

Anti-Oxidant Vitamins, Minerals and Tannins in Oil from Groundnuts and Oyster Nuts Grown in Uganda

Juliet Hatoho Musalima*, Patrick Ogwok and Diriisa Mugampoza

Department of Food Technology, Faculty of Science, Kyambogo University, Kampala, Uganda.

*Correspondence:

Juliet H Musalima, Department of Food Technology, Faculty of Science, Kyambogo University, Kampala, Uganda.

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ABSTRACT

Lipids contain fat soluble vitamins, sterols and polyphenols. This study aimed to determine the anti-oxidant vitamins, minerals and tannins in oil from groundnuts and oyster nuts grown in Uganda. Methods used included; high performance liquid chromatography, atomic absorption spectroscopy and UV spectroscopy. Groundnut oil contained nd to 559 µg/100 g of Vitamin A. Acholi white had the highest vitamin A content. Beta-carotene levels ranged from 0.21 to 1.72 µg/100 and vitamin E varied from 0.88 to 7.19 mg/100 g. Oil from Serenut 6Tan, 7Tan, 13Tan, Rudu red and Rudu white contained 37%, 39%, 48%, 42% and 47% of recommended daily intake for vitamin E. Vitamin A, beta-carotene and vitamin E in oyster nut oil ranged from 19.00 to 29.17 µg/100 g, 2.20 to 3.69 mg/100 g and 0.9 to 1.77 mg/100 g, respectively. The most abundant mineral in groundnut oil was calcium at 0.05 to 3.41 mg/100 g and the least was iron at 0.02 to 0.35 mg/100 g. The predominant mineral in oyster nut oil was magnesium at 42.71 to 55.77 mg/100 g and the least was iron at 0.18 to 0.20 mg/100 g. Tannins ranged from 531.89 to 940.22 µg/100 g in groundnut oil and 333.95 to 412.72 µg/100 g in oyster nut oil. The amounts of vitamin A and beta-carotene and minerals in oil were lower than the recommended daily intake. The low mineral content in both oils is favourable for shelf life. Tannin levels in groundnut and oyster nut oil were below the lethal dose. Oil with notable values of vitamin E could be exploited by breeders to improve content of other cultivars.

Keywords

Anti-oxidant vitamins, Groundnut oil, Oyster nut oil, Minerals, Tannins.

Introduction

In Uganda, groundnuts (*Arachis hypogea L.*) are the second most widely grown legumes after common beans (*Phaseolus vulgaris*) [1]. Although the nut is an excellent source of oil, the highest proportion of groundnuts produced in Uganda is consumed as snacks, stew and paste with low value added to the crop [1,2].

Oyster nut, *Telfairia pedata*, is a member of the Cucurbitaceae family. It is common in Tanzania, Kenya and some parts of Uganda. It is a valuable source of nourishment in East Africa where the nut is used as protein and oil source. Oyster nuts contain 55 to 60% oil [3,4].

The properties of groundnut oil make it suitable as a salad and

frying oil. Its application in cooking is attributed to its high oxidative stability and the presence of tocopherols and carotenoids with antioxidant and nutritional properties [3-6]. Tocopherols contribute to the stability of an oil and have an important role as quenchers of free radicals [7,8]. On the other hand, carotenoids are singlet oxygen quenchers and protect the oil from photo-oxidation [9-11].

The global alliance for improved nutrition report of 2012 mentioned that 2.6 million deaths in the world are due to malnutrition. Globally, 47% under-fives suffer from iron deficiency, 190 million children and 19 million women suffer from vitamin A deficiency disorders. Uganda suffers from hidden hunger as a result of inadequate consumption of vitamins A and D and minerals; iron, calcium and iodine [12]. This is attributed to consumption of low levels of animal products and micronutrient rich vegetables and pulses. Mineral deficiency may not be obvious at first but will manifest its self at a later stage after causing severe damage. A

daily supply is therefore crucial for good health.

Oilseeds contain energy, vitamins, minerals and antioxidants [13-15]. Iron and zinc deficiency is detrimental to growth and cognitive health while calcium is crucial in skeletal development [16]. Potassium keeps the cells alive through the sodium potassium pump. Magnesium is essential in nervous transmission [16-18]. There is scant information on the micronutrients and tannins content in oil from groundnuts and oyster nuts in Uganda. This study, therefore, focused on determining the anti-oxidant vitamins A, E and beta-carotene, minerals; calcium, magnesium, iron, zinc and tannins in oil from groundnuts and oyster nuts grown in Uganda.

Methods

Sample collection and preparation

Nineteen cultivars of groundnuts (Serenut 1 to 14), Egoromoit, Rudu red, Rudu white, Acholi white, red beauty were studied. Serenut 1 to 14 were obtained from the National Semi Arid Research Resources Institute (NaSARRI). Other groundnut cultivars were purchased from Soroti, Arapai, and Achorimongin markets in Teso sub-region, Eastern Uganda. Groundnuts were shelled, sorted, hulled and finely crushed to obtain a flour. Oyster nuts were obtained from three districts; Kamuli in Eastern, Dokolo in Northern and Luwero in Central Uganda and transported to Chemiphar laboratory (Uganda) for analysis.

Only oyster nuts were sorted according to gender. The flat nuts were classified as female and the creased nuts as male (Figure 1). A total of 18 samples (9_{male} and 9_{female}) were peeled to remove the fibrous shell. The inner shell was then split to release the oil bearing cotyledon. Oyster nut cotyledons were pounded using a mortar and pestle to obtain a paste.



Figure 1: a) Female oyster nut (flat), b) Male oyster nut (Creased).

Oil Extraction

Oil extraction was done according to the method adopted from Bligh and Dyer [19]. Briefly, Ten grams of each groundnut flour and oyster nut paste was weighed into a 250 ml flat bottomed flask, followed by 100 ml of chloroform (VWR, USA), mixed for 2 min. using ultraturax (IKA T18, Germany). The mixture was transferred into a 40 ml dionex vial and centrifuged at 2000 rpm for 5 min. The chloroform layer was filtered through a filter paper (Macherey-nagel, 125 mm) containing anhydrous sodium sulphate (VWR, USA). The filtrate (20 ml) was evaporated just to dryness under a stream of nitrogen at 40°C.

Anti-oxidant Vitamins

Vitamin A

Vitamin A level of oil was analysed according to AACC [20], using a high-performance liquid chromatograph (HPLC) 1290 series equipped with a photometric detector and an agilent poroshell column 120 EC-C18, 3.0 x 150 mm, 2.7µm (69397-302) for the measurement of trans- and cis-isomers of retinol [20]. Oil (3 g) was dissolved in a mixture of tetrahydrofuran (VWR, USA): ethanol (VWR, USA) (50:50) and the absorbance assayed at 328 nm. The mobile phase was prepared by mixing 860 ml of HPLC grade methanol and 140 ml de-ionised water. A vitamin A working standard was prepared by dissolving 50 mg of USP-vitamin A acetate concentrate (Sigma) in 100 ml ethanol. Vitamin A working standard was injected into the HPLC system with a mobile phase resolution of 1.5 for trans- and cis-isomers of retinol. Vitamin A was quantified by comparison of chromatographic peak heights for the standard and that corresponding to retinol in the sample extract.

Beta-carotene

Beta-carotene content of oil was determined according to AOAC, [21]. Ten grams (10 g) of oil was mixed with 50 ml of 95% ethanol (VWR, USA) after which it was put in a water bath (GP-200) at 75°C for 20 min. with periodic shaking. The supernatant was decanted, cooled and swirled gently to obtain a homogeneous mixture. Petroleum ether (25 ml) was added and the mixture was left to stand until it separated into two layers. The absorbance of extract of the petroleum ether layer was measured on a UV/VIS spectrophotometer (Perkin Elmer Lambda 35, USA) at a wave length of 436 nm. The instrument was calibrated to the zero-point using a cuvette containing 1 ml petroleum ether (blank). Samples were put in cuvettes to read their corresponding absorbances. The beta-carotene standard curve was prepared by dissolving 15 mg of beta-carotene standard into 100 ml of ethanol. Four working standards were prepared by transferring 1.0, 2.0, 3.0 and 4.0 ml from the stock solution to 50 ml flasks and topping up with ethanol. The concentration of beta-carotene was calculated using the Beer Lambert's law which states that absorbance (A) is proportional to concentration (C) of pigment. $A \propto L$ (if concentration (C) is constant). $A = ECL$; $C = A/EL$ Where: C= concentration of carotene A= absorbance E=extinction coefficient L= thickness of cuvettes (path length) =1 cm E of β-carotene = 1.25×10^4 µg/l.

Vitamin E (alpha-tocopherol)

The concentration of vitamin E (alpha-tocopherol) was determined by high performance liquid chromatography (Perkin Elmer, 200 series LC) according to AACC [20]. A calibration curve was prepared using standard alpha-tocopherol (HPLC: CAS 101191-41-0; Sigma Aldrich). Oil (3g) was dissolved in a mixture of tetrahydrofuran (VWR, USA): ethanol (VWR, USA) (50:50) and emission measured at 330 nm. Fifty microliters (50 µl) of sample extract was injected into the HPLC system. Samples were separated in a reverse phase column (C18, Perkin Elmer, 10µl; 250 mm x 4.6 mm) by employing Methanol-Water (90:10 v/v) as mobile phase at a flow rate of 1 ml/min. The value of α-tocopherol in the standard was detected by the diode array detector (Perkin

Elmer series 200) at 290 nm. The α -tocopherol in the oil sample was determined by comparing the retention time with that of the known α -tocopherol standard. The values were calculated in mg/100 g from the calibration curve.

Minerals

The concentration of calcium (Ca), magnesium (Mg), iron (Fe), and zinc (Zn) were determined by atomic absorption spectrophotometry, (AAS) according to AOAC [22] method number 927.02. Ten (10) grams each of groundnut and oyster nut oil were separately weighed into a crucibles and placed into a muffle furnace (Nabertherm GmbH, Germany, L15/12/B180 No. 210111, 2009). The samples were heated at 550°C for 6 hr to char any organic matter present. The resulting ash was digested in 5 ml of 20% hydrochloric acid (India), and filtered using, (Macherey-nagel filter paper, 125 mm). Procedure blank was also prepared. Standard solutions of Ca, Mg, Fe and Zn (Scharlau), were prepared by measuring 10 μ l of the stock solutions (1000 mg/l); (calcium nitrate in nitric acid 0.5 mol/l, magnesium nitrate in nitric acid 0.5 mol/l, iron (III) nitrate in nitric acid 0.5 mol/l and zinc nitrate in nitric acid 0.5 mol/l) in diluted hydrochloric acid (HCl) using a micro pipette (Cyan pipettes YE3K119092, Belgium) to 100 ml volumetric flask and top up to the mark with distilled water. Standard solutions prepared in the concentrations of 0.1, 0.2 0.3, 0.4, 0.5 ppm were used in calibration. To prepare the calibration standard solutions, 1 ml of standard was pipetted into a volumetric flask of 100 ml and diluted to the mark with 1% nitric acid (VWR, USA). The standards for each of Ca, Mg, Fe and Zn were aspirated into the AAS and the absorbance recorded. Calcium, magnesium, iron and zinc were analysed using AAS (Perkin Elmer, Analyst 400 Shelton CT 06484-4794, USA) by aspirating the liquid sample containing the metals into an air acetylene oxide lean, blue flame to allow atomization of metal atoms. These were then excited by multi-element lamps corresponding to Ca, Mg, Fe or Zn. The absorbance was measured with a conventional UV-visible dispersive spectrometer with photomultiplier detector. The respective wavelengths for detection of Ca, Mg, Fe and Zn were 442.7, 285.2, 248.3 and 213.9 nm. Based on the absorbance of the sample, the mineral content was extrapolated from the standard curve.

Tannins

Levels of tannins were determined according to Howitz [23]. Each of groundnut oil and oyster nut oil was prepared by adding 5.0 ml of 25%:75% water: methanol (VWR, USA) to 5 g of sample and vortexing for about 10 min. Samples were then centrifuged for proper separation. The extract ($\frac{1}{2}$ ml) was transferred to a 10 ml test tube containing 7.5 ml of distilled water, 0.5 ml of Folin-Ciocalteu phenol reagent (VWR, USA) was added followed by 1 ml of 35% sodium carbonate solution (VWR, USA). Mixture was then diluted to 10 ml with distilled water. The mixture was shaken well and kept at room temperature for 30 min. after which it was read at 760 nm on a spectrophotometer. One thousand micrograms (1000 μ g) of standard solution was made by weighing 10 mg in a 10 ml volumetric flask and thereafter made up to 10 ml with distilled water. Portions of 20, 50, 100, 200 & 400 μ g were taken

in clear test tubes. One half of a milliliter (0.5 ml) of Folin-Denis reagent (VWR, USA), and 1 ml of sodium carbonate solution was added to each tube and made up to 10 ml with distilled water. All the reagents in each tube were mixed well and kept undisturbed for about 30 min. and read at 760 nm against reagent blank. The content of tannins was obtained as μ g/g of tannic acid as read from the standard curve.

Statistical analysis

The chemical analyses were performed in triplicate. Data in tables represent mean values \pm standard deviation (SD). Statistical analysis was achieved by use of SPSS version. 17.0 (SPSS, Chicago, IL, USA). To evaluate the differences in Anti oxidant vitamins, minerals and tannins, one-way analysis of variance (ANOVA) was performed at a 5 % significance level ($p < 0.05$) using Turkey's test.

Results and Discussion

Vitamins A, Beta-carotene and Vitamin E in groundnut and oyster nut oil

The vitamin A, beta-carotene and vitamin E levels in groundnut oil are shown in Table 1. Vitamin A in groundnut oil ranged from not detected (nd) to 559 μ g/100 g in oil. Vitamin A in oyster nut oil ranged from 19.00 in oil from Luwero female nut to 29.17 μ g/100 g in Kamuli female nut. Compared to the daily recommended intake of vitamin A (900-1500 μ g and 690 to 1200 μ g) [10] for men and women respectively, the vitamin A content in oyster nut oil and groundnut oil was low. Johnson et al. [24] reported that most vegetable oils and fats are not good sources of vitamin A.

Beta-carotene in groundnut oil ranged from 0.21 to 1.67 mg/ 100 g (Egoromoit; Serenut 13Tan). Beta-carotene content in groundnut oil varied significantly ($p < 0.05$). Variations could be attributed to genotype and maturity of groundnuts β -carotene levels vary with maturity of kernels; the highest levels reported at 60 μ g/l oil occurring in the immature kernels and low levels as the groundnuts advance in age [26,27]. Rafalowski et al., [25], reported 0.82 mg/100 g beta-carotene content in unrefined groundnut oil. Our findings are comparable to the above report.

Carotenoids are yellow to deep red colour materials that occur naturally in fats and oils [6]. The light-yellow color of groundnut oil and olive green color of oyster nut oil may therefore be due to the presence of carotenoid pigments. According to Rafalowski et al., [25], beta-carotene in edible oil is an effective anti-oxidant. Beta-carotene stabilizes oil by acting as singlet oxygen quencher and contributes to the light yellow color of groundnut oil [9-11]. Beta-carotene is the major precursor for vitamin A in the diet [28]. This implies that the quantity of vitamin A was affected by the available content of beta-carotene in the oil. Beta-carotene content in oyster nut oil ranged from 2.20 to 3.69 (mg/ 100 g) (Dokolo female, Kamuli female). Literature sources on beta-carotene in oyster nut oil were unavailable for comparison.

Vitamin E is the major anti-oxidant vitamin in oil and it is associated with oil stability [5,29,30]. Vitamin E protects vitamin

A and essential fatty acids from oxidation in the body cells as well as preventing breakdown of body tissues [10]. Vitamin E in groundnut oil ranged from 0.88 to 7.19 mg/100 g (Acholi white; Serenut 13Tan). Oil from Serenut 6Tan, 7Tan, 13Tan, Rudu red and Rudu white contained 37%, 39%, 48%, 42% and 47% of RDI for vitamin E. Rafalowski et al., [25], reported 21.30 mg/100 g of α -tocopherol in unrefined groundnut oil. Differences may be attributed to cultivar. Vitamin E in oyster nut oil ranged from 0.90 in Kamuli female to 1.77 in Dokolo male. Minzangi et al, [31] reported 0.3 mg/100 g of vitamin E in oyster nut oil. The daily recommendation for adult males and females is 15 mg of vitamin E [16].

Cultivar	Vitamin A (μ g/g)	Beta-carotene (mg/100 g)	Alpha tocopherol (mg/100 g)
Serenut1Red	148 \pm 0.01 ^d	0.63 \pm 0.00 ^b	1.19 \pm 0.06 ^a
Serenut2Tan	40 \pm 0.00 ^c	0.74 \pm 0.00 ^b	1.27 \pm 0.15 ^a
Serenut3Red	10 \pm 0.00 ^a	0.41 \pm 0.01 ^a	1.49 \pm 0.11 ^{ab}
Serenut4Tan	1 \pm 0.00 ^a	0.68 \pm 0.00 ^b	2.86 \pm 0.12 ^b
Serenut5Red	2 \pm 0.00 ^a	0.72 \pm 0.03 ^{cd}	1.59 \pm 0.10 ^{ab}
Serenut6Tan	2 \pm 0.00 ^a	0.44 \pm 0.08 ^a	5.58 \pm 1.07 ^c
Serenut7Tan	21 \pm 0.00 ^b	1.06 \pm 0.04 ^c	5.85 \pm 0.18 ^{cd}
Serenut8Red	37 \pm 0.04 ^b	0.73 \pm 0.02 ^d	1.82 \pm 0.28 ^{ab}
Serenut9Tan	208 \pm 0.05 ^f	1.04 \pm 0.01 ^c	1.25 \pm 0.03 ^a
Serenut10Red	45 \pm 0.05 ^c	0.46 \pm 0.00 ^a	1.25 \pm 0.12 ^a
Serenut11Tan	85 \pm 0.00 ^d	1.06 \pm 0.11 ^c	1.34 \pm 1.19 ^a
Serenut12Red	172 \pm 0.03 ^c	0.44 \pm 0.00 ^a	1.74 \pm 0.36 ^{ab}
Serenut13Tan	167 \pm 0.01 ^e	1.67 \pm 0.18 ^d	7.19 \pm 1.21 ^d
Serenut14Red	167 \pm 0.01 ^e	0.66 \pm 0.05 ^b	1.33 \pm 0.22 ^a
Acholiwhite	559 \pm 0.10 ^e	0.31 \pm 0.01 ^c	0.88 \pm 0.03 ^a
Rudu red	nd	1.71 \pm 0.01 ^d	6.30 \pm 1.01 ^b
Rudu white	16 \pm 0.00 ^b	0.24 \pm 0.03 ^a	7.05 \pm 1.26 ^b
Egoromoit	19 \pm 0.01 ^b	0.21 \pm 0.00 ^a	2.21 \pm 0.06 ^a
Red beauty	nd	1.22 \pm 0.10 ^c	2.22 \pm 0.14 ^a
RDA		na	15 mg/day

Table 1: Vitamin A, E and Beta-carotene in oil from groundnuts. Values are means \pm SD (three replicates). Means followed by the same letter are not significantly different ($p > 0.05$).

Location	Gender	Vitamin A (μ g/100 g)	Beta-carotene (mg/100 g)	Vitamin E (mg/100 g)
Dokolo	Male	23.92 \pm 1.84 ^b	2.88 \pm 0.01 ^{bc}	1.77 \pm 0.02 ^b
	Female	24.16 \pm 2.43 ^b	2.20 \pm 0.02 ^a	1.58 \pm 0.24 ^b
Kamuli	Male	27.50 \pm 0.33 ^c	3.56 \pm 0.04 ^c	1.23 \pm 0.11 ^a
	Female	29.17 \pm 2.67 ^c	3.69 \pm 0.06 ^c	0.9 \pm 0.03 ^a
Luwero	Male	20.09 \pm 3.12 ^a	2.66 \pm 0.06 ^b	1.65 \pm 0.15 ^b
	Female	19.00 \pm 3.99 ^a	2.67 \pm 0.02 ^b	0.99 \pm 0.01 ^a

Table 2: Vitamin A, E and Beta-carotene in oil from oyster nut. Values are means \pm SD (three replicates). Means followed by the same letter are not significantly different ($p > 0.05$).

Minerals in groundnut and oyster nut oil

Minerals, magnesium (Mg), calcium (Ca), iron (Fe) and zinc (Zn)

of groundnut and oyster nut oil are presented in Tables 3 and 4, respectively. Mg ranged from 0.17 to 2.49 mg/100 g (Serenut 8Red; Rudu white), Ca varied from 0.05 to 3.41 mg/100 g, (Rudu red; Serenut 3Red), Fe and Zn were $< 4.0\%$. The Mg content of oyster nut oil ranged from 42.71 to 55.77 mg/100 g, Ca varied from 16.20 to 27.34 mg/100 g. Similar to groundnut oil Fe and Zn were the least prevalent and occurred in levels $< 1.0\%$. Findings in this study indicated low content of Mg, Ca, Fe and Zn in oil from groundnuts and oyster nuts. Oil from Luwero oyster nuts exhibited the highest Ca content while oil from Kamuli nuts showed the highest Mg content.

Sanders et al. [32], reported 3.79 to 8.03 mg/100 g iron in pressed cake of groundnuts. Trace amounts of metals are absorbed by plants during the growing season and introduced during fat and oil processing from tear and wear of machines [33,34]. Mineral elements in oil catalyse oxidation, a factor in edible oil deterioration [35,36]. Iron plays a role in the initiation stage while calcium and magnesium promote the final stages of oxidation [37]. These interactions cause changes in flavour, colour and odour of edible oil. The presence of Ca and Mg in crude oil reduces the efficiency of degumming and refining operations [38]. Groundnuts in this study were shelled prior to oil extraction. It is expected that most of the mineral elements were retained in the testa and peanut cake. Findings of this research were below the maximum residual limit (0.5 mg/100 g) specified by Codex Alimentarius commission [39], for iron in edible oil. Limited information is available on the maximum residual limits for Mg and Zn in oil. The requirement of Mg, Ca, Fe and Zinc to enable the body perform important functions is minimal levels of these minerals. Exceeding the recommended daily intake (RDI) may result in toxicity. The concentrations of minerals in edible oil must be regularly monitored to ensure they do not reach levels that might cause reduction in shelf life of oil and pathological conditions in the human body [38]. The low mineral content of oils in this study is a positive attribute towards stability of the groundnut oil to oxidation.

The mineral content in groundnut and oyster nut oil were too low compared to the RDI. Oil from groundnuts and oyster nuts is therefore not a good source of mineral elements for nutrition purposes. Magnesium and calcium are valued as macronutrients while iron and zinc are micronutrients in plant nutrition. In the human body, minerals are required as enzyme cofactors in many biochemical reactions in the body [18,40].

Cultivar	Magnesium	Calcium	Iron	Zinc	Tannins
Serenut 1Red	1.04 \pm 0.01 ^d	0.89 \pm 0.03 ^c	0.25 \pm 0.04 ^b	0.23 \pm 0.00 ^d	852.28 \pm 0.00 ^e
Serenut 2Tan	2.12 \pm 0.02 ^a	2.05 \pm 0.06 ^a	0.26 \pm 0.39 ^a	0.13 \pm 0.00 ^a	817.01 \pm 1.00 ^e
Serenut 3Red	1.86 \pm 0.02 ^a	3.41 \pm 0.03 ^c	0.14 \pm 0.06 ^a	0.14 \pm 0.01 ^c	715.12 \pm 0.00 ^f
Serenut 4Tan	1.18 \pm 0.03 ^b	1.26 \pm 0.02 ^c	0.35 \pm 0.13 ^a	0.07 \pm 0.01 ^b	727.98 \pm 5.09 ^e
Serenut 5Red	0.86 \pm 0.01 ^b	1.74 \pm 0.05 ^d	0.10 \pm 0.06 ^a	0.08 \pm 0.00 ^b	662.78 \pm 0.01 ^d

Serenut 6Tan	1.92 ± 0.10 ^a	1.65 ± 0.03 ^f	0.35 ± 0.08 ^a	0.36 ± 0.00 ^d	540.44 ± 0.11 ^a
Serenut 7Tan	1.19 ± 0.01 ^b	2.66 ± 0.19 ^c	0.24 ± 0.05 ^a	0.07 ± 0.01 ^b	776.03 ± 0.08 ^f
Serenut 8Red	0.17 ± 0.00 ^c	1.53 ± 0.40 ^a	0.07 ± 0.05 ^a	0.04 ± 0.01 ^a	545.51 ± 0.01 ^b
Serenut 9Tan	0.99 ± 0.02 ^c	1.26 ± 0.02 ^e	0.1 ± 0.05 ^b	0.05 ± 0.00 ^c	554.91 ± 0.92 ^b
Serenut 10Red	1.43 ± 0.01 ^d	2.07 ± 0.06 ^a	0.19 ± 0.04 ^a	0.09 ± 0.00 ^b	531.89 ± 0.00 ^a
Serenut 11Tan	0.67 ± 0.01 ^d	1.56 ± 0.00 ^b	0.02 ± 0.04 ^b	0.05 ± 0.04 ^c	629.73 ± 0.11 ^c
Serenut 12Red	0.81 ± 0.01 ^c	2.20 ± 0.12 ^a	0.02 ± 0.04 ^a	0.09 ± 0.04 ^b	569.42 ± 0.00 ^c
Serenut 13Tan	0.95 ± 0.12 ^c	1.46 ± 0.06 ^b	0.17 ± 0.17 ^a	0.17 ± 0.03 ^a	703.32 ± 0.29 ^d
Serenut 14Red	1.35 ± 0.01 ^c	3.04 ± 0.05 ^b	0.10 ± 0.07 ^a	0.15 ± 0.03 ^c	679.32 ± 0.00 ^e
Acholiwhite	1.02 ± 0.01 ^a	0.66 ± 0.10 ^d	0.28 ± 0.08 ^c	0.07 ± 0.01 ^a	586.57 ± 0.43 ^a
Rudured	2.25 ± 0.07 ^c	0.05 ± 0.00 ^a	0.02 ± 0.00 ^{ab}	0.23 ± 0.02 ^b	933.84 ± 0.84 ^b
Rudu white	2.49 ± 0.01 ^d	0.06 ± 0.00 ^b	0.03 ± 0.00 ^b	0.22 ± 0.00 ^b	918.55 ± 1.27 ^b
Egoromoit	2.06 ± 0.01 ^b	0.06 ± 0.00 ^a	0.02 ± 0.01 ^{ab}	0.53 ± 0.03 ^c	923.85 ± 3.43 ^b
Red beauty	2.31 ± 0.00 ^c	0.05 ± 0.00 ^a	0.02 ± 0.00 ^{ab}	0.55 ± 0.00 ^c	940.22 ± 1.44 ^b
RDI (FAO/WHO, 2004)	190 to 260 mg	1000 to 1300 mg	7.5 to 19.6 mg	3 to 6 mg	

Table 3: Mineral content (mg/100 g) and Tannins (µg/100 g) of oil from groundnuts.

Mean values in columns with similar superscript letters are not significantly different at $p > 0.05$.

Location	Gender	Ca	Mg	Fe	Zn	Tannins
Dokolo	Male	20.97 ± 1.08 ^b	43.20 ± 1.09 ^a	0.18 ± 0.01 ^a	0.42 ± 0.02 ^c	338.50 ± 0.25 ^a
	Female	20.47 ± 1.30 ^b	42.71 ± 0.41 ^a	0.19 ± 0.01 ^a	0.40 ± 0.00 ^c	370.51 ± 1.53 ^b
Kamuli	Male	16.31 ± 1.37 ^a	55.77 ± 0.32 ^c	0.19 ± 0.01 ^a	0.34 ± 0.02 ^b	341.29 ± 2.47 ^a
	Female	16.02 ± 0.60 ^a	53.73 ± 3.19 ^c	0.20 ± 0.02 ^a	0.28 ± 0.01 ^a	333.95 ± 1.66 ^a
Luwero	Male	27.34 ± 0.49 ^c	44.83 ± 0.25 ^a	0.20 ± 0.01 ^a	0.28 ± 0.01 ^a	392.45 ± 4.17 ^b
	Female	25.83 ± 0.99 ^c	47.18 ± 0.08 ^{bc}	0.19 ± 0.01 ^a	0.27 ± 0.01 ^a	412.72 ± 0.01 ^b
RDI (FAO/WHO, 2004)		190 to 260	1000 to 1300	7.5 to 19.6	3 to 6	

Table 4: Mineral content (mg/100 g) and Tannins (µg/100 g) of oil from oyster nuts.

Mean values in columns with similar superscript letters are not significantly different at $p > 0.05$.

Tannins

Tannins are naturally occurring plant polyphenols which combine with proteins and other polymers such as cellulose, hemicellulose

and pectin, to form stable complexes [41,42]. Earlier research on tannins [42-44] indicated that in high concentrations, these compounds impair protein, calcium and iron bioavailability due to their binding ability.

Tannin content in groundnuts varied from 531.89 to 940.22 µg/100 g in oil. Tannins in oyster nut oil ranged from 333.95 to 412.72 µg/100 g. In low concentration, tannins have anti-oxidant properties and may retard lipid peroxidation [45]. Inuwa et al., [46], reported a tannin level of 0.37% (3700 mg /100 g) in groundnut oil and reported a lethal dose of 30 mg/kg. Findings of this study showed much lower values (µg), implying that oils from the nuts examined are safe for human consumption. Previous studies have reported that substantial amounts of tannins are located in groundnut testa [27,47,48]. The low levels of tannins in oil in this study therefore could be ascribed to the removal of groundnut skin and oyster nut shell prior to oil extraction.

Conclusion

Oil from groundnuts and oyster nuts grown in Uganda contains low content of vitamins A and beta-carotene. The vitamin E content of oyster nut oil was low. Oil from Serenut 6Tan, 7Tan, 13Tan Rudu red and Rudu white is a good source of vitamin E and could be used by breeders to improve the content in other groundnut cultivars. The mineral and tannin levels in oil may imply groundnut and oyster nut were favourable for oil stability to oxidation and for human consumption.

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