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Proximate Composition, Amino Acid and Fatty Acid Profiles of Eight Cultivars of Groundnut Grown in Nigeria

B.U. Olayinka[1], A.S. Abdulbaki[2,3], H. Alsamadany[3], Y. Alzahrani[3], O.A. Omorinoye[4], G.R. Olagunju[5], A. Sulyman[6]

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ABSTRACT

Background: Groundnut had been established to have great health benefits on account of its biochemical constituents.
Methods: Eight cultivars of groundnut grown in Nigeria were analyzed using standard protocols for proximate compositions, amino acid and fatty acid profiles with the sole aim of selecting the most promising cultivars in terms of nutrient composition and oil stability.
Result: The results indicated that crude protein was the highest in MK 373 and lesser in Samnut 22. Crude fat ranged from 44.68% in Samnut 21 to 49.98% in Samnut 23. The major amino acids were leucine, glutamic acid and aspartic acid. The cultivars Samnuts 21 and 22 showed higher essential amino acids (EAA), while higher non-essential amino acid (NEAA) was recorded in MK 373. The major fatty acids were palmitic, oleic and linoleic acids. Among the cultivars, Samnut 11 was the only cultivar with better oil quality on account of higher oleic and linoleic O/L and total poly unsaturated fatty acid and total saturated fatty acid (TPUS/TS) ratios that compared well with Codex/WHO standards. The results, in general, have shown that Samnuts 11, 21, 22 and MK 373 are the potentials cultivars that could be selected for breeding programme to improve the quality of groundnut in Nigeria.

Key words: Glutamic acid, Groundnut cultivars, Leucine, Oleic acid, Proximate.

INTRODUCTION

Groundnut (*Arachis hypogaea* L.) is a major crop grown in the arid and semi-arid zone of Nigeria. It is the thirteenth most important food crop of the world, fourth source of edible oil and third source of vegetable protein (Reddy *et al*., 2011). Nigeria is the largest producer of groundnut in Africa and third in the world (USDA, 2014). As a legume, it supplies ample protein and high oil contents (Olayinka and Etejere, 2015). Groundnut seeds contain essential amino acids (EAA) necessary for optimum health (Syed *et al*., 2021). Its oil is rich in oleic and linoleic acids with both acids representing approximately 80% of the oil (Ojiewo *et al*., 2020). These unsaturated fatty acids unlike saturated fatty acids reduce cardiovascular diseases due to their ability to decrease the total and low-density lipoprotein cholesterol levels without reducing high-density lipoprotein cholesterol. High oleic to linoleic ratio (>2) confered many health benefit, good seed oxidative stability and extended shelf life (Achola *et al*., 2017).

Considering these health benefits, it becomes imperative to quantify the amino acid and fatty acids present in several varieties of groundnut grown in Nigeria which appear scanty in literature. The outcome of the study will provide a platform for selection of most promising varieties in terms of oil stability, human health and nutritional qualities for use in breeding programme. It will also provide the basis for selection of cultivars for use in the weaning of infants after six months of breast feeding. With this background, this study was carried out to examine the proximate, amino acid and fatty acids compositions of eight groundnut cultivars grown in Nigeria.

[1]Department of Plant Biology, Faculty of Life Sciences, University of Ilorin, Ilorin, Nigeria.
[2]Department of Plant Science and Biotechnology, Faculty of Life Sciences, Federal University Dutsinma, Katsina state, Nigeria.
[3]Department of Biological Sciences, Faculty of Science, King Abdulaziz University, Jeddah, Saudi Arabia.
[4]Department of Geology and Mineral Sciences, University of Ilorin, Ilorin, Nigeria.
[5]Department of Anaesthesia and Critical Care, Ahmadu Bello University Teaching Hospital, Nigeria.
[6]Federal College of Wildlife Management, New Bussa, Niger State, Nigeria.

Corresponding Author: A.S. Abdulbaki, Department of Plant Science and Biotechnology, Faculty of Life Sciences, Federal University Dutsinma, Katsina state, Nigeria.
Email: abdulbakias@gmail.com

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MATERIALS AND METHODS

Eight cultivars of groundnut used in this study were Samnuts 10, 11, 14, 21, 22, 23 and 24 and MK 373. Groundnut seeds from each of the cultivars were raised under the conventional ridges. At maturity for each of the cultivars, harvesting was done to get the pods. Pods harvested were washed in running water to remove soil particles. The cleaned pods

were manually detached from the plant and air-dried to 12% for period of 7-8 days before the determination of proximate, amino acid and fatty acid compositions of the seeds.

Proximate composition of groundnut seeds were determined following the Official Methods of Analysis of the AOAC (2000). The total carbohydrate content was calculated by difference.

Determination of amino acid profile

Extraction and the instrumentation analysis were carried out following the modified method AOAC (2006) and Obreshkova *et al.* (2012).

Fatty acids profile

Method of preparation of methyl esters

Methylation of fatty acids was carried out using the procedure of Slover and Lanza (1979) with some modifications. The esterified fatty acids were extracted with 1 ml of petroleum ether three times. The ether content was then evaporated and remaining oily surface was injected into gas chromatography for fatty acids determination.

Oil qualities

Oleic and linoleic acid ratio (O/L) was determined using the formula:

$$\frac{\%\ \text{Oleic acid}}{\%\ \text{Linoleic acid}}$$

Iodine value was calculated from:

(0.8601 × % oleic acid) + (1.7321 × % linoleic acid) + (0.7854 × % Eicosapentaenic acid) (Mozingo *et al.*, 1988)

Total saturated fatty acids (TS) =

% Arachidic acid + % palmitic acid +% behenic acid + % Lignoceric acid + % stearic acid

Polyunsaturated/saturated fatty acids ratio =

$$\frac{\%\ \text{Linoleic acid}}{\%\ \text{palmitic acid} + \%\ \text{stearic acid} + \%\ \text{arachidic acid} + \%\ \text{behenic acid} + \%\ \text{lignoceric acid}}$$

Statistical analysis

The data were analysed using One Way Analysis of Variance. Means were separated using Duncan multiple range test at $p<0.05$.

RESULTS AND DISCUSSION

Composition

All the studied cultivars have low moisture contents which is a typical trait of the groundnut seeds in this region (Table 1). Similar values for moisture had been reported by Olayinka and Etejere (2015). However the moisture content differed from that of Musa *et al.* (2010) which ranged from 6.60 to 8.90%. This difference could be the time used in drying the seeds. The low moisture content of groundnut is beneficial with respect to storability and shelf live (Singh *et al.*, 2022). Samples with higher percentage of ash contents are expected to have high concentrations of various mineral elements that speed up the rate of metabolic processes and improve the growth and development (Olorunmaiye *et al.*, 2019). Samples with low fibre contents may not be a good source of roughages which plays an important role in peristaltic movement (Olayinka and Etejere, 2015).

The high protein contents of MK 373 and Samnut 22 could make these cultivars better source of food supplements necessary for growth and development. High concentration of fat in Samnuts 23, 24, MK 373 and 14 could also make these cultivars as suitable sources of nutrients that could improve energy of human beings and animals. Sample with low carbohydrate like MK 373 and Samnut 24 might be ideal for patients requiring low sugar diets.

Amino acids profile

NEAA and EAA accounted for 64% and 36% respectively of the total amino acids. Leucine was the most EAA in all the cultivars while the predominant NEEA was glutamate. Significant differences occurred in all the amino acids among the cultivars except for glycine, alanine, serine, proline, lysine, phenylalanine and tyrosine. The most limited amino acids were methionine and tryptophan (Table 2).

All the cultivars contained all the 9 EAA and it was higher in Samnuts 21, 22 and 11. EAA play vital roles in human growth and development. For instance, leucine is instrumental in repairing and building of muscle and in managing of blood sugar level (Osmond *et al.*, 2019). Lack of tryptophan in the diet may lead to pellagra (Prabhu *et al.*, 2021). It is therefore pertinent to say that groundnut in human

Table 1: Proximate composition of 8 groundnut cultivars grown in Nigeria.

Cultivars	Moisture	Ash	Fibre	Protein	Fat	Carbohydrate
			%			
SAMNUT 10	5.26^{b}	2.64^{bc}	4.26^{c}	26.58^{c}	45.85^{cd}	15.41^{a}
SAMNUT 11	4.20^{de}	2.75^{b}	5.11^{a}	27.99^{c}	45.51^{cd}	14.28^{ab}
SAMNUT 14	4.37^{d}	2.27^{e}	5.16^{a}	27.20^{bc}	48.11^{b}	12.88^{bc}
SAMNUT 21	5.46^{a}	3.31^{a}	4.39^{bc}	29.87^{a}	44.68^{d}	13.11^{b}
SAMNUT 22	5.03^{c}	2.47^{cde}	4.43^{bc}	25.27^{d}	46.15^{c}	15.76^{a}
SAMNUT 23	4.99^{c}	2.54^{bcd}	4.51^{b}	26.73^{c}	49.98^{a}	11.24^{cd}
SAMNUT 24	4.14^{e}	2.46^{cde}	4.99^{a}	28.17^{b}	49.13^{ab}	11.02^{d}
MK 373	5.28^{ab}	2.34^{de}	4.32^{bc}	30.12^{a}	48.03^{b}	9.89^{d}
P-value	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001

diet is expressly indispensable. All the cultivars in this study had lower total EAA than Indian JL and other varieties reported by Eshun (2013).

All the cultivars were rich in NEAA such as glutamic and aspartic acids. Both acids serve as important amino group reservoirs in the body. Glutamic acid plays a primary fuel source for the gastrointestinal tract (Moussou *et al*., 2017). Aspartic acid increases the absorption of mineral supplements, lowers the blood pressure, protects the liver by removing excess ammonia and other toxins from the bloodstream and is important for production of immunoglobulin and antibodies (Obreshkova *et al*., 2012). Sulphur containing amino acids (methionine and cysteine), glycine, histidine and tyrosine were lesser than the recommended values by FAO/WHO/UNO (1985). However, leucine, arginine, glutamic acids showed greater values and possess protective role against oxidative damage produced by hydrogen peroxide (Rathore and Gupta, 2010). The lesser amount of sulphur containing amino acids in all the cultivars necessitated the need to complement groundnut consumption with cereal's diet that are richer in sulphur-containing amino acids.

Fatty acids

Twelve fatty acids were detected in all the cultivars except for margaric and palmitoleic acids that were not found in Samnut 11 and Samnut 21 respectively. Oleic and linoleic acids constituted more than 75% of the total fatty acid (Table 3). Saturated fatty acids amounted to 22.94% with the palmitic acid being the highest. For unsaturated fatty acids, where the bulk were monounsaturated, accounted for 77.06% of the total fatty acids. Statistical difference existed in all the fatty acids among the cultivars.

The foregoing results agreed with those obtained in different studies especially with respect to abundance of acids such as oleic, linoleic and stearic (Mora-Escobedo *et al*., 2015). The oleic acid was higher and the linoleic acid was lesser than those recorded by Achola *et al*. (2017) for the Ugandan groundnut cultivars. The variation recorded could be attributed to different growing conditions. In this study, oleic, linoleic, palmitic and stearic acids formed the bulk of the fatty acids (92%) irrespective of the cultivars. Similar observation had been reported by Achola *et al*. (2017). The significant difference between major and minor fatty acids suggested that there exists genetic variation among the cultivars and such difference could be exploited by plant breeder for fatty acid improvement. In general, there was an inverse relationship between oleic and other major fatty acids in all the cultivars. Similar results had been recorded for all other oil producing crops (Achola *et al*., 2017).

Oil quality

Oleic and linoleic (O/L) ratio, iodine values, total saturated fatty acids (TS), total monounsaturated fatty acid (TMUS), total polyunsaturated fatty acids (TPUS) and TPUS/TS ratio ranged from 1.3-2.2, 78.3-89.9, 20.8-24.2, 37.2-53.5, 24.2-27.9 and 1.05-1.30 respectively (Table 3). All the cultivars fulfilled the codex/WHO standard for most of the oil traits except for O/L and TPUS/TS. All the cultivars except Samnut

Table 2: Amino acid composition of different 8 Nigeria groundnut cultivars.

Nature of amino acid	Amino acid (mg/100 g)	SAMNUTS							MK 373	Mean	FAO/WHO/U NO reference value (mg/100 g)
		10	11	14	21	22	23	24			
Essential	Histidine	2.47^{d}	2.77^{b}	2.55^{c}	2.61^{c}	2.80^{b}	2.89^{a}	2.76^{b}	2.76^{b}	2.70	3.4
	Isoleucine	3.95^{a}	4.11^{a}	3.72^{a}	4.29^{a}	4.00^{a}	3.26^{a}	3.14^{a}	3.11^{a}	3.69	4.2
	Leucine	6.99^{c}	7.01^{c}	6.98^{c}	7.53a	7.31b	6.77d	6.69d	7.16^{bc}	7.06	4.2
	Lysine	4.45^{a}	3.49^{a}	3.82^{a}	3.96a	4.52^{a}	3.91^{a}	3.91^{a}	4.09^{a}	4.02	2.2
	Methionine	0.879^{c}	0.885^{c}	0.101^{d}	0.879c	0.924^{b}	0.973a	0.974^{a}	0.107^{d}	0.72	2.8
	Phenylalanine	5.42^{a}	5.46^{a}	5.88^{a}	5.59a	5.27^{a}	4.88^{a}	5.55^{a}	4.16^{a}	5.28	2.8
	Threonine	2.60^{abc}	2.57^{bc}	2.62^{abc}	2.73^{ab}	2.63^{abc}	2.53^{c}	2.62^{abc}	2.75^{a}	2.03	2.8
	Tryptophan	0.851^{cd}	0.825^{d}	0.821^{d}	0.892^{b}	0.871^{bc}	0.891^{b}	0.945^{a}	0.11^{e}	0.78	-
	Valine	2.62^{e}	3.93^{a}	3.78^{b}	3.76^{b}	3.79^{b}	3.08^{d}	3.47^{c}	3.52^{c}	3.49	4.2
	Total EAA	30.23	31.05	30.272	32.24	32.12	29.184	30.059	27.767	-	
Non-essential	Alanine	4.31^{a}	4.62^{a}	4.03^{a}	2.0	4.35^{a}	4.15^{a}	4.36^{a}	4.45^{a}	4.37	20.3
	Aspartate	10.51^{b}	10.03^{c}	10.64^{b}	9.21d	10.54^{b}	11.43^{a}	10.79^{b}	11.52^{a}	10.58	-
	Arginine	7.52^{a}	8.68^{c}	9.59^{b}	7.73d	7.68^{d}	10.26^{a}	10.21^{a}	9.63^{b}	8.91	4.0
	Cysteine	1.73^{cd}	1.70^{cd}	1.78b^{c}	1.89a	1.69^{d}	1.77bcd	1.77b^{cd}	1.84^{ab}	1.55	2.0
	Glutamate	17.90^{d}	18.26^{c}	17.59^{e}	18.53^{b}	18.59^{b}	18.01d	18.38^{bc}	18.98^{a}	18.28	6.3
	Glycine	5.56^{a}	5.44^{a}	5.57^{a}	5.28^{a}	5.35^{a}	5.75^{a}	5.66^{a}	5.72^{a}	5.54	18.3
	Proline	4.51^{a}	4.44^{a}	4.31^{a}	4.47^{a}	4.67^{a}	4.08^{a}	4.02^{a}	4.16^{a}	4.33	-
	Serine	5.20^{a}	4.70^{a}	4.88^{a}	5.28^{a}	5.24^{a}	5.02^{a}	4.85^{a}	5.46^{a}	5.08	-
	Tyrosine	3.22^{a}	3.44^{a}	3.22^{a}	3.72^{a}	3.69^{a}	3.27^{a}	3.76^{a}	3.34^{a}	3.46	2.8
	Total NEAA	45.64	46.66	46.94	46.9	46.91	48.16	48.65	49.13		

Table 3: Fatty acids compositions of 8 cultivars of groundnut grown in Nigeria.

Nature of the acid	Fatty acid (mg/100 g)	SAMNUTS								Range value	Codex/WHO standard
		10	11	14	21	22	23	24	MK 373		
Saturated	Myristic acid (C14:0)	0.14^{d}	0.70^{b}	0.60^{h}	0.62^{a}	0.96^{a}	0.06^{e}	0.17^{c}	0.32^{b}	0.06-0.96	nd-0.1
	Palmitic acid (C18:0)	11.58^{c}	10.87^{h}	11.14^{f}	11.34^{e}	11.87^{a}	10.97^{g}	11.83^{b}	11.38^{d}	10.87-11.87	8-1.4
	Margaric acid (C17:0)	0.02^{c}	ND	0.01^{e}	0.03^{a}	0.02^{c}	0.01^{e}	0.01^{e}	0.01^{e}	0.01-0.03	nd-0.1
	Stearic acid (C18:0)	5.14^{c}	5.30^{a}	4.50^{g}	4.03^{h}	5.23^{b}	4.55^{f}	4.59^{e}	4.94^{d}	4.03-5.30	1.0-4.5
	Arachidic acid (C20:0)	1.63^{h}	2.28^{c}	1.80^{g}	3.16^{a}	1.89^{f}	2.09^{d}	2.58^{b}	2.09^{e}	1.80-3.16	1.0-2.0
	Behenic acid (C22:0)	2.04^{f}	2.15^{e}	1.57^{h}	2.38^{c}	2.39^{b}	2.71^{a}	2.27^{d}	2.02^{g}	1.57-2.71	1.5-2.5
	Lignoceric acid (C24:0)	1.49^{e}	1.60^{d}	1.19^{h}	1.89^{a}	1.79^{c}	1.42^{f}	1.83^{b}	1.20^{g}	1.19-1.89	0.5-2.5
Mono-unsaturated	Palmitoleic acid (C16:1)	0.32^{e}	0.43^{d}	0.68^{b}	ND	0.50^{c}	0.72^{a}	0.10^{g}	0.12^{f}	0.10-0.72	nd-0.2
	Oleic acid (C18:1)	51.16^{d}	52.81^{a}	36.46^{h}	50.93^{e}	49.94^{f}	52.71^{b}	48.35^{g}	51.38^{c}	36.46-52.81	35-69
	Erucic acid (C22:1)	0.99^{a}	0.11^{b}	0.02^{h}	0.12^{c}	0.04^{e}	0.11^{b}	0.02^{h}	0.03^{f}	0.02-0.99	nd-0.3
Poly-unsaturated	Linoleic acid (C18:2)	25.92^{e}	24.05^{h}	27.09^{b}	25.14^{f}	26.34^{c}	24.98^{g}	27.89^{a}	26.13^{d}	24.05-27.09	12-43
	Arachidonic acid (C20:3)	0.04^{h}	0.06^{e}	0.05^{g}	0.07^{c}	0.09^{a}	0.06^{f}	0.07^{d}	0.08^{b}	0.04-0.09	1.0-2.0
	O/L	1.97	2.19	1.35	2.03	1.89	2.01	1.73	1.97	1.3-2.2	2.0-4.0
	IV	88.9	87.07	78.29	87.34	88.57	85.59	89.89	89.46	78.3-89-9	86-107
	TS	22.05	22.91	20.83	23.45	24.15	21.82	23.28	21.96	20.8-24.2	12-27.8
	TMUS	52.48	53.35	37.17	51.06	50.56	53.54	48.47	51.53	37.2-53.5	35.7-69
	TPUS	25.97	24.11	27.13	25.21	26.43	25.04	27.96	26.22	24.2-27.9	12-43.3
	TPUS/TS	1.17	1.05	130	1.08	1.09	1.15	1.20	1.19	1.05-1.19	0.8-1.0

14 had O/L ratios either closer to 2 or slightly greater than 2 (standard value). This implies that these cultivars could be recommended to producers as having high quality fatty acid composition. The reported O/L ratio in this study agreed to those values recorded for groundnut varieties in Mexico, Uganda and Ethiopia (Achola *et al*., 2017; Mora-Escobedo *et al*., 2015; Yusuf *et al*., 2019). It was however higher than the reported values for varieties grown in Peru (Grosso and Guzman, 1995). With respect to TPUS/TS ratio, only Samnut 11 showed TPUS/TS ratio that is slightly higher than standard and such could be regarded as having the best oil quality. Other in this category includes Samnuts 21 and 22. Yusuf *et al*. (2019) had observed that the best oil quality is expected to be the one with TPUS/TS ratio close to one and O/L ratio of 2-4.

Samnut 11 had the highest oleic acid content, good linoleic acid, highest O/L ratio and moderate TPUS/TS ratio and as such be considered as having the best oil quality in terms of stability to oxidative damage and healthy fat among the cultivars. The beneficial effect of groundnut consumption in preventing coronary heart disease has been attributed to its high oleic and linoleic acid contents (Kris-Etherton *et al*., 2008). Also, the increase in oleic acid and the reduction of linoleic, stearic and palmitic acids has been established to be useful parameters for breeding programme (Smith *et al*., 2020). The present study offers such opportunity for breeding varieties with high oleic acid.

CONCLUSION

The study established that all the cultivars had high crude protein and fat contents that are predominant in MK 373 and Samnut 23 respectively. Samnut 22 had the highest total EAA and MK 373 had the highest total NEAA. Oleic, linoleic, palmitic and stearic acids varied among the cultivars and contributed to the bulk of fatty acids. However, Samnut 11 had the highest oleic acid content, good linoleic acid, highest O/L ratio, better TPUS/TS ratio and the lowest palmitic and stearic acids. The established variation in biochemical components of groundnut cultivars studied could be exploited by the breeders to develop cultivars with

the improvement in EAA and monounsaturated oleic acids that have been shown to confer on the seed greater oxidative stability, higher shelf-life and tremendous health benefits.

Conflict of interest: None.

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