Screening of Selected Groundnut (*Arachis Hypogaea L.*) Varieties for Kernel Quality

[1]Msaakpa,T.S. and [2]Agaba,B.E

[1]Department of Plant Breeding and Seed Science, University of Agriculture, Makurdi, Benue State.
[2]Department of Crop Production, Adamawa State University, Mubi.

Abstract- Field experiments were conducted at the University of Agriculture, Makurdi and National Cereal Research Institute Substation, Yandev during 2011 and 2012 cropping seasons. Laboratory experiments were done at Benue University, Makurdi and Adamawa State University, Mubi. The objective was to determine the kernel quality of seven groundnut varieties at Makurdi and Yandev locations. The field experiments were laid out in Randomized Complete Block Design with three replications. Kernel quality parameters evaluated included: proximate composition, fatty acid composition, and elemental composition. Results showed significant variation among the parameters evaluated. Results on proximate composition showed that Borno-Red and Samnut-21 were significantly higher in protein (40.47%) at Makurdi and Yandev locations respectively; Samnut-16 gave higher Lipid (40.50%) at Yandev; while Ebunaigbaji produced higher carbohydrate content (4.92%). On fatty acid composition, Dan-Bomboyo both in Makurdi and Yandev, recorded the highest Oleic/Linoleic ratio of 3.74 and was also higher in Lauric and Oleic acid content. Samnut-22 gave higher Palmitic, Palmitoleic and Linolenic acids; while Samnut-16 produced higher Myristic and Linoleic acids. For elemental composition, Ijiwanda was higher in Potassium and Iron; Samnut-16 in Calcium and Copper; Dan-Bomboyo jn Magnesium; Samnut-21 in Sodium and Zinc. It was concluded that the study identified groundnut varieties with varying kernel qualities that can be selected from according to the product to be made. The variation in kernel quality among the varieties was probably due to differences in environmental conditions at Makurdi and Yandev locations and in the genetic make-up.

Index Terms- screening, groundnut, varieties, selected, location, kernel quality

I. INTRODUCTION

Groundnut (Arachis hypogaea L.) belongs to the family, Fabaceae (Wikipedia,2010). Groundnut is the 13th most important food crop and 4th most important oilseed crop of the world (Kees Stigter, 2011). It is grown in 23.95 million hectares with a total production of 36.45 million metric tons and average yield of 1520 kg/ha in 2009 (FAOSTAT,2011). Major groundnut producing countries are China, 40%; India, 16.64%; Nigeria, 8.2%; USA, 5.9%; and Indonesia, 4.1%.

Groundnut is grown for its high quality digestible oil and protein-rich seeds (kernels). Seeds of groundnut contain 40-50% fat, 20-50% protein and 10-20% carbohydrate. The kernels are also nutritional source of vitamin E, Niacin, Folacin, Calcium, Phosphorus, Magnesium, Zinc, Iron, Riboflavin, Thiamine and Potassium. Oil extracted from kernels is used as culinary oil, animal feed and industrial raw material (oil cakes and fertilizer). These multiple uses of groundnut make it an excellent cash crop for domestic markets as well as for foreign trade in several developing and developed countries (Kees Stigter, 2011). On equal weight basis (kg for kg), groundnut contains more protein than meat and about 49% oil (Bharati, 2010).

Improved groundnut varieties have been developed and released for use in Nigeria, and include: Samnut 10, Samnut 11, Samnut 16, Samnut 19, Samnut 21, Samnut 22, Borno Red and Dan- Bomboyo. The performance of these varieties appear satisfactory mostly under the ecological settings of the Northern Guinea Savannah of Nigeria. With increasing consumer preference for high quality edible oils and the desire to increase groundnut export to the world market, there is need to investigate the kernel quality of groundnut varieties under the environmental settings (locations) in the Southern Guinea Savannah agro-ecological zone of Nigeria. The objectives of this study were therefore : to determine the kernel quality of selected groundnut varieties at Makurdi and Yandev locations, to identify groundnut variet- ties with high kernel quality to meet market demand and to assess the effects of location and variety on kernel quality.

MATERIALS AND METHODS

Materials

Seeds of groundnut varieties namely: Samnut 16, Samnut 21, Samnut 22, were obtained from Institue of Agricultural Research (IAR) Samaru- Zaria; Borno Red and Bomboyo from Maiduguri; Ebunaigbaji and Ijiwanda from Oju Local Government Area of Benue State. Permethrin (sheper) insecticide was purchased from an agro-chemical store in Makurdi for pest control. Cutlasses and hoes were also purchased from the open market and used for clearing and ridge making.

Methods

Field studies were conducted at the Teaching and Research Farm, University of Agriculture Makurdi and National Cereal Research Institute substation, Yandev; laboratory experiments on kernel quality at Benue State University Makurdi and Adamawa State University, Mubi. These locations fall within the Southern Guinea Savannah Agro-ecological zone of Nigeria (Agboola, 1979). The field experiment was laid out in Randomized Complete Block Design with seven treatments and three replications. The treatments were: five improved varieties (Samnut 16, Samnut 21, Samnut 22, Borno Red, Dan- Bomboyo) and two local varieties (Ebunaigbaji and Ijiwanda). The experimental plots were cleared in April and ridges were manually prepared in May 2011. Two seeds were sown per hole and spaced 75 cm x 20 cm with a population density of 66,000 plants per hectare. Sowing was done in May 2011 when rains were established enough for crop establishment.

Thinning to one seedling per stand was done two weeks after sowing (WAS). The gross plot size was 25m x12m ($300m^2$), with net plot size of 3m x 3m ($9m^2$). The plots were weeded manually twice, before and after flowering at 4 and 8 WAS. The plants were sprayed fortnightly with Permethrin (sheper) insecticide at the rate of 1.1kg a. i. chemical per 15 litres of water starting from 4 WAS to minimize insect damage by leaf rollers, grasshoppers and aphids. Kernel quality evaluation and results were determined in the laboratory according to recommended procedures.

Data Collection

Proximate Composition – laboratory experiments were carried out to determine the following kernel parameters:

Fat Content

The technique of Pearson (1976) was adopted for fat content extraction. Seventy (70) grams of groundnut sample was weighed into a handkerchief bag and placed in the Soxhlet extractor. The Soxhlet extractor was fitted into a $500cm^3$ flask and $350cm^3$ of petroleum ether ($60 – 80^0c$) was poured into the flask containing few anti- bumping granules. Extraction was carried out for three hours. Each sample was repeated three times (triplicate extraction) and the mean value of the triplicate in percentage and volume of fat extracted was recorded under Makurdi and Yandev locations.

Crude Protein

Micro- Kjedahl method was adopted for determination of crude protein content. Few anti- bumping granules (1.0g K_2SO_4) and anhydrous copper sulphate ($CuSO_4$) were added to 1.12g Kjedahl digestion flask containing $25.0cm^3$ of sulphuric acid (98w/v). The Kjedahl digestion flask was heated slowly until frothing subsided and then vigorously with occasional rotation (to ensure even digestion and avoid over heating of the content) until a clear solution was obtained. The solution was diluted to $250cm^3$ and few drops of phenol phthalein and $70cm^3$ of 40% sodium hydroxide were added. The ammonia liberated was trapped in 4% of boric acid solution ($100cm^3$) contained in a $500cm^3$ conical flask to which two drops of methyl red indicator were added. Distillation was stopped after the colour change. The content of the conical flask was titrated with 0.1mol hydrochloric acid. The percentage nitrogen was calculated as :

$$\text{Nitrogen}(\%) = \underline{0.014 \times C \times VA} \quad X \quad 100$$

Where:
C= molarity of Hcl
V= titre value of Hcl
Crude protein= % nitrogen x 6.25
Three replicate determinations were made and the average recorded.

Ash Content

Fourteen moisture dishes (crucibles) were dried in an oven for 30 minutes, cooled in dessicators for 30 minutes, weighed and the weight was recorded as W_1 for each crucible. The crucibles were labelled according to varieties (Samnut 16, Ssmnut 21, Samnut 22, Borno Red, Bomboyo, Ebunaigbaji, Ijiwanda) under Makurdi and Yandev locations. Two grams (2.0g) of each groundnut sample (variety) were weighed into the crucibles. These were placed in the furnace for three hours at 600^0c. After cooling, the crucibles were weighed. Ash content was determined as follows:

$$\frac{W_2 - W_1}{W_3 - W_1} \times 100$$

Where:
W_1= weight of crucible
W_2= weight of sample (2.0g)
W_3= weight of crucible + ash

Crude Fibre

Two grams (2.0g) of the sample (variety) was weighed into a 600ml beaker. 0.25 to 0.50g anti- bumping granules and 200ml of 1.25% w/v sulphuric acid were added to the beaker and boiled for 30 minutes. Thereafter, it was filtered and the solids were washed with warm water and 1.25% sodium hydroxide. The residue was placed in a crucible and dried for 2 hours at 130^0c, then it was cooled and weighed (W_1). Afterwards, it was ashed at 550^0c, cooled and weighed (W_2).

$$\text{Crucible fibre (\%)} = \frac{W_1 - W_2}{\text{Weight of Sample}} \times 100$$

Where:
W_1 = weight of crucible + lid + residue (g)
W_2 = weight of crucible + lid + ash (g)

Carbohydrate Content

Total carbohydrate was calculated by difference with the exclusion of crude fibre :
C (%) = 100 – P + F + A + W
Where :
P = percentage of protein
F = percentage of fat
A = percentage of ash
W = percentage of water

Moisture Content

This method involves the measurement of loss in weight due to evaporation of water (dehydration). Crucible dishes were washed and placed in an oven at 100^0c for 30 minutes to dry. Thereafter, the crucible dishes were cooled in desiccators for 30 minutes and weighed to determine the initial weight. Five (5) grams of groundnut seeds were added to the crucibles and placed in an oven at 110^0c for 3 hours. This was repeated to get constant weight.

Mineral Content (elemental composition)

Analyst 400 Atomic Absorption Spectrophotometer (AAS) was the instrument used to determine the elements of interest. When the setup of the instrument was completed, the elements of interest were selected. Acetylene cylinder was opened and the final output was ensured to be 14 psi, and the flame was ignited. To run the samples, oil was ashed and digested; the filtered samples were aspirated into the instrument after prepared standards were initially aspirated to get a calibration curve for the element of interest. The elemental composition (ppm) of groundnut that was determined included: Potassium, Calcium, Magnesium, Sodium, Iron, Zinc, Copper, Lead and Phosphorus.

Fatty Acid Composition

Gas Chromatography and Mass spectrophotometer was used to determine fatty acid composition according to AOAC (1998). Operating condition : temperature (0^0c) ; injector, 285 ; initial temperature, 100^0c (held 4 min.) ; ramp, 3^0c/min; final temperature, 240^0c ; hold, 15 min ; carrier gas, helium; flow rate, 0.75ml/min ; linear velocity, 18cm/s; split ratio, 200 : 1. Gas chromatography analysis was carried out on a Shimadzu GC- 17 A Chromatograph equipped with Mass Spectrometer detector : Shimadzu GCMS- QP 5050 using an identical column. One um of each diluted sample with analytical grade dichloromethane was injected.

The data collected was analyzed statistically using the Analysis of Variance Procedure described by Steel and Torrie (1980). Treatment means were compared by the Fischer's Least Significant Difference Procedure (F-LSD) , at 5% level of probability. Procedure by GenStat Release (PC/Windows) Copyright 2009, VSN International Limited was used.

RESULTS

Proximate Composition

Table 1 is a summary of results on effects of location and variety on proximate composition of groundnut. Makurdi and Yandev locations differed significantly in ash content only with Makurdi location being significantly higher (2.90%) than Yandev (2.80%). The locations did not differ significantly in protein, lipid, carbohydrate, fibre and moisture content. No significant difference was also observed among the seven varieties in all the proximate parameters. Variety Ijiwanda ranked higher in protein (40.14%) and lipid (40.09%); Ijiwanda in carbohydrate (4.79%) ; Samnut 22 in ash (3.08%) and Samnut 21 in moisture content (8.78%).

Location x variety interaction on protein and carbohydrate content was significant (Table 2). Makurdi x Borno Red and Yandev x Samnut 21 interactions produced significantly higher protein (40.47 %) when compared to other location x variety interactions. In carbohydrate content, Makurdi x Ebunaigbaji and Makurdi x Ijiwanda interactions ranked significantly higher (4.92%) respectively. Other location x variety interaction effects on lipid, fibre, ash and moisture content were not significant. But Ijiwanda and Dan-Bomboyo were least in lipid (39.35%) in Makurdi, Ebunaigbaji in fibre at Yandev (4.60%), Borno Red and Dan- Bomboyo in ash at Yandev (2.70%) and Ijiwanda in moisture content at Yandev (8.53%).

Elemental Composition (ppm)

Results on effects of location and variety on elemental composition of groundnut are presented in Table 3. The locations differed significantly in Potassium, Sodium, Iron and Phosphorus; with Yandev location being higher except in Phosphorus. The seven varieties differed significantly in all elements except Lead. Variety Ebunaigbaji ranked higher in Potassium (937.50ppm) and Iron (2.24ppm) ; Dan- Bomboyo in Calcium (17.79ppm) and Magnesium (3.75ppm) ; Samnut 21 produced higher Sodium (231.57ppm), Zinc (0.78ppm) and Phosphorus (0.07ppm) ; while Samnut 16 gave higher copper (46.38ppm) and these were significantly different when compared to other varieties. The composition of Lead was least followed by that of Phosphorus.

Location x variety interaction on the elements was significant except Magnesium and Lead (Table 4). Ijiwanda at Yandev yielded significantly higher Potassium (995.00ppm). At Makurdi, Dan- Bomboyo was significantly higher in Calcium (19.66ppm). Significantly higher Sodium (238.00ppm), Zinc (0.92ppm) and Phosphorus (0.08ppm) were produced by Samnut 21 at Yandev location. Yandev x Ebunaigbaji interaction gave significantly higher Iron (3.20ppm) ; while at Yandev, Samnut 16 recorded 48.97 ppm in Copper and this was higher and differed significantly from other location x variety interactions.

Fatty Acid Composition

Results on effects of location and variety on fatty acid composition are summarized in Table 5 as follows :

Lauric Acid – The seven varieties exerted significant difference in Lauric acid with Dan- Bomboyo being higher (10.13%) and Samnut 22 least (0.65%), but location effects were not significant.

Myristic Acid – Significant variation was observed in Myristic acid among the varieties. Samnut 16 produced significantly higher Myristic acid (6.98%) followed by Ebunaigbaji (6.24%), while Samnut 21 had the least (1.03%).

Palmitic Acid – Table 5 shows that location effects on Palmitic acid were not significant, but varieties differed significantly in Palmitic acid, being higher with Samnut 22 (20.75%) and least with Borno Red (1.68%).

Palmitoleic Acid – Varietal effects on Palmitoleic acid were significant, but not location effects. Borno-Red gave significantly higher Palmitoleic acid (0.94%) compared to other varieties, while Dan-Bomboyo was least with 0.24%.

Stearic Acid – The seven groundnut varieties differed significantly in Stearic acid content, with Borno Red being higher (8.66%), and Dan- Bomboyo least with 2.45%. Effects of location were not significant.

Oleic Acid – The difference in Oleic acid among the varieties was significant, but not among the locations . Significantly higher Oleic acid was observed with Dan-Bomboyo (62.41%) followed by Ijiwanda (60.39%) when compared to other varieties.

Linoleic Acid – The effects of varieties on Linoleic acid content were significant. Samnut 16 yielded significantly higher Linoleic acid (32.94%) compared to other varieties which was followed by Samnut 21 (31.02%). Effects of location on Linoleic acid was not significant.

Linolenic Acid – The varieties differed significantly in Linolenic acid content. Samnut 22 ranked significantly higher in Linolenic acid (1.60%) when compared to other varieties except Samnut 21 (1.48 %) and Samnut 16 (1.42%). Location had no significant effect on Linolenic acid.

Oleic/Linoleic Ratio – Groundnut varieties differed significantly in Oleic : Linoleic ratio (Table 5) with Dan-

Bomboyo being higher (3.74) followed by Ijiwanda (3.14). Effect of location on Oleic : Linoleic ratio was statistically the same (2.25).

Location and Variety Interactions- Results of location and variety interactions on fatty acid composition are presented in Table 6. Location x variety interactions on all the fatty acids were not significant, but Makurdi x Samnut 22 and Yandev x Samnut 22 interactions produced higher Palmitic acid content (20.75%). Makurdi x Borno Red and Yandev x Borno Red interacrions gave higher Palmitoleic acid (0.94%) and Stearic acid (8.66%) contents. Table 6 also shows that Makurdi x Dan-Bomboyo and Yandev x Dan-Bomboyo interactions yielded higher Oleic acid value of 62.41%. Results also revealed that Makurdi x Samnut 22 and Yandev x Samnut 22 interactions produced higher Linolenic acid (1.48). Location x variety interactions on Oleic: Linoleic ratio did not produce significant effects , but Makurdi x Dan-Bomboyo and Yandev x Dan-Bomboyo interactions gave higher Oleic: Linoleic ratio (3.74).

DISCUSSION

Proximate Composition

The protein content range of 39.38 % (Ijiwanda) to 40.47 % (Borno Red) agrees with the findings of Kees Stigter (2011) who observed that groundnut seeds contain 20 – 50 % protein. Carbohydrate was significant for varietal and interaction effects. Both soluble and insoluble fibres are found in groundnut. They help to reduce cholesterol levels and prevents constipation. The fibre content in the proximate composition was not significant at location, varietal and interaction effects.

Ash content which explains the extent of impurities in groundnut was not significant. The range of 2.70 % to 3.20 % agrees with the ash content of 3.08 % reported by Nelson and Carlos (1995).

Fatty Acid Composition

The groundnut varieties differed significantly in fatty acid composition; this is because several factors affect fatty acid composition. These include: variety, seasonal variation, agronomic practices, disease and insect damage, location and temperature conditions under which the crop is grown (Anderson et al., 1998). Oleic, Linoleic and Palmitic acids constituted over 80 % of the total fatty acids and could be recommended for the production of margarine. The level of Oleic acid was high which implies high oil stability and better shelf life of groundnut seeds, because Oleic acid is a mono- unsaturated fatty acid, being less prone to oxidation rancidity (Rahman et al., 2001). Unsaturated fatty acids have also been found to reduce plasma cholesterol levels (Psaltopouou et al., 2004). Replacing saturated fats with mono- unsaturated and poly- unsaturated fats is more effective in preventing coronary heart disease in women than reducing overall fat intake (Hu et al., 1997).

Ensuring adequate intake of poly- unsaturated fatty acid is a good way to encourage antioxidant vitamin E intake. The favourable fatty acid profile of groundnut and overall fatty acid intake means that it can contribute to a mixed diet which reduces total fat and saturated fatty acids which is a dietary approach to stop hypertension (Appel et al., 1997). The Oleic and Linoleic acid contents of the groundnut varieties analyzed accounted for 69.42 to 82.03 % of the total fatty acids. These results are consistent with the findings of Kratz et al (2002) who reported that Oleic and Linoleic acids constituted approximately 80 % of the total fatty acid composition of groundnut. The levels of Oleic (40.21 to 62.41 %) and Linoleic acid (16.41 to 32.94%) follow the range observed by Nelson and Carlos (1995). They found 36 to 67 % Oleic and 15 to 43 % Linoleic acid in the groundnut varieties they analyzed. Linoleic and Linolenic fatty acids are the Omega – 6 and Omega – 3 fatty acids and cannot be synthesized by human enzymes, hence are very essential fatty acids in human nutrition. The Linoleic/Linolenic ratio of Samnut 16 (25.15) and Ebunaigbaji (26.70) made these varieties stand higher than others. Groundnut varieties with higher Oleic/Linolenic acid ratio exhibit increased shelf life of products (Kratz et al., 2002). Oleic/Linoleic ratio is found to increase with groundnut maturity and is affected by varieties and environmental factors (Pattee et al., 1995).

Elemental Composition

The good availability of Calcium, Magnesium and Phosphorus indicates that the groundnut varieties are rich in the minerals for bone formation and dental health. Calcium is very essential in blood clotting, muscle contraction and in certain enzymes in metabolic processes (Wikipedia, 2010). Potassium enables electrolyte balance and efficient neuromuscular activity. Higher intake of Potassium has been recommended because of its beneficial effect on elevated blood pressure; groundnut seeds are a significant source of dietary Potassium (Whelton, 1997). Sodium is an essential element in cell fluids and control of body fluid balance. Zinc plays a key role in enzyme systems and has a role in immune responses. Phosphorus has a role in the metabolism of carbohydrates, fats and transport of fatty acids (Nutritional Values of Peanut Products, 2013). Copper helps to prevent anemia and is a component of many enzyme systems. Iron is essential for haemoglobin formation in red blood cells. The results of elemental composition showed that the concentrations of Potassium, Calcium, Sodium and Iron were significant.

CONCLUSION

Results of the study conducted in 2011 and 2012 had identified groundnut varieties with higher kernel quality. These include Borno Red which was higher in protein (40.47%) at Makurdi location and Samnut 21 (40.47%) at Yandev location; Samnut 16 recorded higher Lipid (40.50%) at Yandev location, while Ebunaigbaji was higher in carbohydrate content (4.92%).

Based on the results of fatty acid composition, Dan-Bomboyo both in Makurdi and Yandev had the highest Oleic/Linoleic ratio of 3.74 followed by Ijiwanda (3.14). For elemental composition, Ijiwanda recorded higher Potassium (995.00ppm) at Yandev; Samnut 16 , higher Calcium (19.36ppm) at Yandev; Dan Bomboyo, higher Magnesium (3.80ppm) at Makurdi. At Yandev, Samnut 21 produced higher Sodium (238.00ppm) and Zinc (0.92ppm); while Ijiwanda gave more Iron (2.93ppm) at Makurdi and Samnut 16, higher copper (48.97ppm) at Yandev. This implies that the study identified groundnut varieties with various quality attributes that can be selected from according to the product to be made.

Table 1: Effects of Location and variety on proximate composition (%) of groundnut in 2011 cropping season.

location	protein	lipid	carbohydrate	fibre	Ash	Moisture Content
makurdi	39.84	39.53	4.35	4.71	2.90	8.69
yandev	39.94	39.69	4.20	4.69	2.80	8.67
lsd (0.05%)	N.S	N.S	N.S	N.S	0.07	N.S
c.v. (%)	0.10	0.20	1.90	3.20	3.20	0.60
varieties						
borno red	40.04	39.79	4.04	4.73	2.75	8.63
dan-Bomboyo	39.70	39.50	4.70	4.73	2.73	8.65
ebunaigbaji	39.92	39.52	4.31	4.73	2.85	8.62
ijiwanda	39.60	39.42	4.79	4.73	2.93	8.60
sammut 16	40.14	40.09	3.57	4.73	2.93	8.60
sammut 21	40.03	39.45	4.25	4.70	2.80	8.78
sammut 22	39.81	39.50	4.29	4.65	3.08	8.68
lsd (0.05%)	**N.S**	**N.S**	**N.S**	**N.S**	**N.S**	**N.S**
c.v. (%)	**0.3**	**0.20**	**4.00**	**5.50**	**0.70**	**1.60**

Table 2: effects of location x variety interaction on proximate composition (%) of seven varieties of groundnut planted in makurdi and yandev in 2011 cropping season.

location x Variety	protein	lipid	carbohydrate	fibre	Ash	Moisture Content
makurdi x Borno Red	40.47	40.05	3.23	4.80	2.80	8.65
makurdi x Dan-Bomboyo	39.59	39.35	4.44	4.75	2.75	8.60
makurdi x Ebunaigbaji	39.81	39.45	4.92	4.70	2.85	8.75
makurdi x Ijiwanda	39.38	39.35	4.92	4.75	2.90	8.70
makurdi x Samnut 16	40.25	39.69	3.92	4.65	3.00	8.60
makurdi x Samnut 21	39.59	39.45	4.76	4.65	2.80	8.75
makurdi x Samnut 22	39.81	39.40	4.24	4.65	3.20	8.70
yandev x Borno Red	39.60	39.53	4.85	4.65	2.70	8.60
yandev x Dan-Bomboyo	39.80	39.65	4.44	4.70	2.70	8.70
yandev x Ebunaigbaji	40.03	39.60	4.17	4.60	2.80	8.80
yandev x Ijiwanda	39.82	39.50	4.65	4.70	2.80	8.53
yandev x Samnut 16	40.03	40.50	3.22	4.80	2.85	8.60
yandev x Samnut 21	40.47	39.45	3.73	4.75	2.80	8.80
yandev x Samnut 22	39.81	39.60	4.34	4.65	2.95	8.65
lsd (0.05%)	**0.66**	**N.S**	**0.62**	**N.S**	**N.S**	**N.S**
c.v. (%)	**1.00**	**1.60**	**8.10**	**9.30**	**13.30**	**5.50**

Table 3: effects of location and variety on elemental composition (ppm) of groundnut in 2011 cropping season.

location	potassium	calcium	Magnesium	sodium	iron	zinc	copper	lead	phosphorus
makurdi	230.29	14.95	3.39	98.27	0.85	0.69	44.08	0.01	0.07
yandev	496.27	15.21	3.41	117.48	1.21	0.69	44.84	0.01	0.05
lsd (0.05%)	1.05	NS	NS	4.80	0.17	NS	NS	NS	0.01
c.v. (%)	0.10	3.00	3.2	1.00	3.00	2.10	0.30	11.10	3.70
varieties									
borno red	103.00	14.18	3.68	52.27	0.43	0.70	44.09	0.01	0.05
dan-Bomboyo	102.50	17.97	3.75	106.43	0.34	0.72	44.54	0.01	0.06
ebunaigbaji	937.50	11.99	1.69	83.62	2.24	0.64	44.28	0.01	0.06
ijiwanda	559.00	14.19	3.62	51.00	1.72	0.62	44.18	0.01	0.04
sammut 16	160.44	17.42	3.70	134.40	0.51	0.72	46.38	0.02	0.06
sammut 21	148.00	13.79	3.75	231.57	1.56	0.78	43.73	0.02	0.07
sammut 22	532.50	16.04	3.69	95.84	0.41	0.65	44.07	0.01	0.05
lsd (0.05%)	**1.14**	**9.98**	**0.46**	**4.94**	**0.15**	**0.09**	**0.55**	**NS**	**0.07**
c.v. (%)	**0.10**	**3.50**	**1.80**	**1.30**	**4.70**	**1.30**	**0.50**	**00**	**0.90**

Table 4: effects of location x variety interaction on elemental composition (PPM) of groundnut in 2011 cropping season.

location	variety	potassium	calcium	Magnesium	sodium	iron	zinc	copper	lead	phosphorus
makurdi	X borno red	101.00	14.27	3.67	91.20	0.25	0.80	44.18	0.01	0.05
makurdi	X dan-Bomboyo	101.00	19.66	3.797	54.15	0.35	0.79	44.29	0.01	0.08
makurdi	X ebunaigbaji	945.00	11.73	1.690	144.90	1.28	0.66	44.35	0.01	0.08
makurdi	X ijiwanda	123.00	14.37	3.550	54.90	2.93	0.61	44.18	0.01	0.04
makurdi	X sammut 16	116.00	15.48	3.680	106.05	0.60	0.67	43.78	0.02	0.08
makurdi	X sammut 21	116.00	14.46	3.650	225.15	0.30	0.64	43.78	0.02	0.10
makurdi	X sammut 22	110.00	14.69	3.670	11.53	0.23	0.62	44.02	0.01	0.05
yandev	X borno red	105.00	14.08	3.690	13.33	0.61	0.59	44.00	0.01	0.05
yandev	X dan-Bomboyo	104.00	16.27	3.700	158.70	0.33	0.64	44.78	0.01	0.05
yandev	X ebunaigbaji	930.00	12.26	1.680	22.35	3.20	0.62	44.20	0.01	0.05
yandev	X ijiwanda	995.00	14.00	3.680	47.10	0.50	0.63	44.18	0.01	0.04
yandev	X sammut 16	204.87	19.36	3.720	162.75	0.42	0.76	48.97	0.02	0.03
yandev	X sammut 21	180.00	13.12	3.680	238.00	2.82	0.92	43.67	0.02	0.08
yandev	X sammut 22	955.00	17.39	3.710	180.15	0.58	0.68	44.11	0.01	0.06
	LSD (0.05%)	**1.56**	**2.62**	**n.s**	**6.812**	**0.21**	**0.12**	**0.82**	**n.s**	**0.01**
	C.V (%)	**0.30**	**10.50**	**11.40**	**3.80**	**12.40**	**11.10**	**1.00**	**70.00**	**9.70**

Table 5: effects of location and variety on fatty acid composition (%) of groundnut in 2011 cropping season.

location	Lauric	Myristic	palmitic	palmitoleic	stearic	oleic	linoleic	linolenic	ratio
makurdi	3.79	3.52	10.45	0.47	4.48	51.52	24.80	0.82	2.25
yandev	3.79	3.52	10.45	0.47	4.48	51.52	24.80	0.82	2.25
lsd (0.05%)	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S
c.v. (%)	0.9	0.30	0.1	5.4	0.30	0.0	1.0	1.24	2.03
varieties									
borno red	1.21	3.24	1.68	0.94	8.66	58.82	24.21	1.24	2.43
dan-Bomboyo	10.13	5.87	2.41	0.24	2.45	62.41	16.41	0.80	3.74
ebunaigbaji	7.40	6.24	3.98	0.54	2.94	54.77	24.03	0.94	2.28
ijiwanda	5.39	6.21	3.21	0.25	5.23	60.39	19.21	1.31	3.14
sammut 16	0.78	6.98	20.42	0.40	2.93	40.21	32.94	1.42	1.22
sammut 21	0.98	1.03	20.68	0.46	3.04	41.33	31.02	1.48	1.33
sammut 22	0.65	1.06	20.75	0.49	6.14	42.67	26.75	1.60	1.60
lsd (0.05%)	**1.14**	**0.01**	**0.02**	**0.04**	**0.03**	**0.02**	**0.78**	**0.23**	**0.10**
c.v. (%)	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**

Table 6: effects of location x variety interaction on fatty acid composition (%) of groundnut in 2011 cropping season.

location		variety	Lauric	Myristic	palmitic	palmitoleic	stearic	oleic	linoleic	linolenic	ratio
makurdi	X	borno red	1.21	3.24	1.68	0.94	8.66	58.82	24.21	1.24	2.43
makurdi	X	dan-Bomboyo	10.13	5.87	2.41	0.24	2.45	62.41	16.41	0.08	3.8
makurdi	X	ebunaigbaji	7.40	6.24	3.98	0.54	5.23	54.77	24.03	0.09	2.28
makurdi	X	ijiwanda	5.39	6.21	3.21	0.25	2.93	60.39	19.21	0.09	3.14
makurdi	X	sammut 16	0.78	6.98	20.42	0.40	3.04	40.21	32.94	1.31	1.22
makurdi	X	sammut 21	0.98	1.03	20.68	0.46	6.14	41.33	31.02	1.42	1.33
makurdi	X	sammut 22	0.65	1.06	20.7	0.49	8.66	42.67	26.75	1.48	1.60
yandev	X	borno red	1.21	3.24	1.68	0.94	2.45	58.82	23.21	1.24	2.43
yandev	X	dan-Bomboyo	10.13	5.87	2.41	0.24	2.94	62.41	16.41	0.08	3.80
yandev	X	ebunaigbaji	7.40	6.24	3.98	0.54	5.23	54.77	24.03	0.09	2.28
yandev	X	ijiwanda	5.39	6.21	3.21	0.25	2.93	60.39	19.21	0.09	3.14
yandev	X	sammut 16	0.78	0.98	20.42	0.40	2.93	40.21	32.94	1.31	1.22
yandev	X	sammut 21	0.98	1.03	20.68	0.46	3.04	41.33	31.02	1.42	1.33
yandev	X	sammut 22	0.64	1.06	20.74	0.49	6.14	42.67	26.75	1.48	1.60
	lsd (0.05%)		**N.S**	**N.S**	**N.S**	**N.S**	**N.S**	**N.S**	**N.S**	**N.S**	**N.S**
	c.v. (%)		**3.10**	**0.10**	**0.2**	**7.01**	**0.50**	**0.0**	**2.6**	**2.3**	**3.5**

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AUTHORS

First Author – Msaakpa,T.S., Department of Plant Breeding and Seed Science, University of Agriculture, Makurdi, Benue State.
Second Author – Agaba,B.E, Department of Crop Production, Adamawa State University, Mubi.