

FATTY ACID COMPOSITION OF *Dioscorea dumetorum* (Pax) VARIETIES

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ABSTRACT

The purpose of the present investigation was to study the fatty acid compositions of edible and wild *Dioscorea dumetorum* (Pax) varieties harvested from farms and forests of Ikot Akpanabia village in Akwa Ibom State, Nigeria in order to evaluate their nutritional and biochemical significance. Tubers were conveyed from farm sites wrapped in clean dry paper in cardboard boxes to the laboratory. Samples were washed, peeled, sliced and oven dried for 6 hours at 55°C before analysis. Fatty acids were determined in both varieties of *Dioscorea dumetorum* using gas chromatographic technique. Total fat content was low in both varieties with the wild variety recording the lowest (0.45%) but were not significantly different ($P>0.05$). The percentage composition of individual fatty acid ranged from 0.12% to 35.08% for edible *Dioscorea dumetorum* and 0.11% to 39.77% for the wild variety. The most abundant fatty acids in the two varieties were palmitic (C 16:0, 22.9-29.8%), oleic (C 18:1, 14.5-17.7%), and linoleic (C 18:2, 35.08-39.77%), with the wild variety recording higher values except for palmitic acid. Generally the fatty acid compositions of the two varieties *Dioscorea dumetorum* were patterned in a similar way and only trace amounts were obtained for caprylic (C 8: 0), Capric (C 10: 0), hendecanoic (C 11: 0), arachidonic (C 20: 1) and erucic (C 22: 1) acids. The unsaturation ratio was higher in the wild *Dioscorea dumetorum* (1.60) than the edible *Dioscorea dumetorum* (1.20). There were differences in the fatty acid profiles of the edible and the wild *Dioscorea dumetorum* though not in all fatty acids. *Dioscorea dumetorum* varieties were found to also contain unusual fatty acids, erucic and hendecanoic acids. The two varieties were found to be good sources of the essential fatty acid (linoleic acid) with the wild *D. dumetorum* being a better source of fatty acids for the teeming Nigerian population if it is processed for consumption or commercial purposes.

Key words: Fatty acids, *Dioscorea dumetorum*, yam, varieties

INTRODUCTION

Yam (*Dioscorea spp.*) is one of the staples of the African, the Caribbean and the South Pacific (Inter-tropical area) regions. In these regions, yams represent 12 % of human diet [1]. In Africa, the human diet has yam as a key component long before the Western civilization and it is the same throughout the world today. In Nigeria, the use of yam as food had increased because of the significance of its nutritional properties. The cultural and economic importance of edible yam has also increased hence the high demand for this product. Eleven species are cultivated among the forty to fifty domesticated species, which are occasionally eaten though only six species represent an important part of feeding with West Africa producing 18.4 million tons (75%) of world production. Fifteen million tons (81%) of West Africa production is produced in Nigeria [2]. These important varieties include *Dioscorea rotundata* (white yams), *Dioscorea cayenensis* (yellow yam), *Dioscorea alata* (water yam), *Dioscorea dumetorum* (cluster yam), *Dioscorea bulbifera* (aerial yam) and *Dioscorea esculenta* (Chinese yam) with first four species being indigenous to Africa [3].

Dioscorea dumetorum, popularly called sweet yam is one of the six species of yams that are cultivated in Nigeria. It is easily identifiable by its trifoliate compound leaves which resemble other flowering plants with stomata occurring only on the lower surface [4]. Its stem twines anticlockwise. The tubers are large and coarse. They may be yellow, white or pale. It is a good source of carbohydrate, protein, vitamins and minerals when compared with other common species of yam [5]. The yam, *Dioscorea dumetorum* like other edible yams exist in both edible and wild types. The amino acid profile of the *Disocorea dumetorum* has been reported to be quite balanced in essential amino acids with slight deficiency in sulphur containing amino acids and lysine as the most limiting [6]. The study also reported the wild variety of *Dioscorea dumetorum* to be richer and better in protein quality than the edible variety. Crude extracts of *Dioscorea dumetorum* tubers have been reported to have hypoglycemic effects [7] and the hypoglycemic principle has been reported as dioscoretine [8]. Low lipid contents have been reported for most yams [9]. It is also well known that diets basically prepared from yams are not rich in fats and fat-soluble vitamins. However, their fatty acids may be beneficial to human beings and animals since plant fatty acids have become a major player in the alleviation of most human diseases. Reports on fatty acid contents of other common varieties of yam are available in the literature [10]. Nature has adapted fatty acids of vegetable sources such as n-3 and n-6 fatty acids for important cell regulatory functions through the arachidonic acid cascade [11, 12]. The significance of free long-chain polyunsaturated fatty acids on membrane electrical excitability in cardiac myocytes of neonatal rats has been reported [13]. Polyunsaturated fatty acids known to regulate prostaglandin synthesis, thus promoting wound healing [14, 15] cannot be synthesized by man and must be obtained from the diet [16]. In the light of recent dietary and medical importance and emphasis on the role of fatty acids in human physiology, the knowledge and application of the nutritional potential of *Dioscorea dumetorum* varieties with emphasis on their fatty acid profile can be useful in functional food production. In the present investigation, an attempt was made to screen for the first

time, the fatty acid compositions of the edible and wild yams (*Dioscorea dumetorum* varieties) to put on record their nutritional similarities and differences.

MATERIALS AND METHODS

Collection and treatment of samples

The wild and the edible types of *Dioscorea dumetorum* were obtained from Ikot Akpanabia, Akwa Ibom State, in the South- Eastern part of Nigeria and analyzed for their fatty acid compositions. Fifty fresh tubers of edible variety of *Dioscorea dumetorum* were randomly selected from yams harvested from five different farms in Ikot Akpanabia village, Nsit Ubium Local Government Area, Akwa Ibom State, Nigeria in the month of December, 2004. Equally, fifty fresh tubers of the wild variety were randomly selected from yams obtained from five locations in the forest in Ikot Akpanabia village, Nsit Ubium Local Government Area, Akwa Ibom State, Nigeria in the month of December, 2004. Each farm location contributed a maximum of eleven tubers. The tubers were washed, air dried and the fibrous roots removed. The tubers were weighed to obtain fresh weight and were conveyed wrapped in clean dry paper in cardboard boxes from the site to the laboratory. Tubers from each variety were independently sliced into chips and the chips were dried in an air draught oven at 55°C for 6 hours. The dried chips were ground using National Blender (National, England, UK) into powder and stored in airtight containers with plastic screw caps.

Chemical analysis

The crude fat contents of the varieties were determined by a method described by Association of Analytical Chemists (AOAC) [17]. The fats were converted to free fatty acids by saponification. The fatty acids were converted to their methyl esters. Fatty acids were determined by gas chromatographic analysis using the methods of AOAC [17]. Analysis was carried out in a commercial laboratory (Eurofins Scientific Incorporated, Memphis-Tennessee, USA). All oil samples were analyzed in triplicates and the results were presented as an average of three determinations.

Statistical analysis

Descriptive statistics (mean, range) were calculated while statistical significance of difference was determined by analysis of variance with the Statistical Analytical System (SAS) software package with SPSS version [18].

RESULTS

The results of crude fat content and fatty acid composition of *Dioscorea dumetorum* varieties are presented in Table 1. The data showed that the crude fat content of the wild *Dioscorea dumetorum* variety (0.45%) was insignificantly ($P>0.05$) lower than value obtained for the edible *Dioscorea dumetorum* (0.62%). The fatty acid composition of edible *Dioscorea dumetorum* ranged from 0.12% to 35.08% and that of the wild variety from 0.11% to 39.77%. The results showed palmitic (22-29%), oleic (14-17%) and linoleic (35-39%) acids as the predominant fatty acids in the two varieties of *Dioscorea dumetorum*. The most abundant saturated fatty acid was

palmitic acid, while the total saturated fatty acids amounted to 36.7% and 36.5% of the total fatty acids for edible and wild *Dioscorea dumetorum*, respectively. Similarly, the most abundant unsaturated fatty acid was linoleic acid, while the total unsaturated fatty acids constituted 50% and 56.3% of total fatty acids, respectively for edible and wild varieties of *Dioscorea dumetorum*.

The polyunsaturated to saturated fatty acids (P/S) ratio obtained was 1.20 and 1.60 for edible and wild varieties, respectively. Figures 1 and 2 show the sequence of the fatty acids in the wild and edible varieties of *Dioscorea dumetorum*, respectively and the sequence are according to their chromatographic retention times.

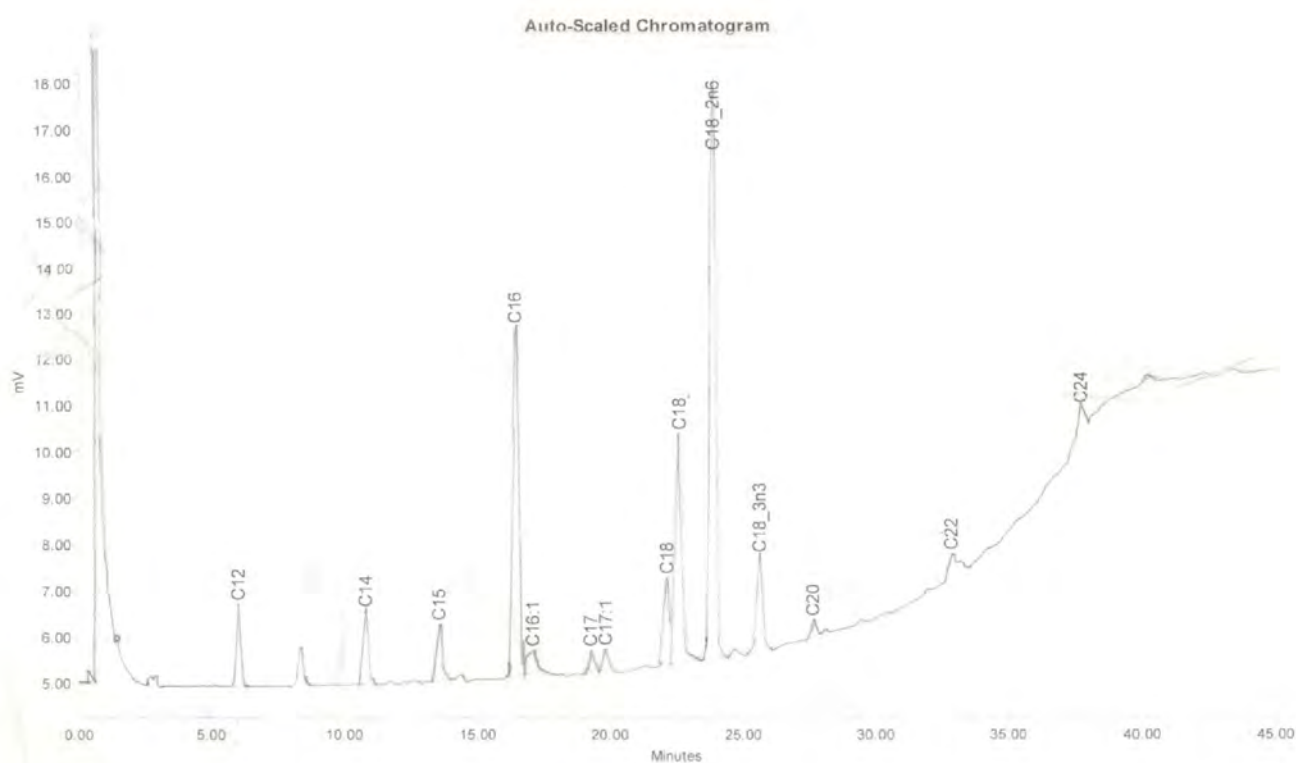


Figure 1: Fatty acid composition of wild *Dioscorea dumetorum*

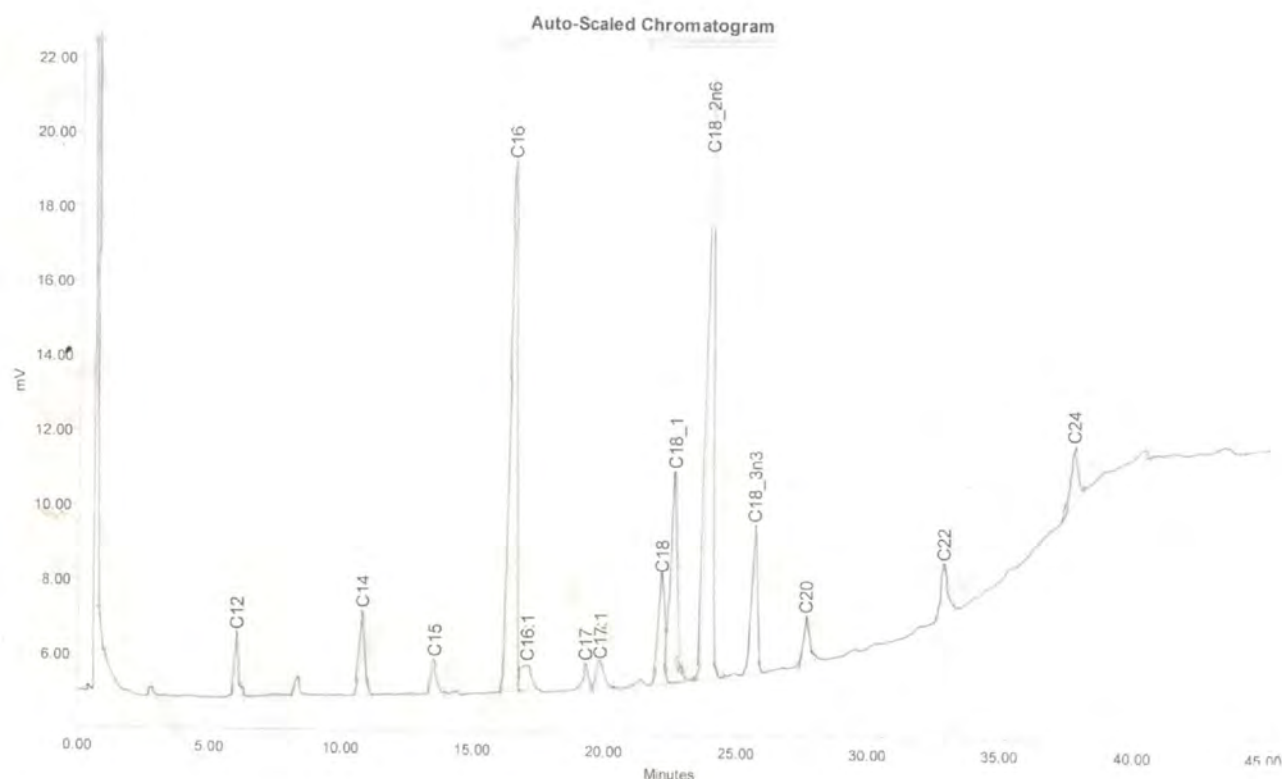


Figure 2: Fatty acid profile of edible *Dioscorea dumetorum*

DISCUSSION

The fatty acid compositions of the wild and edible *Dioscorea dumetorum* showed a similar pattern with reports on other *Dioscorea spp* [10]. However, there was a slight variation in lauric acid and myristic acid contents.

Linoleic acid, an essential fatty acid found in *Dioscorea dumetorum* varieties is an indicator, pointing to the need to exploit these yams for their nutritional values. Unsaturated fatty acids, particularly linoleic acid are required nutrients essential for normal functioning of the human body. Plant fatty acids serve as good and healthy fat to the consumers and the low incidence of coronary heart disease among rural Nigerians may be due to the consumption of these yams and sea-foods among other local foodstuffs. It is also important to note that the unsaturation ratio of both varieties of *Dioscorea dumetorum* were high but higher in the wild variety than edible variety of this yam. The unsaturation ratios of the lipids in both varieties are similar

to that of sweet potato but considerably lower than that of Irish potato [10]. The unsaturation ratio of the wild *Dioscorea dumetorum* variety is higher than values reported for *Dioscorea alata* (1.4) and *Dioscorea bulbifera* (1.4) but lower than that of *Dioscorea rotundata* (1.80) and *Dioscorea cayenensis* (1.80) [10]. It is, however, noteworthy to mention that yams are not whole meal but are eaten with soups, pepper soups or vegetable sauces that are rich in proteins and fatty acids [19]. In this respect, the nutritional value of *Dioscorea dumetorum* meal may improve significantly. The phytochemical constituents of *Dioscorea dumetorum* as reported by Ogunro [20] might serve some medicinal purposes.

The results of this investigation also revealed that *Dioscorea dumetorum* contains normal fatty acids as well as unusual fatty acids like erucic and hendecanoic acids. Erucic acid, a rare plant fatty acid found in the *Dioscorea dumetorum* varieties, is also a component of rapeseed oil, known to have some health implications. In addition, hendecanoic acid, a well-known antimycotoxin is present in *Dioscorea dumetorum* varieties in trace amount. It is, therefore, necessary to look beyond the food values of this yam to its phytochemicals, especially the alkaloids that are leached in the preparation process. This is because alkaloids of plant sources are important biopharmaceuticals. The presence of arachidonic acid though in small quantity is another important reason why the biological significance of *Dioscorea dumetorum* varieties in health and diseases be explored. Arachidonic acid has been reported to serve as a precursor of prostaglandin and thromboxane biosynthesis [21],

The role of fatty acids, especially the polyunsaturated fatty acids (PUFAs) in the management of coronary heart disease can be considered as the function of fatty acids of plant origin. It has been reported that dietary changes achieved greater reductions in cardiovascular risk factors and coronary heart disease mortality in a secondary prevention trial than any of the cholesterol-lowering studies to date [22]. The consumption of *Dioscorea dumetorum* will, therefore, supplement dietary fat with such essential fatty acids as linoleic acid and others, which are high in this yam. Pure individual n-3 PUFAs, eicosapentaenoic acid (EPA), decosahexaenoic acid (DHA), and α -linolenic acid (LNA), have been reported to prevent fatal ventricular arrhythmias in a reliable dog model of sudden cardiac death [23, 24, 25].

CONCLUSION

The two varieties of *Dioscorea dumetorum* did not show significant and consistent differences in their fatty acid contents. All the fatty acids present in the edible variety were found in the wild variety, indicating that both varieties are good sources of dietary fatty acids. Percentage composition of individual fatty acids ranged from 0.11% to 39.77% in the varieties. The most abundant fatty acids in both varieties were palmitic, oleic and linoleic acids. It is suspected that just as cassava has taken its rightful place in the world market today, *Dioscorea dumetorum*, if given the necessary attention will spring a surprise as a potential raw material in the nutritional and pharmaceutical industries. Consumption of *Dioscorea dumetorum* varieties can add quality to dietary lipids of the consumers as well as contribute substantially to the

essential fatty acid requirement of people in areas where the *Dioscorea dumetorum* varieties are consumed as staple food.

The findings of this study thus open up new areas of research in the utilization of *Dioscorea dumetorum* in functional food production. In addition, the effect of this lesser known oil as a pharmaceutical agent effective in the treatment of cancer and other degenerative diseases is ongoing in our Laboratory.

Table 1: Crude fat and fatty acid profile of *Dioscorea dumetorum* varieties

Crude fat content/fatty acid	<i>D. dumetorum</i> (edible)	<i>D. dumetorum</i> (wild)
Crude fat (g %)	0.62±0.03	0.45±0.15
g/100g total fatty acid		
(C8:0) Caprylic	0.12 (trace)	0.11 (trace)
(C10:0) Capric	0.12 (trace)	0.11 (trace)
(C11:0) Hendecanoic	0.12 (trace)	0.11 (trace)
(C12:0) Lauric	2.53	3.88
(C14:0) Myristic	4.31	4.43
(C16:0) Palmitic	29.84	22.95
(C16:1) Palmitoleic	2.30	2.40
(C18:0) Stearic	6.12	5.67
(C18:1) Oleic	14.56	17.73
(C18:2) Linoleic	35.08	39.77
(C18:3) Linolenic	8.61	6.52
(C20:0) Arachidic	2.45	1.00
(C20:4) Arachidonic	0.12 (trace)	0.11 (trace)
(C22:1) Erucic	0.12 (trace)	0.11 (trace)
(C24:0) Lignoceric	3.05	1.26
Unsaturation ratio*	1.20	1.60

Mean of 3 determinations

$$* \text{ Unsaturation ratio} = \frac{C_{18:2} + C_{18:0}}{C_{16:0} + C_{18:0}}$$

REFERENCES

1. **Malaurie B** In vitro storage and safe international exchange of yam (*Dioscorea spp.*) germplasm. *Electronic Journal of Biotechnology @ <http://ejb.ucv.cl/review>*. 1998. Accessed 20-12-2005
2. **FAO**. Food and Agriculture Organisation. Roots, tubers, plantains and bananas in human nutrition. FAO, Rome, 1990.
3. **FAO/WHO/UNU**. Energy and Protein requirements. *Tech. Rep Series 724*, World Health Organisation, Geneva, 1985.
4. **Onwueme IC** The tropical tuber crops: Yams, Cassava, Sweet potatoes, Cocoyams. Chichester: Wiley, 1978.
5. **Eka OU** The chemical composition of yam tubers. In: Osuji G. (ed.) *Advances in yam research: The biochemistry and technology of the yam tubers (51-74)*. Enugu: Biochemical Society of Nigeria, 1985.
6. **Alozie Y, Akpanabiatu MI, Umoh IB, Eyong EU and GAO Alozie** Amino acid composition of *Dioscorea dumetorum* varieties. *Pak. J. Nut.* 2009; **8(2)**: 103-105.
7. **Undie AS and PI Akubue** Pharmacological evaluation of *Dioscorea dumetorum* Tuber used in traditional antidiabetic therapy. *Ethnopharmacology* 1986; **15(2)**: 133-144.
8. **Iwu MM, Okunji CO, Akah P, Tempesta MS and D Corley** Dioscoretine: The hypoglycemic principle of *Dioscorea dumetorum* tubers. *Planta Medica* 1990; **56**: 119-120.
9. **Osagie AU** The yam tuber in storage. Benin: Post harvest research unit, Department of Biochemistry, University of Benin, 1992: 25-32.
10. **Opute FI and AU Osagie** Fatty acid composition of total lipids from some tropical storage organs. *J. Sc. Fd. Agric.* 1978; **29**: 959-962.
11. **Leaf A and PC Weber** Cardiovascular effects of n-3 fatty acids. *N. Engl. J. Med.* 1988; **318**: 549 – 557.
12. **Essien EU, Esenowo GJ and MI Akpanabiatu** Lipid composition of lesser known tropical seeds. *Plt. Fd. Hum. Nutri.* 1995; **48**: 135 – 140.
13. **Kang JX, Xiao YF and A Leaf** Free, long-chain, polyunsaturated fatty acids reduce membrane electrical excitability in neonatal rat cardiac myocytes. *Proc. Natl. Acad. Sci. U.S.A.* 1995; **92**: 3997 – 4001.

14. **Bowman WC and MJ Rand** Textbook of pharmacology. 2nd Edition. Oxford: Blackwell. 1980.
15. **Gibson RA** Australian fish-an excellent source of both arachidonic and 3 polyunsaturated fatty acids. *Lipids* 1983; **18**: 743-752.
16. **Alasalvar C, Taylor KD, Zubcov E. Skahidi F and M Alexis** Differentiation of cultured and wild sea bass (*Dicentrarchus labrax*): Total lipid content, fatty acid and trace mineral composition. *Fd. Chem.* 2002; **79**: 145-150.
17. **AOAC.** Official Methods of Analysis. 17th Edition. Washington DC: Association of Official Analytical Chemists, 2000.
18. **SAS.** Statistical Analytical System. Cary NC, US: SAS Institute Inc., 1999.
19. **Akpanabiatu MI, Bassey NB, Udosen EO and EU Eyong** Evaluation of some minerals and toxicants in some Nigerian soup meals. *J. Fd. Comp. Anal.* 1998; **11**: 292 – 297.
20. **Ogunro Y** Nutritional and toxicological studies on *Dioscorea dumetorum* (Trifoliolate yam) varieties. PhD Thesis, University of Calabar, 2006.
21. **Pompeia C, Freitas JS, Kim JS, Zyngier SB and R Curi** Arachidonic acid cytotoxicity in leukocytes: Implications of oxidative stress and eicosanoid synthesis. *Biology of the Cell* 2002; **94(4-5)**: 251-265.
22. **de Lorgeril M, Salen P, Martin JL, Monjaud I, Delays J and N Mamelle** Mediterranean diet, traditional risk factor, and the rate of cardiovascular complications after myocardial infarction: final report of the Lyon diet heart study. *Circulation* 1999; **99**: 779 – 785.
23. **Billman GE and H Hallaq** Prevention of ischemia-induced ventricular fibrillation by n-3 fatty acids. *Proc. Natl. Acad. Sci. USA.* 1994; **91**: 4427 – 4430.
24. **Billman GE, Kang JX and A Leaf** Prevention of fatal ischemia-induced ventricular arrhythmias by dietary pure n-3 polyunsaturated fatty acids in dogs. *Circulation* 1997; **32(11)**: 1161 - 1168.
25. **Billman GE, Kang JX and A Leaf** Prevention of ischemia-induced cardiac sudden death by n-3 polyunsaturated fatty acids. *Lipids* 1999; **32**: 1161 – 1168.