D. K. (1986) Tannin Analysis of Food Products. Food Sci. and Nutr. 24, 401 - 449.
- Eka, O. U. (1977). Studies on the level of oxalic acid and phytic acid in traditional foods of Northern Nigeria. West African Journal Biol. and App. Chem, 20: 26- 30.
- Fox, B. A. and Cameron. A. G. (1984). Food Science: A Chemical Approach. (4th Ed). Holder and Stoughton London.
- Guthrie. A. G. and Picciano, M. F. (1995). Human Nutrition. McGraw Hills, USA.
- Ihekoronye A. I. and Ngoddy. P. O. (1985). Integrated Food Science and Technology. MacMillan. Edu. Press, London.
- Jack. G. A. Rambeck W. A. and Kollmer. W. E (1985). Retention of cadmium in organs of rat after single dose of labelled cadmium – 3 – phytate. Biol. Trace Elem. Res. 6: 69-74.
- Marfor, E. K; Simpson, B. K. Idown, J. S. and Oke. O. L. (1990). Effects of local food processing on phytate levels in cassava, cocoyam and maize. J. Agri. Food Chem.. 38: 1580 – 1583.
- McWilliams, M. (1979). Food Fundamentals: John Wiley, and Sons Inc. New York, U.S.A.
- Munro, A. and Bassir, O. (1989). Oxalates in Nigerian vegetables. West African Journal of Biol. and App. Chem, 12: 14 – 18.
- Murray, R. K. Granner, O. K. Mayers, P. A. and Rodwell, V. W. (2003). Harper's Biochemistry (26th Ed). McGraw – Hill, London.
- Nelson, R. L, Yoo, S. J. Tannure J.C. and Adrianopoulos. G. (1989). The effect of iron on experimental colorectal carcinogenesis. Anti Cancer Res. 9: 1477 – 1482.
- Nolar, K. B., Duffin, P. A. and McWeensy D. J (1987). Effects of Phytate on Mineral Bioavailability. J. Sci. food Agric. 40: 79 – 85.
- Nwachukwu N. (2002). Studies on the nutritional and antinutritional substances in some selected Nigerian indigenous spices. Ph. D. Thesis, FUT0.
- Nwokolo, E. N. and Bragg, D. B. (1977). Influence of phytic acid and crude fiber on the bioavailability of minerals from four protein supplements in growing chicken. Canadian Journal of Animal Science. 57: 475- 477.
- Oguntona, J. (1998). Green leafy vegetables: In: Nutritional quality of plant foods Osagie U. A and Eka. O. U. (Eds). Post harvest Research Unit, Department of Biochemistry University of Benin. Nigeria
- Okaka, J. C., Enoc, N. J. and Okaka, N. C. (1992). Human Nutrition: An Integrated Approach. Enugu State University of Technology publ, Enugu.
- Oke, O. L. (1965) Phytic acid-phosphorus content of Nigerian food stuffs. Indian J. Med. Res. 53: 417-420.
- Oke, O. L. (1969) Oxalic acid in plant and nutrition. World Review on Nutrition and dietetics. 10: 262 – 303.
- Okoh, P. N. Obilana, A. T, Njoku, P. C. and Adikwu, A. O. (1982). Proximate analysis, amino acid composition, and tannin content of some Nigerian plants and their potential in animal feeds. Animal Feed Sci, and Technology. 7: 359 – 362.
- Okolie, N. P. and Ugochukwu, E. N. (1989). Cyanide content of some Nigerian legumes and the effects of simple processing. Food Chem.. 32: 209-216.
- Onwuka. C. F. I. (1992) Tannin and saponin content of some tropical browse species. Trop. Agri. 69: 176 – 180.
- Osagie, A.U. Muzquiz, M., Burbano, C. Cuadrado, C. Ayet, G. and Castano, A. (1996). Some antinutritional constituents in ten staple

- food items in Nigeria. *Trop. Sci*, 36: 109 – 115.
- Ozo, O.N. and Caygill, J .C. (1986) .O. dihydroxyphenol oxidase acting on natural polyhydric phenolics and enzymatic browning of edible yam. *J. Food. Sci. Agric.* 37: 283 – 288.
- Price. K. R. John, I. T and Fredrick, G. R. (1987). The chemical and biological significance of saponins in foods and feeding stuffs. *Food Sci. and Nutr.*, 26: 27 – 90
- Tindall, H. D (1975). Commercial vegetable growing. Oxford Univ. Press, London.
- Wink, M. (1993). Quinoline alkaloids. *Mtd. Plant Biochem.* 8: 197-239.
- Wise, A. (1981). Protective actions of cadmium phytate against acute lead toxicity in mice. *Bull. Enviro. Contam. Toxicol*, 27: 630 – 633.