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Review: Organic foods from Annona *squamosa* (Gishta) and *Catunaregam nilotica* (Kirkir)

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ABSTRACT: Non-conventional fruits, which grow wildly, are being considered because their constituents have unique chemical properties and may augment the supply of organic food. *Annona squamosa* and *Catunaregam nilotica* are considered an important source for wild organic fruits in Sudan. The two fruits are produced without using any fertilizers and chemicals. The fruits are used as organic food by rural populations mainly for domestic consumption in many Sudanese states. They have multiple uses, including the fruits, seeds, oil, bark, and leaves. The oil and protein contents of *Annona squamosa* and *Catunaregam nilotica* are very high. The major fatty acids in *A. squamosa* and *Catunaregam nilotica* oils are oleic, linoleic, palmitic, and stearic. The tocopherol content of the extracted oils is very high with delta-tocopherol as the predominant tocopherol in *A. squamosa* oil, and beta-tocopherol in *C. nilotica* oil. The two fruits contained mainly protein and oil components and can be considered a good source for organic food.

KEYWORDS: *Amino Acids, Annona squamosa, Catunaregam nilotica, Fatty Acids, Organic food, Seed oil, Tocopherols*

INTRODUCTION

Organic foods are made in a way that complies with organic standards set by national governments and international organizations (http://www.ams.usda.gov). For the vast majority of human history, agriculture can be described as organic; only during the 20th century was a large supply of new synthetic chemicals introduced to the food supply. This more recent style of production is referred to as "conventional". Under organic production, the use of conventional non-organic pesticides (including insecticides, fungicides, and herbicides) is precluded. However, contrary to popular belief, certain sprays and other materials that meet organic standards are allowed in the production of organic food (http://www.omri.org). The difference in nutritional value of organic foods compared with commercial foods has been studied many times. The difficulties in controlling soil factors such as available nutrients, texture, organic matter, and other factors of temperature, light, seed type, planting and harvesting dates as well as post harvest handling makes obtaining statistically reproducible studies difficult to impossible (Smith 1993). Catunaregam nilotica is a wild fruit belong to the family Rubiaceae and known locally in Sudan as kerkir. *C. nilotica* is widespread in Central and East Africa as well as in Cameroon and Nigeria (Steentoft, 1988). In Sudan it is found in south and north Kordofan states. It grows as a medium height shrub (usually less than 3m) with grey drupes, stiff spines, and deciduous leaves clustered below the spines. It has a broad range of applications in the indigenous medical system (Huda *et al.*, 2002). *C. nilotica*

still grows as a wild plant in different areas in western Sudan states. No research data on its commercial production and its oil composition are available (Mariod et al., 2010). Mariod *et al*., (2010) extracted *C. nilotica* oil using two different methods. They reported very high oil content (40.0%) with linoleic, oleic, palmitic and stearic as the major fatty acids, and high amount of tocopherol (110.5 mg/100g oil).

Annona squamosa L., Annonaceae, is a well known tree in Sudan where locally known as Ghishta and widely cultivated and distributed in western states (Korofan and Darfour). The fruit is commonly known as custard apple it is a native of West Indies, it is widely grown throughout the tropics in India and popularly cultivated in the north eastern parts of Thailand, mainly for its edible fruit. Its seed is well known for killing head lice but has no report about the active component (Intaranongpai et al., 2006). The plant, deciduous and small; reaching a maximum of 6 m in height with many lateral branches, grows well in regions of medium humidity. Its seeds comprise 30% of its fruits weight, which is edible (Cardeiro *et al.,* 2005). The major fatty acids of *A. squamosa* oil are oleic, linoleic, palmitic, and stearic. The tocopherol content of *A. squamosa* oil is 16.6 mg/100g oil, with delta-tocopherol as the predominant tocopherol (Mariod et al., 2010). *A. squamosa* seed oil was reported to be used in soap and plasticizer industry as well as in alkyd manufacturing, the seeds are acrid and poisonous. Bark, leaves and seeds contain the alkaloid anonaine (Morton, 1987).

Consumer concern regarding possible adverse health effects of foods produced using intensive farming methods has led to considerable interest in the health benefits of organically-produced crops and animal products. There appears to be wides-pread perception amo-ngst consumers that such methods result in foods of higher nutritional quality (Williams, 2002). The present review care about producing organic food from *A. squamosa* and *C. nilotica* fruits and seeds

A. squamosa and _C. nilotica_ as an organic food source

The increase in demand and consumption of organc (also known as ecological or biological) foods has mainly been due to an increasing number of consumers associating significant environmental, biodiversity, ethical (e.g. animal welfare, local, and fair trade) and food quality and safety benefits with organic foods and/or food production systems. Future increases in demand will therefore rely on maintaining and/or improving consumer confidence in the benefits of organic foods (Cooper *et al*., 2007).

Edible organic oils from A. _squamosa_ and _C. nilotica_

Fats and oils are recognized as essential nutrients in both human and animal diets. Nutritionally, they are concentrated sources of energy (9 cal/g); provide essential fatty acids which are the building blocks for the hormones needed to regulate bodily systems; and are a carrier for the oil soluble vitamins A, D, E, and K. They also enhance the foods by providing texture and mouth feel, imparting flavor, and contributing to the feeling of satiety after eating (Strayer *et al*., 2006).

Mariod *et al.* (2010) studied the proximate analysis of *A. squamosa* and *C. nilotica* seed kernels (Table 1): It is clear from their results that the two samples show higher levels in protein and oil content. The oil content of Catunaregam nilotica seed kernel using cold and Soxhlet extraction methods was significantly ($p<0.05$) higher (40, 41.2%) than that of *A. squamosa* (26.8, 27.5%). The difference in oil content between cold extraction, and Soxhlet

extraction method was not significant and can be attributed to the fact that during Soxhlet extraction high temperature employed in solvent evaporation may have resulted in sample heating which will allow oil droplets to come out of the sample easier. The oil content of *C. nilotica* kernels was higher than most Sudanese conventional oilseeds (cottonseed, sunflower and groundnut), while that of *A. squamosa* was lower than cottonseed, sunflower, sesame and groundnut (Mariod et al., 2009). These results indicated clearly that the seeds from these two trees constitute a potential source of organic edible oils and fats. Therefore, from an economical point of view, the production of organic oil from such seeds could be of interest.

Physicochemical properties of oils produced from *A. squamosa* and *C. nilotica*

The organic oils obtained from Catunaregam nilotica and Annona squamosa kernels were odourless, of good colour, and of good appearance. The physicochemical properties of these oils were represented in table 2. The two oils were significantly different ($P \leq 0.05$) concerning the physcio-chemical properties as *A. squamosa* oil showed higher values in refractive index, acid value, peroxide value, saponification value and specific gravity, respecttively, than *C. nilotica* oil. From table 2 *A. squamosa* oil saponification value which gives an indication of the nature of the fatty acids in the fat, was lower than that (186.4) reported by Morton (1987). From table 2 it can be sumarized that the method of extraction affect significantly ($P \leq 0.05$) only on acid value, and no significant changes were observed in refractive index, peroxide value, saponification value and specific gravity of the two oils. Compared with Codex standards (Codex 1999) for cottonseed, sunflower, sesame and groundnut oils the *A. squamosa* and *C. nilotica* oils showed lower values for specific gravity, refracttive index and saponification values.

Fatty acid composition of oils produced from *A. squamosa and C. nilotica*

Mariod *et al.* (2010) reported the fatty acid composition of *A. squamosa* and *C. nilotic*a oils (table 3). The major fatty acid in the two plants were palmitic (16:0), stearic (18:0), oleic (18:1n-9), and linoleic (18:2n-6) acids. The oils were significantly ($P \leq 0.05$) different in their fatty acid composition. The extraction method did not affect the fatty acid composition of the two plants. In *A. squamosa* oils, C18:1 was the most dominant fatty acid; it was 49.2 and 50.5% in ASSE and ASCE, respectively, linoleic acid (C18:2) was the second most dominant fatty acid was 22.3 and 22.7% in ASSE and ASCE, respectively. In *C. nilotica* oils, C18:2 was the most dominant fatty acid; it was 63.1 and 63.4% in CNCE and CNSE, respectively, followed by oleic acid which was found to be 10.5 and 10.4% in CNCE and CNSE, respectively. Palmitic (C16:0) and stearic (C18:0) acids exhibited the third and fourth highest fatty acid contents in the four oils, palmitic acid was 15.6 and 15.2% in ASSE and ASCE, respectively and 9.7 and 9.8%, in CNCE and CNSE, respectively. While stearic acid was 10.6 and 9.3% in ASSE and ASCE, respectively, and 5.1 and 5.4%, in CNCE and CNSE, respectively. The striking feature of the four seed oils was the relative high level of polyunsaturated fatty acids (PUFA) which accounted for 71-74% of total identified fatty acids, and the high linoleic acid content *C. nilotica* kernel oil makes it nutritionally valuable. The remaining fatty acids contributed only few percentages to the total fatty acid percent.

Differences in the fatty acid composition of the seed oil may exist

even within the same variety. For example, Ansari *et al.* (1985) and Ahmad et al. (2006) reported that, the dominant fatty acids in the seed oil of Annona squamosa were oleic (37.0%), palmitic (25.1%) and linoleic (10.9%). While Rafeeq et al. (2002) reported 29.0% oleic, and 32.0% linolic. The results of the three research groups differ significantly with Mariod *et al.,* (2010) results with respect to the major fatty acids in the seed oil of *A. squamosa.*

Tocopherols composition of oils produced from *A. squamosa and C. nilotica*

Tocopherols are a class of chemical compounds of which many have vitamin E activity. It is a series of organic compounds consisting of various methylated phenols. Alpha-tocopherol is the main source found in supplements and in the European diet, while gamma-tocopherol is the most common form in the American diet. The compound α-tocopherol, a common form of tocopherol added to food products, is denoted by the E number E307. Tocotrienols, which are related compounds, also have vitamin E activity. All of these various derivatives with vitamin activity may correctly be referred to as "vitamin E" tocopherols and tocotrienols are fat-soluble antioxidants but also seem to have many other functions in the body (*Jiang et al*., 2001).

The content of the tocopherols in freshly extracted oils of *A. squamosa* and *C. nilotica* was reported by Mariod *et al*., (2010) (table 4). Among the tocopherols identified α-tocopherol was 4.9, 4.4, 31.6 and 28.5 mg/100 g in ASCE, ASSE, CNCE and CNSE, respectively, and delta-tocopherol was 11.7, 11.0, 8.4, and 10.5, respectively. Beta and gamma-tocopherols were found only in *C. nilotica* oil and beta-tocopherol was abundant accounting for 65.7 and 63.8 mg/100 g in oil extracted using cold extraction and Soxhlet extraction methods. The total tocopherol amount was significantly different in *A. squamosa* and *C. nilotica* oils, and that method of extraction was not affected signify-cantly on tocopherol amount. *C. nilotica* oils (CNCE and CNSE) showed higher amounts of tocopherols 110.5, 107.9 mg/ 100 g, respectively, compared to other common oils such as sesame (33-101 mg/100), groundnut (17-130 mg/100) and sunflower (44-152 mg/ 100 g) oils (Codex, 1999). The main tocopherol of the *A. squamosa* oils was delta-tocopherol, which constituted more than 70% of the total tocopherols. In case of *C. nilotica* oils β-tocopherol was the predominant and constituted more than 59%. The other tocopherols in the oil of the two samples were below 1 mg/100 g each.

Protein and amino acid profile of *A. squamosa* and *C. nilotica*

In human, amino acids are obtained through the consumption of foods containing proteins. Ingested proteins are then broken down into amino acids through digestion, which typically involves denaturation of the protein through exposure to acid and hydrolysis by enzymes. Some ingested amino acids are used for protein biosynthesis, while others are converted to glucose through gluconeogenesis, or fed into the citric acid cycle. This use of protein as a fuel is particularly important under starvation conditions as it allows the body's own proteins to be used to support life, particularly those found in muscles (Brosnan, 2003).

In case of organic *A. squamosa and C. nilotica* proteins, they are a high protein vegan alternative to soy and animal products and help in detox-ification of our systems. In human applications, organic *A. squamosa* and *C. nilotica* proteins are suitable for use

as organic foods to be used for feed infants, elderly and severely ill people.

Organic *A. squamosa* and *C.nilotica* protein refers to a highly digestible and non-allergenic protein that is extracted from *A. squamosa* and *C. nilotica* with organically approved methods. An organic method generally narrates a way of derivation where an element is extorted without using artificial ingredients like pesticides, herbicides, and genetically modified organisms (GMOs). The same is applied for the production of organic *A. squamosa* and *C. nilotica* protein where the traditional methods are followed to minimize or eliminate the use of synthetic agricultural inputs like fertilizers, pesticides, hormones and antibiotics. In general, organic proteins include both plant proteins and animal proteins, and the proteins may be fresh or processed depending upon the methods of production, sources and consumer perception (www.*organicproteins.com*).

The amino acids profile of *A. squmosa* and *C. nilotica* seed is presented in Table 5. (Mariod et al., 2010). Values are given for 16 different amino acids, and sums for essential amino acids (EAA) and non-essential amino acids (NEAA). The total amount of the essential amino acids (phenylalanine, leucine, valine, threonine, isoleucine, methionine, tyrosine, histidine, argnine, cystine and lysine) found in *A. squamosa* and *C. nilotica* seeds were 4.302 and 8.319 g/100g proteins, respectively. The percentage of sulphur –containing amino acids (methionine and cystine) in A. squamosa seed was 0.106 g/100g protein, while in *C. nilotica* seed was 0.206 g/100g, which was the lower among the others. The of aromatic amino acids (phenylalanine +tyrosine) was 0.671 and 1.311 g/100g protein in *A. squamosa* and *C. nilotica*, respectively.

The amino acids content of *A. squamosa* and *C. nilotica* seeds showed a high difference when compared with egg, sesame and broad bean amino acids. All the essential amino acids with the exception of tryptophan which was not analyzed were found to be present in high amount in *C. nilotica* seed, when compared to that of three different foods (table 5). The individual essential amino acids of *C. nilotica* seeds were higher somewhat to that of egg and broad bean but egg are higher in methionine+cystine and isoleucine amino acids (Mariod, *et al.,* 2010).

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Table 1. Roximate analysis of seeds of A. squamosa and C. nilotica.

Sample	Moisture (%)	Fat (%)	Protein (%)	Ash (%)	Fiber (%)	CHO (%)
Annona squamosa	6.7± 0.2[a]	26.8± 0.4[a]	17.5± 0.2[a]	2.2± 0.1[a]	16.8±0.2[a]	30.0± 0.3[a]
Catunaregam nilotica	6.4± 0.1[a]	40.0± 0.6[b]	22.2± 0.3[b]	2.8± 0.1[a]	14.0± 0.2[b]	14.6± 0.2[b]

*Source Mariod *et al*., (2010). **All determinations were carried out in triplicate and mean value ± standard deviation (SD) are reported. [ab]Values with different superscript letters within a row indicate significant difference at $p<0.05$.

Table 2. Physicochemical properties of Annona squamosa and Catunaregam nilotica oil**

Physicochemical parameters	ASCE	ASSE	CNCE	CNSE
Oil content (% w/w)	26.8± 0.1[a]	27.5± 0.1[a]	40.0± 0.2[b]	41.2± 0.2[b]
Refractive index (40±1°C)	1.470±0.005[a]	1.470±0.005[a]	1.475±0.003[b]	1.475±0.003[b]
Acid value (mg KOH/g)	0.89± 0.01[a]	1.54± 0.1[b]	0.61± 0.01[c]	0.22± 0.01[c]
Peroxide value (meq O_2/kg oil)	1.0± 0.2[a]	0.9± 0.1[a]	0.8± 0.1[a]	1.0± 0.2[a]
Saponifcation value	185.7± 0.21[a]	184.5± 0.11[a]	182.6± 0.1[b]	181.4± 0.1[b]
Specific gravity (30 ± 1°C)	0.816±0.001[a]	0.816±0.001[a]	0.818±0.001[b]	0.818±0.001[b]

*Source Mariod et al., 2010. ** All determinations were carried out in triplicate and mean value ± standard deviation (SD). [abcd]Values with different superscript letters within a row indicate significant difference at $p<0.05$. ASCE=Annona squamosa cold extraction, ASSE=Annona squamosa Soxhlet extraction**.** CNCE=Catunaregam nilotica cold extraction, CNSE=CNSP=Catunaregam nilotica Soxhlet extraction

Tabe 3. Fatty acid composition (% of total) of Annona squamosa and Catunaregam nilotica oils**

Fatty acid	ASCE	ASSE	CNCE	CNSE
10:0	0.3±0.1[a]	0.2±0.1[a]	3.7±0.4[b]	4.1±0.2[b]
14:0	0.7±0.2[a]	0.6±0.3[a]	0.9±0.2[b]	0.8±0.1[b]
16:0	I5.6±0.5[a]	15.2±0.5[a]	9.7±0.4[b]	9.8±0.4[b]
18:0	10.6±0.4[a]	9.3±0.4[a]	5.1±0.2[b]	5.4±0.2[b]
18:1n-9	49.2±0.6[a]	50.5±1.2[a]	10.5±0.5[b]	10.4±0.7[b]
18:2n-6	22.3±0.5[a]	22.7±0.6[a]	63.1±0.7[b]	63.4±1.3[b]
18:3D 9,12,15	ND	ND	0.4±0.1[a]	0.6±0.1[a]
20:0	1.3±0.1[a]	1.5±0.1[a]	5.9±0.3[b]	5.3±0.2[b]
22:1 n:13	ND	ND	0.7±0.1[a]	0.2±0.1[a]
Unsaturated FA (%)	71.5	73.2	74.3	74.0
Oleic/linoleic ratio	2.2	2.2	0.16	0.16

*Source Mariod et al., 2010. **Each value is the mean ± SD of triplicate determinations. ND=not identified, [ab]values with different superscript letters within a row indicate significant difference at $p<0.05$. ASCE=Annona squamosa cold extraction, ASSE=Annona squamosa Soxhlet extraction**.** CNCE=Catunaregam nilotica cold extraction, CNSE=CNSP=Catunaregam nilotica Soxhlet extraction

Table 4. Tocopherol Content (mg/100 g) of Annona squamosa and Catunaregam nilotica oils**

Sample	α-T	β-T	γ-T	δ-T	Total
ASCE	4.9±0.1[a]	0.0±0.0[a]	0.0±0.0[a]	11.7±0.3[a]	16.6±0.4[a]
ASSE	4.4±0.1[a]	0.0±0.0[a]	0.0±0.0[a]	11.0±0.3[a]	15.5±0.3[b]
CNCE	31.6±0.5[b]	65.7±0.6[b]	4.7±0.2[b]	8.4±0.3[b]	110.5±0.6[c]
CNSE	28.5±0.4[c]	63.8±0.6[c]	5.1±0.2[c]	10.5±0.3[c]	107.9±0.6[d]

*Source Mariod et al., 2010. **All determinations were carried out in triplicate and mean value ± standard deviation (SD). [abcd]Values with different superscript letters within columns indicate significant difference at $p<0.05$. ASCE=Annona squamosa cold extraction, ASSE=Annona squamosa Soxhlet extraction**.** CNCE=Catunaregam nilotica cold extraction, CNSE=Catunaregam nilotica Soxhlet extraction

Table 5. Amino acid composition of Annona squamosa and Catunaregam nilotica seed compared with egg, sesame and bean (g per 100g protein)[a]

Amino acid	A. squamosa*	C. nilotica*	Egg**	Sesame**	Broad Bean**
Threonine	0.324±0.1	0.738±0.4	0.634±0.3	0.763±0.3	0.159±0.1
Methionine+cystine	0.106±0.1	0.206±0.1	0.717±0.5	0.988±0.6	0.071±0.1
Valine	0.642±0.2	1.031 ±0.5	0.174±0.1	0.985±0.6	0.374±0.2
Isoleucine	0.464±0.2	0.822±0.5	0.778±0.5	0.773±0.5	0.222±0.1
Leucine	0.845±0.3	1.608±0.6	1.091±0.4	1.433±0.4	0.389±0.1
Phenylalanine +Tyrosine	0.671±0.2	1.311±0.6	1.224±0.5	1.614±0.5	0.368±0.1
Histidine	0.139±0.1	0.695±0.6	0.301±0.1	0.523±0.2	0.126±0.1
Lysine	0.407±0.2	0.823±0.4	0.863±0.5	0.585±0.3	0.338±0.1
Argnine	0.704±0.4	1.085±0.6	0.754±0.6	2.586±1.0	0.760±0.5
Total EAA	4.302	8.319	6.536	10.25	2.807
Aspartic Acid	0.684±0.3	1.464±0.7	0.892±0.6	0.094±0.1	0.659±0.2
Glutamic acid	0.995±0.5	1.876±0.6	0.121±0.1	0.366±0.1	0.781±0.3
Serine	0.299±0.1	0.655±0.4	0.672	0.072±0.1	0.240±0.1
Glycine	0.392±0.1	0.834±0.1	0.302±0.1	0.054±0.1	0.201±0.1
Alanine	0.594±0.2	1.058±0.7	0.503±0.2	0.140±0.1	0.255±0.1
Total NEAA	2.964	5.883	2.490	1.391	2.136
Total amino acids	7.266	14.202	9.026	11.641	4.943

[a]All determinations were carried out in triplicate and mean value ± standard deviation (SD) reported. *Source Mariod et al., 2010. **Source: Paul, A.A and D.A.T. Southgate, (1979) "McCance and Widdowson" "The Composition of Foods "4th edition, Crown Copyright, London, U.K.,