ISSN 0975-6299 Vol 2/Issue 1/ Jan-Mar 2011

International Journal of Pharma and Bio Sciences

RESEARCH ARTICLE

BIO CHEMISTRY

FATTY ACID COMPOSITION OF ZONOCERUS VARIEGATUS, MACROTERMES BELLICOSUS AND ANACARDIUM OCCIDENTALE KERNEL

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ABSTACT

The fatty acid composition of winged termites, *Macrotermes bellicosus*; variegated grasshopper, *Zonocerus variegatus* and cashew kernel (unroasted and roasted), *Anacardium occidentale* were reported. Oleic acid (18:1) was the most concentrated in all the samples with (%): 49.2 (M. *bellicosus*), 29.3 (*Z. variegatus*), 65.4 (A. *occidentale*, unroasted) and 64.6 (A. *occidentale*, roasted); while stearic acid (18:0) was the least concentrated with respective values as in the above trend: 8.5, 5.7, 7.2 and 7.2. Roasting enhanced the availability of linoleic acid (18:2) from 16.0 to 17.5%. The polyunsaturated fatty acid/saturated fatty acid (P/S) values were: 0.21 (M. *bellicosus*), 2.19 (Z. *variegatus*), 0.90 (A. *occidentale*, roasted), showing that Z. *variegatus* fatty acid was the best.

KEYWORDS

Fatty acid composition, *M. bellicosus, Z. variegatus, A.occidentale.*

INTRODUCTION

The variegated grasshopper, *Zonocerus variegatus*, is widely spread in Western and Central Africa. It is primarily associated with forest regions but extended to the Savannah region where it is restricted to reverine habitat [1]. It is a polyphagus insect that feeds on leaves and defoliates many farm crops. It usually occurs in large number and can easily be collected throughout West Africa [2]. It is widely consumed in Ikare, Ondo State, Nigeria. They are generally prepared in a manner similar to that of crickets and consumed by all age group of all tribes [3]. The composition and the food properties of the Z. *variegatus* have been reported [4]. The amino acid composition [5, 6] and the infrared characterization of its oils [6] have also been reported.

The winged termites, *Macrotermes bellicosus* are exopterygotous insects which belong to the order Isoptera of the class Insecta. Due to their eating habits, termites act as scavengers because of their ability to clear wastes from surroundings [7]. Termites are also useful to man, mainly as food for man and animals. Beyond West Africa, much importance has been attached to termites as food. Hickin [8] reported that they are on sale in the United States, together with other insects, enveloped in candy. In places where meat and other protein-containing foods are scarce termites constitute a useful source of protein. Harris [9] reported that four sacks full are harvested annually from one colony of *Macrotermes* in Uganda, and slightly roasted alates from Leopoldville market gave a fat content of 44.4 % and protein of 36.0 %. Chimpanzees occasionally feed on termites [10]. de Bont [11] believed that termites constitute basic food for the young of many species of bird. The anatomical weight composition, proximate, mineral and amino acid composition of M. *bellicosus* have been reported [12].

The cashew is a low, sprawling evergreen tree with a gnarled or twisted trunk, possessing alternate, simple, leathery, oval or obovate glabrous leaves which are rounded and often notched at the apex. The fruit consists of a soft, shiny, pear shaped, swollen, juicy basal portion or hypo carp, commonly known as a cashew apple. It is the swollen peduncle and receptacle, reddish or yellow in color when ripe. The 'apple' bears at its summit a kidney- shaped, single seeded nut with a hard, grey-green pericarp or shell. This seed fruit attains its full size before the enlargement of the receptacle. The seeds are exalbuminous with a reddish brown testa, two large white cotyledons and a small embryo. The seeds are inedible when raw and must be cooked or roasted to drive off the volatile oil before it is opened or shelled [13]. Work had been carried out on the amino acid composition of cashew nut [14].

Fat provide a major portion of man's energy supplies, giving weight-for-weight more than twice as much energy as proteins or carbohydrates [15]. Just as the proportion of carbohydrate in the human diet is influenced by ecological and economic factors, so also is the level of fat, which varies considerably from 6-10% in underdeveloped and overpopulated areas to 35-45% in the more prosperous countries.

The major aims of this project were to analyse the fatty acids profile of *Zonocerus variegatus, Macrotermes bellicosus, and Anacardium occidentale* kernel (unroasted and roasted) and to compare their fatty acid qualities.

ISSN 0975-6299 Vol 2/Issue 1/ Jan-Mar 2011

MATERIALS AND METHODS

Zonocerus variegatus were collected in a swoop and put in a dry container with a tight cover and brought to the laboratory. The insects were oven- dried at 55 ^{0}C, cooled, and the edible portion (200 g) was dry- milled into flour and kept in deep freezer in McCartney bottles pending analysis.

Macrotermes bellicosus were collected in a swoop. They were de-winged and oven-dried at 60-80 ^{0}C, cooled and about 200 g portion was dry-milled and kept in deep freezer (-4 ^{0}C) in McCartney bottles before analysis.

The seeds of *Anacardium occidentale* were purchased from the merchants. They were sun-dried and divided into two portions of 500 g each. One part was shelled and dry-milled into flour and kept in the freezer before analysis. The other part was also shelled, roasted, cooled, and dry-milled and kept in freezer for analysis.

The oil sample was extracted from the various sample flours by Soxhlet extraction using petroleum ether of Analar grade (British Drug House, London), boiling range 40-60 ^{0}C, for 5 h [16]. The oil extracted was converted to the methy1 ester [17]. The fatty acid methyl esters were analyzed using a PYE Unicam 304 gas chromatograph (PYE Unicam, Cambridge, UK) fitted with a flame ionization detector and a PYE Unicam PU4810 computing integrator. Helium was used as the carrier gas. The column initial temperature was 150 ^{0}C rising at 5 ^{0}C/min to a final temperature of 220 ^{0}C while the injection port and the detector were maintained at 220 and 250 ^{0}C, respectively. A polar (250QC3/BP1-0.5) capillary column (25.00m X 0.33mm; SGE Scientific Glass Engineering Co., UK) was used to separate the esters. The peaks were identified by comparison with standard fatty acid methyl esters obtained from Sigma Chemical Co., (St Louis, MO, USA).

RESULTS AND DISCUSSION

Table 1 presents the fatty acid composition of *M. bellicosus*. The most concentrated fatty acid was oleic (18:1) with a value of 49.2 %, palmitic (16:0) was next (31.4 %) and least was stearic (18:0) with a value of 8.5 %. Table 2 presents the fatty acid composition of *Z. variegatus*. Here again oleic was the most concentrated (29.3 %) and closely followed by α – linolenic (18:3) with a value of 22.8 %. Stearic was least (5.7 %). The unknown acid value here (9.4 %) was much higher than in *M. bellicosus* (2.3 %). In Table 3 is presented the unroasted *A. occidentale* fatty acid. Oleic was the highest (65.4 %) followed by linoleic (16.0 %) and the least was stearic (7.2 %). Table 4 presents the fatty acid composition of roasted *A. occidentale*. Again, oleic was the most concentrated (64.6 %), followed by linoleic (17.5 %) and least was stearic (7.2 %). In both *A. occidentale* samples, the unknown acid values were low: 0.9 % (unroasted) and 0.4 % (roasted). Table 5 shows the comparison of the unroasted and roasted fatty acid values of *A. occidentale*. Here the value of the acids were very close as shown by the coefficient of variation percent (CV %) whose values ranged between 0.80-6.50. The CV % for the unknown fatty acids in Table 5 was however very high (53.17); also roasting enhanced the availability of linoleic acid which moved from 16.0 % (unroasted) to 17.5 % (roasted) which was an increase of 1.541 (9.64 %).

The crude fat content of *M. bellicosus* was reported as 52.73 % [12]; for *Z. variegatus* it was 13.3% [4]; for *A. occidentale* it was 48.25 % (unroasted) and 41.40 % (roasted) [18]. These literature values showed that *Z .variegatus* was the least fatty. The crude fat levels were used to calculate the total fatty acids by multiplying each crude fat with a factor of 0.956 and then calculated the level of each fatty acid per total fat for the *A. occidentale* kernels [19].

Table 1

Fatty acids composition of winged termites (% total fatty acids)

Fatty acid[a]	Concentration
Palmitic (16:0)	31.4
Stearic (18:0)	8.5
Oleic (18:1)	49.2
Linoleic (18.2)[b]	8.6
Unknown	2.3

[a]Oleic (C18:1, n-9); linoleic (C18:2, n-6).

[b]Essential fatty acid.

Table 2

Fatty acids composition of variegated grasshopper (%)

Fatty acid	Concentration
Palmitic (16:0)	13.5
Stearic (18:0)	5.7
Oleic (18:1)	29.3
Linolenic (18:2)	19.2
α – Linolenic (18.3)[a]	22.8
Unknown	9.4

[a]α – Linolenic (18:3, n-3); essential fatty acid.

Table – 3

Fatty acids composition of cashew kernel (unroasted) (%)

Fatty acid		**Concentration**
Palmitic	(16:0)	10.5
Stearic	(18:0)	7.2
Oleic	(18:1)	65.4
Linoleic	(18:2)	16.0
Unknown		0.9

Table 4
Fatty acids composition of cashew kernel (roasted) (%)

Fatty acid		Concentration
Palmitic	(16:0)	10.3
Stearic	(18:0)	7.2
Oleic	(18:1)	64.6
Linoleic	(18:2)	17.5
Unknown		0.4

Table 5
Fatty acids composition levels of unroasted and roasted cashew kernel compared

Fatty acid	Levels		Mean	Standard deviation	CV %[a]	Difference	
	unroasted (C_1)	roasted (C_2)				C_1-C_2	%
16:0	10.5	10.3	10.4	0.14	1.30	0.192	1.82
18:0	7.2	7.2	7.2	0.06	0.80	0.082	1.13
18:1	65.4	64.6	65.0	0.57	0.87	0.802	1.23
18:2	16.0	17.5	16.8	1.09	6.50	-1.541	-9.64
Unknown	0.86	0.39	0.63	0.33	53.17	0.466	54.50

[a]CV % = Coefficient of variation percent.

The current results in the four samples were in contrast to the results obtained for dehulled and hulled African yam beans (AYB) where stearic acid was the most concentrated and followed by linoleic acid [20, 21]. Linoleic acid is the most concentrated fatty acid in pigeon pea [22], soybean [23], corn oil and safflower oil [24]. Linoleic and oleic acids are major fatty acids in peanut, soybean, chick pea, garden pea, broad bean and lentil which conformed with current results in *A. occidentale*. This observation is also prevalent in melon seeds [25, 26]. Cowpea, black-eyed pea, kidney and California small white bean have linoleic and linolenic acids as the major fatty acids [20]. The value of the unknown fatty acid in the AYB (dehulled) was 9.83 % (average), close to the value of 9.4 % in *Z. variegatus*. It was 5.2 % in pigeon pea (*Cajanus cajan*) which is close to 2.3 % in *M. bellicosus* and 0.9 % in soybean [27] which is similar to *A. occidentale* (unroasted) with a value of 0.9 %.

The n-6 (18:2) and n-3 (18:3) fatty acids have critical roles in the membrane structure [28,

[29] and as precursors of eicosanoids (20:1), compete for the same enzymes and have different biological roles, the balance between n-6 and the n-3 fatty acids in the diet can be of considerable importance [30]. The ratio of linoleic to α – linolenic acid in the diet should be between 5.1 and 10.1 [30]. In the current report only *Z. veriegatus* contained both acids at a ratio of 0.8:1 which is far below the above stated standard.

Table 6 presents fatty acids distribution according to saturation and unsaturation of components (%) in the samples. It has been concluded that relative to carbohydrates, the saturated fatty acids (SFA) elevate serum cholesterol, while the polyunsaturated fatty acids lower serum cholesterol [31, 32]. The SFA, palmitic (16:0) has been established as one of the most important of the dietary risk factors in coronary heart disease (CHD) [13]. The three protein-lipid complexes (lipoproteins) in the blood are low – density lipoproteins (LDL), high-density lipoproteins (HDL) and very- low – density lipoproteins (VLDL). High levels of total blood cholesterol are associated with the incidence of CHD as well as high intakes of SFA [33]. A direct comparison of myristic and palmitic acids showed that both raise LDL cholesterol relative to oleic acid [34]. The other major SFA in the samples, stearic acid (18:0), may not be as hypercholestrolemic as palmitic (because it is converted to oleic acid) [35]. The SFA in all the samples ranged from 17.5-39.9 % which was relatively low compared to the oleic acid (29.3-65.4 %).

Table 6
Fatty acids distribution according to saturation of components (%) in the samples

Fatty acid[a]	Winged termite	Variegated grasshopper	Cashew kernel	
			unroasted	roasted
TSFA	39.9	19.2	17.8	17.5
TUFA	57.8	71.4	81.4	82.1
TMUFA	49.2	29.3	65.4	64.6
TDUFA	8,6	19.2	16.0	17.5
TTUFA	-	22.8	-	-
TNEFA	89.1	48.5	83.2	82.1
TEFA	8.6	42.1	16.0	17.5
P/S	0.21	2.19	0.90	1.001

[a]TSFA (total saturated fatty acid); TUFA (total unsaturated fatty acid); TMUFA (total monounsaturated fatty acid); TDUFA(total diunsaturated fatty acid); TTUFA (total triunsaturated fatty acid); TEFA (total essential fatty acid); P/S (polyunsaturated fatty acid/ saturated fatty acid).

Table 7

Levels of each fatty acid present in100 g of unroasted cashew nut kernel containing 48.3 g fat

Fatty acid	Concentration	Level of fatty acid
Total fatty acid	46.1	-
16:0	10.5	4.84
18:0	7.2	3.32
18:1	65.4	30.2
18:2	16.0	7.38
Total	-	45.7
46.1-45.7	-	0.42
Percentage difference	-	0.9

Table 8

Levels of each fatty acid present in 100 g of roasted cashew nut kernel containing 41.4 g fat

Fatty acid	Concentration	Level of fatty acid
Total fatty acid	39.6	-
16:0	10.3	4.08
18:0	7.2	2.85
18:1	64.6	25.6
18:2	17.5	6.93
Total	-	39.4
39.6-39.4	-	0.16
Percentage difference	-	0.4

Table 9

Levels of each fatty acid in unroasted and roasted cashew nut compared

Fatty acid	Unroasted	Roasted	Mean	SD	CV%
Total fatty acid	46.1	39.6	42.9	4.60	10.7
16:0	4.84	4.08	4.46	0.54	12.0
18:0	3.32	2.85	3.09	0.33	10.8
18:1	30.2	25.6	27.9	3.25	11.7
18:2	7.38	6.93	7.16	0.32	4.44
Total calculated	45.7	39.4	42.6	4.45	10.5
Difference	0.42	0.16	0.29	0.18	63.4
% difference	0.90	0.40	0.65	0.35	54.4

SD = Standard deviation.

The total non- essential fatty acids (TNEFA) and total essential fatty acids (TEFA) values are shown in Table 6. The essential fatty acids (18:2 and 18:3) (EFA) were 42.1 % (*Z. variegatus*) > 17.6 % (roasted *A. occidentale*) > 16.0 % (unroasted *A. occidentale*) > 8.6 % (*M. bellicosus*). The comparison of TEFA and TSFA (Table 6) assisted to calculate the ratio of polyunsaturated fatty acids (PUFA) to saturated fatty acids (P/S). The P/S value for the samples ranged from 0.21 – 2.19. The relative amounts of PUFA and SFA in oils is important in nutrition and health. P/S is important in determining the detrimental effects of dietary fats. The higher the P/S ratio the more nutritionally useful is oil. This is because the severity of arteriosclerosis is closely associated with the proportion of the total energy supplied by saturated and polyunsaturated fats [38, 39]. Most of the P/S values were better than 0.54 – 0.72 reported for dehulled AYB [20]. Although the levels of P/S were low in *M.bellicosus* (0.21) and unroasted *A. occidentale* (0.90), the presence of appreciable amount of linoleic acid (an essential fatty acid) in the two samples could ameliorate the atheriosclerosis tendencies of these oils [38].

Table 7 presents the levels of each fatty acid present in 100 g unroasted cashew kernel containing 48.3 g fat and Table 8 presents same in 100 g of roasted cashew kernel containing 41.4 g fat. All parameters considered: total fatty acids, other fatty acids, total calculated fatty acids, difference and the percentage difference were all higher in the unroasted than the roasted cashew kernels on pair wise comparisons. The amount (g) of each fatty acid was a reflection of the experimentally obtained fatty acid. Table 9 shows the comparison of the levels of the fatty acids of the kernels in their 100 g samples. Least varied parameter was the linoleic (18:2) with a value of 4.44 % whereas the differences calculated gave most varied value of 63.4 %. This type of calculation gave the value of 1.15 g palmitic acid in 100 g goats' milk and 0.84 g stearic acid in 100 g whole egg [19].

ACKNOWLEDGEMENT

The author is grateful to Prof. E.T. Akintayo for his technical assistance in the analysis of the samples.

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