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Effects of fertilization on the proximate composition of fresh and stored groundnuts (*Arachis hypogaea* L.)

Evans A. Alenyorege[1*], Felix K. Abagale[1], Albert Yawson[1], Nelson Opoku[2]

[1]*Department of Agricultural Mechanization & Irrigation Technology, Faculty of Agriculture, University for Development Studies, P.O Box TL 1882, Tamale, Ghana*

[2]*Department of Biotechnology, Faculty of Agriculture, University for Development Studies, P.O Box TL 1882, Tamale, Ghana*

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Abstract

The study was aimed at evaluating the proximate composition of groundnuts cultivated using Yaralegume and Humate Green OK fertilizers at four (4) communities in the Lambussie-Karni District of the Upper West Region of Ghana. In all, twenty four (24) fresh and stored groundnut samples were analysed using standard methods and procedures. The results indicated average moisture, crude protein, crude fat, crude fibre, ash and carbohydrate contents of 3.65 %, 24.78 %, 44.70 %, 5.65 %, 2.18 % and 19.16 % for fresh groundnuts and 3.88 %, 27.08 %, 47.62 %, 6.76 %, 2.28 % and 12.28 % for stored groundnuts respectively. After storage, 83.33 %, 58.33 % and 66.67 % of the samples recorded increase in moisture and crude protein, fibre and ash content, and crude fat correspondingly. However, 91.67 % of the samples had reduced levels of carbohydrate after storage. Fertilization did not have a significant impact on the proximate composition of both categories of groundnuts and therefore, the use of these fertilizers to improve the proximate composition of groundnuts may not be recommendable but storage could improve proximate composition.

* **Corresponding Author:** Evans A. Alenyorege ✉ alenyoregee@yahoo.com

Introduction

Groundnut is a vital crop for resource-poor farmers in Ghana, critical for their economic prosperity and nutritional welfare. Improvements in groundnut productivity and output are also crucial because of its potential to regain and increase export earnings. Groundnut is the principal source of dietary protein, oil/fat and vitamins such as thiamine, riboflavin and niacin. Groundnut is an important oil seed crop and food grain legume. It contains about 50% oil, 25-30 % protein, 20 % carbohydrate and 5% fibre and ash which make a substantial contribution to human nutrition (Fageria *et al.*, 1997). Groundnut is the sixth most important oilseed crop in the world and grown on 26.4 million ha worldwide with a total production of 37.1 million metric tones and an average productivity of 1.4 metric t ha^{-1} (FAO, 2007).

Application of fertilizers could improve groundnut output per unit area up from the current yield of 0.8 t ha^{-1} (Okello *et al.*, 2010) which is far much below the potential yield level of 3 t ha^{-1}. The improved yield of groundnuts will therefore reduce the quantity of current importation of the crop, hence reduction of the low dietary diversity issues. Ghana's estimated groundnut yield level is around 1.4 mt ha^{-1} and close to the world average, in between the African and Asian averages of about 1 and 2 mt ha^{-1} respectively. Like most groundnuts in Africa, Ghana's crop is produced almost entirely without irrigation and fertilization.

Plant nutrient deficiency is a major limitation to crop production efficiency and nutritional quality, and a predisposing factor for infection (Graham *et al.,* 2007). Plant nutrient deficiencies can reduce both the quantity and quality of nutritive components of plants. Soil quality and soil fertility have a direct influence on the nutrient content of food crops and the nutrient output of farming systems (Bruulsema *et al.,* 2012). Soil fertility improvements can increase productivity and allow for greater diversity of crops without increasing the area cultivated. Thus, attention should be given to the role that soil fertility can play in increasing the nutrient output of cropping systems (Graham *et al.,* 2007). When plants become deficient in a particular nutrient, other nutrients also may be affected so that the vitamins, protein, carbohydrate, fat and other essential nutritional components that plants are grown for will be affected. As primary food and feed sources, plants must provide nutrients in adequate quantity, safety and quality. Factors that result in a nutrient deficiency for plants also affect their nutrient value or nutrient availability for animals or man. Major causes of nutrient deficiency are inadequate supply, lack of access to forms of nutrients available for absorption, or disease denial of nutrients necessary to maintain plant health and nutrient quality (Graham *et al.,* 2007). Benefits of nutrient sufficiency of the plant are achieved through increased production efficiency and greater productivity of more nutritious and safer food (Datnoff *et al.,* 2007). The study was therefore aimed at assessing the proximate composition of groundnuts cultivated using Yaralegume and Humate Green OK fertilizers at four (4) communities in the Lambussie-Karni District of the Upper West Region of Ghana.

Materials and method

Study areas

The field experiments were conducted in four (4) communities; Samoa (N10.83208; W002.56059), Korro (N10.88371; W002.5688), Konguoli (N10.84229; W002.66427) and Hiinneteng (N10.85800; W002.69651) all in the Lambussie-Karni District of the Upper West Region of Ghana. The Lambussie-Karni District falls in the Guinea Savanna climatic zone and experiences two major seasons with a single maxima (short rainy season and a long dry spell). The rainy season starts from June to October each year and gives way to the dry season from November to May. The occurrence of drought or floods affects crop growth thereby culminating in reduced crop yields each year, as additional nutrients intake by the crops is impaired. The on-farm fertilization experiment was established in the wet season of 2014. Planting was done in July 2014 and harvested in October 2014.

Experimental description and sampling

The experiment was laid out in a completely randomized design (CRD) with no fertilizer application as control treatment (T_1), full rate of Yaralegume (3.75 Kg/100 m^2) as second treatment (T_2) and a combination of Yaralegume at half rate (1.88 Kg/100 m^2) and Humate Green OK liquid fertilizer solution (3L/100 m^2) as third treatment (T_3). One groundnut variety (Shitaochi or Chinese) was planted to all experimental plots. Plot size per treatment was 10 m × 10 m (100 m^2). The plant spacing was 0.50 m inter-row and 0.10 m in-row. Groundnuts from each plot were harvested and sundried. From respective lots, 1.0 kg of dried groundnuts was picked as fresh samples (without storage) and the remainder stored in mini polypropylene bags for five months (November, 2014 to March, 2015). After storage, 1.0 kg of groundnuts was picked as stored samples from respective lots. This was done in all four (4) communities. Subsequently, each of the fresh and stored samples per experimental unit per community was hand-shelled; working samples (25 g) were prepared accordingly and from which analytical samples (15 g) were taken for proximate composition analysis.

Proximate composition analysis of groundnuts

The proximate composition analysis (moisture, ash, fiber, crude fat, protein and carbohydrates) of all the samples was determined following standard procedures at the University for Development Studies Spanish Laboratory Complex in Nyankpala. The moisture and ash were determined using weight difference method as described by Kirk and Sawyer (1991). The nitrogen value, which was the precursor for protein of the groundnuts, was established by Kjeldahl's method described by Kirk and Sawyer (1991), involving digestions, distillation and titration of samples. The nitrogen value was converted to protein by multiplying with a factor of 6.25. Carbohydrate was also determined by difference method, where the sum of all the other parameters per sample in percentages was subtracted from 100 %. Crude fibre was determined as described by Sungsoo *et al.* (1999) and Crude fat content determined by the method of Kirk and Sawyer (1991).

Data analysis

Data collected was subjected to one-way analysis of variance (ANOVA) using Gen Stat discovery edition 3 (VSN International Ltd). Statistically significant differences were reported at $p < 0.05$. If the overall F-test was significant ($p < 0.05$), then Fisher's Least Significant Difference (LSD) test was used to compute the smallest significant difference between two means and alphabetical notations used as superscripts to mark the differences at significant levels.

Results and discussion

Effects of fertilization on moisture content of fresh and stored groundnuts

Fertilization did not impact significantly on the moisture content (Table 1) of the groundnuts eventhough there existed an increase in moisture content of samples with storage. El Tinay *et al.* (1989) stated that moisture content of groundnut seeds was not significantly affected by biological, inorganic or organic fertilizers but rather by relative humidity of the surrounding atmosphere at the time of harvest and during storage.

Table 1. Percentage moisture content of fresh and stored groundnuts.

Sample Identity		Moisture Content (%)	
A	B	Fresh Groundnuts	Stored Groundnuts
HAT_1	HAT_1S	$4.16^{a}\pm0.22$	$4.08^{ab}\pm 0.07$
HAT_2	HAT_2S	$3.77^{ab}\pm0.19$	$3.98^{ab}\pm0.16$
HAT_3	HAT_3S	$3.63^{ab}\pm0.07$	$3.94^{ab}\pm0.26$
KGT_1	KGT_1S	$3.17^{ab}\pm0.85$	$3.90^{abc}\pm0.26$
KGT_2	KGT_2S	$3.88^{ab}\pm0.21$	$3.48^{c}\pm0.20$
KGT_3	KGT_3S	$3.67^{ab}\pm0.24$	$4.14^{a}\pm0.08$
KOT_1	KOT_1S	$3.75^{ab}\pm0.25$	$3.94^{ab}\pm0.06$
KOT_2	KOT_2S	$3.15^{ab}\pm1.11$	$3.46^{bc}\pm0.43$
KOT_3	KOT_3S	$3.87^{ab}\pm0.30$	$4.01^{a}\pm0.18$
SAT_1	SAT_1S	$3.78^{ab}\pm0.10$	$4.02^{ab}\pm0.06$
SAT_2	SAT_2S	$3.26^{b}\pm1.23$	$3.83^{ab}\pm0.16$
SAT_3	SAT_3S	$3.76^{ab}\pm0.07$	$3.76^{bc}\pm0.17$
$LSD_{(0.05)}$		0.949	0.341
CV(%)		15.5	5.2

HA= Hiinneteng, KG= Konguoli, KO= Korro and SA= Samoa. T_1= Control (no fertilizer); T_2 = Yaralegume fertilizer only and T_3 = Yaralegume

+Humate Green OK fertilizers. A = Fresh groundnut samples and B = Stored Groundnuts samples. ^{a,b,c,d,e,f} *Means that do not share a letter are significantly different ($p < 0.05$).*

With several days of sun drying, moisture content in both fresh and stored groundnuts was brought below 5 % hence lower than the 7-7.5 % indicated by Davidson *et al.* (1982) and 6-8 % (Kaaya *et al.,* 2006) as optimum levels for safe storage. However this moisture content agrees with 3.3 to 6.9 % by Mutegi *et al.* (2013), 3.40 % (Ayoola *et.al.*, 2012) and 4.11 % (Kumar *et al.*, 2013) for raw groundnut samples. The observed slight increase in moisture in over 80 % of the samples after storage has been explained by Ladele and Njoku (1984) as a likely result of metabolic or oxidation water and/or moisture absorbed from the environment during storage.

Effect of fertilization on crude protein content of fresh and stored groundnuts

The crude protein content of the groundnut seeds varied between 22 and 30 % and this is presented in Table 2. The combined effect of Yaralegume fertilizer and Humate Green OK (T_3) had a 100 % increase in crude protein of stored groundnuts with the control (T_1) and Yaralegume fertilizer only (T_2) treatments each producing a 75 % increase in protein content of stored groundnuts.

Table 2. Percentage crude protein content of fresh and stored groundnuts.

Sample Identity		Protein Content (%)	
A	B	Fresh Groundnuts	Stored Groundnuts
HAT$_1$	HAT$_1$S	25.04^{cd}±0.41	26.53^{cde}±0.23
HAT$_2$	HAT$_2$S	21.54^{f}±0.81	25.48^{ef}±0.20
HAT$_3$	HAT$_3$S	22.24^{f}±0.49	27.93^{b}±0.45
KGT$_1$	KGT$_1$S	28.19^{a}±0.17	25.13^{f}±1.12
KGT$_2$	KGT$_2$S	28.54^{a}±0.10	29.50^{a}±0.78
KGT$_3$	KGT$_3$S	24.34^{d}±0.75	27.23^{bcd}±0.49
KOT$_1$	KOT$_1$S	25.74^{bc}±0.11	30.38^{a}±0.54
KOT$_2$	KOT$_2$S	24.69^{cd}±0.20	25.65^{ef}±0.65
KOT$_3$	KOT$_3$S	26.44^{b}±0.41	27.58^{bc}±0.64
SAT$_1$	SAT$_1$S	23.80^{de}±1.29	26.53^{cde}±0.62
SAT$_2$	SAT$_2$S	24.18^{d}±0.69	27.05^{bcd}±0.08
SAT$_3$	SAT$_3$S	22.59^{ef}±0.40	26.00^{def}±0.74
LSD$_{(0.05)}$		1.285	1.326
CV(%)		2.4	2.2

HA= Hiinneteng, KG= Konguoli, KO= Korro and SA= Samoa. T_1= Control (no fertilizer); T_2 = Yaralegume fertilizer only and T_3 = Yaralegume +Humate Green OK fertilizers. A = Fresh groundnut samples and B = Stored Groundnuts samples. ^{a,b,c,d,e,f} *Means that do not share a letter are significantly different ($p < 0.05$).*

This, coupled with the optimal protein content of fresh groundnuts (22-30 %) which agreed perfectly with 22 to 30 % obtained by Savage and Keennan (1994); 29.12 % crude protein obtained by Kavitha and Parimalavalli (2014); 25.0 % (Badau *et al.,* 2013); 21.80 % (Ayoola and Adeyeye, 2010); and 24.40 % (Wakshama *et al.,* 2010). The presence of phosphate in Yaralegume fertilizer had an influence on the protein content since Deshmukh *et al.* (1993) found that the application of Phosphorus containing fertilizers to groundnut increased protein content.

Effect of fertilization on crude fat content of fresh and stored groundnuts

Over 65 % of the fresh samples increased in fat content (Table 3) after storage, indicating the possible residual effect of the treatments even though some samples from the control plot also appreciated in fat content. This could possibly be attributed to previous fertility status of the control plots. Fat content for both fresh and stored samples ranged from 39.98-47.78 % and 44.67- 55.33 % respectively. This is in line with the observations of Asibuo *et al.* (2008) and Savage and Keennan (1994) who reported that fat content of groundnut ranged from 33.60 – 54.95 % and 42 to 52 % respectively. Sample number HAT$_3$ produced the lowest fat content of 39.98 % after harvest and the highest of 55.33 % after storage (HAT$_3$S) indicating fat accumulation with time. Plots without fertilizer treatments produced fresh groundnuts with higher fat content in 3 out of the 4 communities (75 %) and 2 out of the 4 communities (50 %) after storage indicating minimal impact of fertilizers if groundnut are purposely for fat or oil production. It was evident that the fertilizers used had a 25 % and 50 % reducing effect on the fat content of fresh and stored groundnuts respectively.

Table 3. Percentage crude fat content of fresh and stored groundnuts.

Sample Identity		Fat Content (%)	
A	B	Fresh Groundnuts	Stored Groundnuts
HAT_1	HAT_1S	$46.67^a±2.00$	$48.38^c±1.19$
HAT_2	HAT_2S	$42.22^a±0.84$	$46.00^e±0.29$
HAT_3	HAT_3S	$39.89^a±2.80$	$55.33^a±1.55$
KGT_1	KGT_1S	$47.78^a±1.50$	$46.67^d±0.72$
KGT_2	KGT_2S	$43.67^a±0.33$	$45.33^f±0.24$
KGT_3	KGT_3S	$46.78^a±3.67$	$45.68^{ef}±0.45$
KOT_1	KOT_1S	$44.22^a±0.51$	$47.33^d±0.47$
KOT_2	KOT_2S	$46.11^a±5.74$	$49.00^c±0.30$
KOT_3	KOT_3S	$44.56^a±0.51$	$47.67^d±0.72$
SAT_1	SAT_1S	$46.67^a±0.67$	$45.00^f±0.40$
SAT_2	SAT_2S	$45.00^a±1.00$	$44.67^f±0.32$
SAT_3	SAT_3S	$42.89^a±0.19$	$50.33^b±0.50$
$LSD_{(0.05)}$		3.870	1.193
CV(%)		5.1	1.5

HA= Hiinneteng, KG= Konguoli, KO= Korro and SA= Samoa. T_1= Control (no fertilizer); T_2 = Yaralegume fertilizer only and T_3 = Yaralegume +Humate Green OK fertilizers. A = Fresh groundnut samples and B = Stored Groundnuts samples. ^{a,b,c,d,e,f} Means that do not share a letter are significantly different ($p < 0.05$).

Effect of fertilization on crude fibre content of fresh and stored groundnuts

Seven (7) out of the twelve (12) fresh samples tested increased in crude fibre content with time as presented in Table 4. There existed significant differences ($p < 0.05$) within fresh samples and a near perfect run of significance within stored samples. There was no total improvement in fibre content due to combined application of Yaralegume and Humate Green OK fertilizers. This might be attributed to uncontrolled release of nutrients in the soil through mineralization of Humate Green OK fertilizer which might have facilitated poor crop growth.

Table 4. Percentage crude fibre content of fresh and stored groundnuts.

Sample Identity		Fibre Content (%)	
A	B	Fresh Groundnuts	Stored Groundnuts
HAT_1	HAT_1S	$3.58^e±0.07$	$5.04^g±0.21$
HAT_2	HAT_2S	$7.31b^c±0.53$	$10.13^a±0.14$
HAT_3	HAT_3S	$2.37^f±0.23$	$6.41^f±0.16$
KGT_1	KGT_1S	$3.01^{ef}±0.36$	$5.18^g±0.13$
KGT_2	KGT_2S	$2.56^f±0.56$	$8.10^d±0.31$
KGT_3	KGT_3S	$7.28^c±1.00$	$3.16^h±0.78$
KOT_1	KOT_1S	$7.00^c±0.52$	$5.21^g±0.61$
KOT_2	KOT_2S	$10.24^a±0.45$	$11.08^a±0.16$
KOT_3	KOT_3S	$4.16^d±0.67$	$3.21^a±0.16$
SAT_1	SAT_1S	$5.07^d±0.17$	$9.12^c±0.04$
SAT_2	SAT_2S	$7.12^c±1.44$	$7.05^{ef}±0.08$
SAT_3	SAT_3S	$8.05^b±0.68$	$7.42^{de}±0.13$
$LSD_{(0.05)}$		1.117	0.703
CV(%)		11.7	4.8

HA= Hiinneteng, KG= Konguoli, KO= Korro and SA= Samoa. T_1= Control (no fertilizer); T_2 = Yaralegume fertilizer only and T_3 = Yaralegume +Humate Green OK fertilizers. A = Fresh groundnut samples and B = Stored Groundnuts samples. ^{a,b,c,d,e,f} Means that do not share a letter are significantly different ($p < 0.05$).

Effect of fertilization on ash content of fresh and stored groundnuts

Not all fresh and stored samples were significantly different, nevertheless 58.33 % of the samples increased in ash content in the range of 2.08- 2.59 % after 150 days of storage as shown in Table 5. Before storage, all samples which had ash content below 2 % revealed ash contents above 2 % but less than 3 % . This agrees with ash content values reported by Kavitha and Parimalavalli (2014) and Badau *et al.* (2013) who had ash contents in the range of 2.45-

2.78 % and disagrees with works by Abdualrahman (2013) and Wakshama *et al.* (2010) who had ash contents as 3.17 % and 3.50 % respectively.

Table 5. Percentage ash content of fresh and stored groundnuts.

Sample Identity		Ash Content (%)	
A	B	Fresh Groundnuts	Stored Groundnuts
HAT_1	HAT_1S	$2.06^{cdef}±0.49$	$2.14^{ab}±0.01$
HAT_2	HAT_2S	$1.99^{cdef}±0.51$	$2.54^{a}±0.13$
HAT_3	HAT_3S	$1.88^{def}±0.32$	$2.08^{ab}±0.14$
KGT_1	KGT_1S	$2.59^{bcd}±0.40$	$2.50^{a}±0.24$
KGT_2	KGT_2S	$2.87^{ab}±0.21$	$2.13^{ab}±0.13$
KGT_3	KGT_3S	$3.18^{a}±0.20$	$1.59^{b}±0.42$
KOT_1	KOT_1S	$2.63^{abc}±0.27$	$2.52^{a}±0.54$
KOT_2	KOT_2S	$2.22^{bcde}±0.26$	$2.57^{a}±0.27$
KOT_3	KOT_3S	$1.58^{ef}±0.26$	$2.59^{a}±0.11$
SAT_1	SAT_1S	$1.29^{f}±0.21$	$2.55^{a}±0.37$
SAT_2	SAT_2S	$2.12^{bcdef}±0.13$	$2.09^{ab}±0.01$
SAT_3	SAT_3S	$1.77±^{def}0.20$	$2.11^{ab}±0.11$
$LSD_{(0.05)}$		0.524	0.567
CV(%)		14.2	11.4

HA= Hiinneteng, KG= Konguoli, KO= Korro and SA= Samoa. T_1= Control (no fertilizer); T_2 = Yaralegume fertilizer only and T_3 = Yaralegume +Humate Green OK fertilizers. A = Fresh groundnut samples and B = Stored Groundnuts samples. ^{a,b,c,d,e,f} Means that do not share a letter are significantly different ($p < 0.05$).

Effect of fertilization on carbohydrate content of fresh and stored groundnuts

It was observed that carbohydrate in all but one fresh sample (KGT_3) reduced appreciably after storage. Carbohydrate content was significantly high in the range of 13.79 to 28.61 % in fresh samples and adversely low in the range of 3.36 to 18.43 % in stored samples as presented in Table 6. It was evident that the combined effect of Yaralegume and Humate Green OK (T_3) produced fresh groundnuts with significantly high carbohydrate content whilst fresh groundnuts from control plots produced comparably low levels of carbohydrate. The reduction in carbohydrate content in over 90 % of the samples after storage could be attributed to possible activities of fungi. It is expected that the presence of fungi will possibly result in carbohydrate reduction in samples since it serves as a source of food for energy for survival, establishment and multiplication of the fungi (Tanuja *et al.*, 2012). During possible fungal infestation, the carbohydrate content of groundnuts decreased due to the utilization of carbohydrates by the fungi through amylolytic activities (Somani and Pandrangi, 1992).

Table 6. Percentage carbohydrate content of fresh and stored groundnuts.

Sample Identity		Carbohydrate (%)	
A	B	Fresh Groundnuts	Stored Groundnuts
HAT_1	HAT_1S	$18.60^{bcd}± 2.98$	$13.15^{c}±0.16$
HAT_2	HAT_2S	$23.56^{ab}±1.04$	$11.72^{cde}±0.29$
HAT_3	HAT_3S	$28.61^{a}±0.85$	$3.36^{g}±0.61$
KGT_1	KGT_1S	$15.08^{cd}±1.34$	$16.34^{b}±1.60$
KGT_2	KGT_2S	$18.44^{bcd}±0.25$	$11.60^{de}±0.83$
KGT_3	KGT_3S	$15.50^{cd}±4.15$	$18.43^{a}±0.41$
KOT_1	KOT_1S	$16.94^{bcd} ± 0.57$	$10.85^{e}±0.74$
KOT_2	KOT_2S	$13.79^{d}±7.95$	$8.11^{f}±0.28$
KOT_3	KOT_3S	$19.31^{bcd}±0.89$	$15.16^{b}±0.19$
SAT_1	SAT_1S	$19.36^{bcd}±2.75$	$12.86^{cd}±0.49$
SAT_2	SAT_2S	$19.40^{bcd}±3.49$	$15.06^{b}±0.27$
SAT_3	SAT_3S	$21.38^{bc}±0.51$	$10.72^{e}±0.77$
$LSD_{(0.05)}$		6.720	1.470
CV(%)		16.1	5.5

HA= Hiinneteng, KG= Konguoli, KO= Korro and SA= Samoa. T_1= Control (no fertilizer); T_2 = Yaralegume fertilizer only and T_3 = Yaralegume +Humate Green OK fertilizers. A = Fresh groundnut samples and B = Stored Groundnuts samples. ^{a,b,c,d,e,f} Means that do not share a letter are significantly different ($p < 0.05$).

Conclusion

The study revealed that apart from varietal advantage, both fresh and stored groundnuts yielded in optimal levels, moisture, crude protein, crude fat, crude fibre, ash content and carbohydrate. Fertilizer treatments did not significantly affect proximate composition but minimal increased levels were observed in proximate composition of groundnuts except carbohydrate content after storage. From the results of the study, application of any of these two fertilizers might not be necessary if it is mainly applied for the purpose of increasing the proximate composition aspect of nutritional quality but rather storing groundnuts for at least five (5) months could serve this purpose.

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