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Full Length Research Paper

Chemical composition of groundnut, *Arachis hypogaea* (L) landraces

Asibuo, James Yaw[1]*, Akromah, Richard[2], Safo-Kantanka, Osei[2], Adu-Dapaah, Hans Kofi[1], Ohemeng-Dapaah, Seth[1] and Agyeman, Adelaide[1]

[1]CSIR-Crops Research Institute, P. O. Box 3785, Kumasi, Ghana, W/Africa.
[2]Department of Crop and Soil Science, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana.

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Groundnut production and utilization in Ghana has tripled in the last decade due to its high nutritive value and the number of uses it can be put into. The chemical quality of seeds of Ghanaian groundnut are different from those of other countries, however, no previous studies has been done. This study was initiated to examine the nutritional quality of 20 groundnut varieties grown in Ghana. Dry samples were examined for oil content, crude protein, total carbohydrate, calcium, potassium, magnesium, sodium, zinc, copper, iron and manganese. Results from these analyses showed significant variation between the parameters measured. Virginia cultivars which belong to subspecies *hypogaea* had higher oil content (49.7%) than the Spanish and Valencia market types, which belong to subspecies *fastigiata* (47.3%). The mean protein content of subspecies *fastigiata* was however higher (25.69%) than subspecies *hypogaea* (22.78%). The mineral elements examined were substantial in reducing malnutrition especially in young and growing children. Broni fufuo, a Spanish market type had the highest crude protein content (30.53%) and the least oil content (33.60%) and is idea for products which require more protein and less oil. Substantial genetic variability exists for chemical composition and nutritional traits which could be utilised for various food preparations and selection for breeding purpose.

Key words: *Arachis hypogaea*, groundnut, protein, oil, minerals.

INTRODUCTION

Groundnut production in Ghana has nearly tripled in the last decade (168,200 t in 1995 to 420,000 t in 2005) primarily due to increases in the area under cultivation which increased from 180,400 in 1995 to 450,000 ha in 2005 (FAO, 2006). Average yields however continue to remain below 1.0 t ha^{-1} which is far below the potential yields of 2.0-3.0t ha^{-1}. Beside income for farmers, groundnut provides an inexpensive source of high quality dietary protein and oil. The vast food preparations incorporating groundnut to improve the protein level has helped in no small way in reducing malnutrition in the developing countries. The special taste and flavour of foods containing groundnut is important in the acceptance of these food preparations.

The seeds of most groundnut cultivars contain about 50% oil (Worthington and Hammons, 1971), and therefore the quality of the oil and groundnut products depend to a large extend on the oil fraction. The oil content of groundnut differs in quantity, the relative proportion of fatty acids, geographical location, seasons and growing conditions (Brown et al., 1975; Holaday and Pearson, 1974; Young et al., 1974). Groundnut seed contains 44 to 56% oil and 22 to 30% protein on a dry seed basis and is a rich source of minerals (phosphorus, calcium, magnesium, and potassium) and vitamins (E, K, and B group) (Savage and Keenan, 1994). Groundnut protein is increasingly becoming important as food and feed sources, especially in developing countries where protein from animal sources are not within the means of the majority of the populace. The seed has several uses as

*Corresponding author. E-mail: jyasibuo@gmail.com.

whole seed or processed to make peanut butter, oil, soups, stews and other products. The cake has several uses in feed and infant food formulations. Groundnut provides considerable amounts of mineral elements to supplement the dietary requirements of humans and farm animals. Groundnut seeds are reported to contain 9.5 to 19.0% total carbohydrates as both soluble and insoluble carbohydrate (Crocker and Barton, 1957; Rao et al., 1965; Oke, 1967; Abdel Rahman, 1982; Woodroof, 1983).

The chemical composition of groundnut seeds has been evaluated in relation to protein level (Young and Hammons, 1973), amino acid composition (Young et al., 1973) and fatty acid composition (Grosso and Guznam, 1993) in some countries. With increasing consumer preference for high quality edible oils in Ghana and the desire to increase groundnut export to the world market, there is the need to investigate the quality of groundnut cultivars grown in the country and to improve the varieties to meet the market demand. This study sought to determine protein, oil, fatty acids, carbohydrate and minerals in the cultivars grown in the country to form the basis for further breeding activity for quality improvement and to inform end users which genotypes to select for their products.

MATERIALS AND METHODS

Characterisation of groundnut cultivars

Twenty groundnut varieties were collected from the Crops Research Institute (under the Council for Scientific and Industrial Research), Fumesua, Ghana and planted in May, 2004 to determine their subspecies. The varieties were grouped into two subspecies according to their branching pattern, presence or absence of flowers on main stem, flower arrangement on leaf axils: (1) *hypogaea* (Virginia market types) and (2) *fastigiata* (Spanish and Valencia market types). Cultivars with flowers on the main stem, sequential branching and flowering were grouped into subspecies *fastigiata* and those without flowers on the main stem, alternative branching pattern and alternate flowering were grouped into *hypogaea* subspecies category (Krapovickas and Gregory, 1994). Days to 50% flowering, days to maturity and pod yields were taken. Sound mature kernels were handpicked after drying and sent to International Crops Research Institute for the Semi Arid Tropics (ICRISAT) in Patancheru, India for analyses of protein, soluble sugars, oil, and fatty acids.

Oil content

Oil content was determined using a commercial nuclear magnetic resonance spectrometer as described by Jambunathan et al. (1985). All readings were taken on oven–dried (110°C 16 h) samples and the values were expressed on a uniform 5% seed moisture content basis.

Crude protein and total soluble sugars

The protein content was determined with a Technicon Autoanalyser (Pulse Instrumentation Ltd, Saskatoon, SK) (Singh and Jambunathan, 1980). Total soluble sugar was extracted with hot aqueous ethyl-alcohol and the sugar treated with phenol sulphuric acid as described by Dubois et al. (1956) with slight modifications. Starch content of defatted flour was determined by Southgate (1976) and Dubois et al. (1956) methods. All analyses were conducted in duplicate.

Mineral elements

The dry ashing method was used. Defatted groundnut samples (0.5 g) were weighed into a crucible and ashed in a muffle furnace at 600°C for 4 h. The ash was cooled and dissolved in dilute HCl (HCl:glass distilled water 1:3, v/v) and a few drops of concentrated nitric acid added. The crucible was kept on a hot sand bath and boiled. The content was allowed to cool and transferred to 50 ml volumetric flask and the volume made up to the 50 ml mark with glass distilled water. The above solution was used for the estimation of Zn, Cu, Fe and Mn. For Na, K and Mg, 1 ml of the aliquot was diluted to 25 ml after adding 0.5 ml of a solution containing 50,000 ppm Lanthanum (Lanthanum chloride was added for the suppression of interference). For Ca, the steps for K, Na and Mg were followed except that instead of using 1 ml for dilution, 5 ml was used. The solutions were sprayed into atomic absorption spectrophotometer to determine the concentrations of the various elements with suitable standards. Data analyses were carried out with GenStat (version 5).

RESULTS AND DISCUSSION

Days to 50% flowering differed from 26 to 29 days, days to maturity 88 to 106 days. There was significant difference ($p<0.05$) in grain yield (Table 1). Grain yields were general low. Significant differences ($p<0.01$) were observed among the 20 cultivars for oil, crude protein and carbohydrate (Table 2). Oil content ranged from 33.6 to 54.95%. The mean oil content of Virginia types were slightly higher (49.7%) than the Spanish types (47.3%). The previous composition studies in groundnut reported Virginia varieties had higher oil content than Spanish types (Dwivedi et al., 1993), which is comparable with the present study. Crude protein of seed ranged from 18.92 to 30.53%. Seed protein content of most of the cultivars was higher than cowpea which contains about 24% seed protein (IITA, 1989).

Cowpea and groundnut are the major protein sources to the poor and rural dwellers. Broni fufuo had the highest crude protein content (30.53%) while Sinkazie had the least (18.92%). The results also demonstrate that groundnut is a valuable source of protein for improving the nutrition of humans and farm animals. Broni Fufuo had unusually low oil content (33.65%) and higher crude protein content. With the increasing demand for products with less fat and oil, this variety can be used for products which require low oil and high protein content. Cultivars with oil content more than 50% could be used as donors in breeding programmes to improve the oil content of lines with low oil content. Carbohydrate differed between 19.02 and 27.16% with a mean of 23%. Carbohydrate content ranging from 6.0 to 24.9% was reported by Duke (1981) in groundnut. There were significant ($p<0.01$) differences in potassium, sodium, calcium and magnesium

Table 1. Days to 50% flowering days to maturity and grain yield (kg ha^{-1}) of the 20 groundnut Ghanaian landraces.

Variety	Subspecies	Day to 50% flowering	Days to maturity	Pod yield (kg ha^{-1})
1. Dagomba	Hypogeae	29	98	948
2. F-Mix	,,	29	100	861
3. Nkatepa	,,	28	98	748
4. Manipinta	,,	28	106	864
5. Sinkazie	,,	29	106	951
6. Kumawu early	,,	29	96	765
7. Nkate kokoo	,,	27	98	815
8. Baasare	Fastigita	26	92	686
9. Broni nkatee	,,	26	90	853
10. Afu	,,	28	92	921
11. Nkoranza local	,,	27	96	798
12. Atebubu local	,,	28	92	680
13. Aprewa	,,	28	90	903
14. Kintampo local	,,	27	92	1045
15. Shitaochi	,,	26	90	1038
16. Broni	,,	27	94	841
17. Kamaloo	,,	28	90	906
18. Kofi Nsarko	,,	26	94	639
19. Kowoka	,,	27	96	943
20. Broni fufuo	,,	26	88	575
Mean		28	95	839
Cv (%)		5.2	10.6	12.8
SED		0.48	2.3	55.8

Table 2. Protein, carbohydrate and oil content (%) of whole kernel in 20 groundnut varieties.

Variety	Botanical group	Protein	Carbohydrate	Oil
1. Dagomba	Hypogeae	22.87	21.18	50.50
2. F-Mix	,,	24.77	26.48	43.00
3. Nkatepa	,,	22.76	23.02	49.30
4. Manipinta	,,	25.78	19.28	48.60
5. Sinkazie	,,	18.92	24.90	52.30
6. Kumawu early	,,	23.71	22.85	49.50
7. Nkate kokoo	,,	20.63	19.02	54.95
8. Baasare	Fastigiata	26.00	21.53	49.05
9. Broni nkatee	,,	27.86	24.72	45.80
10. Afu	,,	27.71	21.27	46.15
11. Nkoranza local	,,	25.76	23.63	47.60
12. Atebubu local	,,	21.15	21.89	52.20
13. Aprewa	,,	24.87	21.61	48.30
14. Kintampo local	,,	24.75	20.86	48.75
15. Shitaochi	,,	20.09	19.83	54.65
16. Broni	,,	26.50	24.78	46.20
17. Kamaloo	,,	29.80	22.91	44.25
18. Kofi Nsarko	,,	22.21	21.96	49.05
19. Kowoka	,,	26.68	20.94	48.80
20. Broni fufuo	,,	30.53	27.16	33.60
Mean		23.67	23.0	48.88
Cv (%)		1.50	0.46	1.0
SED		0.50	0.34	0.50

Table 3. Zinc, Copper, Iron and Manganese content in defatted samples of 20 groundnut varieties (mg/100 g).

Variety	Sub-species	Zinc	Copper	Iron	Manganese
1. Dagomba	Hypogeae	6.1	1.9	2.9	1.9
2. F-Mix	,,	4.4	1.9	2.0	1.9
3. Nkatepa	,,	5.0	2.1	3.5	1.5
4. Manipinta	,,	5.0	2.4	3.0	2.9
5. Sinkazie	,,	5.1	2.1	2.0	2.2
6. Kumawu early	,,	6.2	2.4	3.2	2.2
7. Nkate kokoo	,,	6.5	2.0	2.4	2.1
8. Baasare	Fastigiata	5.8	2.2	3.6	2.2
9. Broni nkatee	,,	5.4	1.7	3.2	2.1
10. Afu	,,	5.3	1.7	3.3	2.2
11. Nkoranza local	,,	6.0	1.8	3.7	2.4
12. Atebubu local	,,	5.9	1.9	2.6	2.5
13. Aprewa	,,	5.3	1.7	2.7	1.9
14. Kintampo local	,,	0	0	0.2	2.1
15. Shitaochi	,,	5.4	2.7	3.7	2.6
16. Broni	,,	6.3	2.2	3.7	1.9
17. Kamaloo	,,	5.0	1.7	3.3	1.7
18. Kofi Nsarko	,,	4.9	2.1	2.6	1.8
19. Kowoka	,,	4.9	1.8	2.4	1.8
20. Broni fufuo	,,	5.6	2.2	2.6	1.9
Mean		5.2	1.9	2.8	2.1
Cv (%)		2.6	2.7	2.9	1.6
SED		0.3	0.1	0.2	0.07

(Table 3). Potassium content ranged from 1180 to 1693 mg/100 g, sodium ranged from 19 to 40 mg/100 g, calcium ranged from 44 to 134 mg/100 g and magnesium ranged from 308 to 456 mg/100 g. The range of K, Na and Mg in the 20 cultivars was generally higher than the results of other workers (Oke, 1967; Derise et al., 1974; Galvaro et al., 1976; Khalil and Chughatai, 1983). They found the following ranges: 92-200 mg Ca, 10-343 mg Mg, 1.4-33.3 mg Na, 1150-1450 mg K per 100 g. This might be due to the limited quantity of genotypes these researchers studied and which probably came from small geographic areas. Screening of genotypes from more botanical groups and from different locations will give a better picture. The level of calcium was within the range given by the above workers

Zinc ranged from 0 to 6.5 mg/100 g with a mean of 5.2 mg/100 g. Copper differed from 0 to 2.7 mg/100 g with a mean 1.9 mg/100 g. Iron ranged from 0.2 to 3.7 mg/100 g with a mean of 2.8 mg/100 g (Table 4). Manganese ranged from 1.7 to 2.9 mg/100 g with a mean of 2.1 mg/100 g. All the varieties had appreciable amounts of zinc, copper, iron and manganese, except “Kintampo local” which had no Zinc and copper. The results agree with results of several workers (Oke, 1967; Derise et al., 1974; Galvaro et al., 1976; Khalil and Chughatai, 1983). The amounts of micronutrients in the cultivars were nutritionally significant, because small quantities are needed by the body. Khalil and Chughatai, (1983) observed that the amount of copper in 100 g of roasted groundnut seed is enough for the daily requirement of human beings. Derise et al. (1974) noted that roasting groundnut does not lead to reduction in the levels of mineral elements but rather increases the levels since volatile compounds are lost through heating, except sodium where a small reduction was observed. Significant diversity exists in the groundnut varieties used for the study and offers the possibility of selecting genotypes with desire attributes for use in the breeding programmes.

Conclusion

Significant genetic variations were observed for the quality attributes studied among the groundnut varieties. This would not only form the basis of selecting parents with desirable attributes for breeding programme but also guide groundnut users the right varieties to choose for their products.

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Table 4. Potassium, sodium, calcium and magnesium content in defatted sample of 20 groundnut varieties (mg/100 g).

Variety	Sub-species	Potassium	Sodium	Calcium	Magnesium
1. Dagomba	Hypogeae	1495	33	118	385
2. F-Mix	,,	1610	31	78	308
3. Nkatepa	,,	1493	26	91	343
4. Manipinta	,,	1360	25	59	354
5. Sinkazie	,,	1693	28	75	388
6. Kumawu early	,,	1349	25	68	373
7. Nkate kokoo	,,	1478	35	88	359
8. Baasare	Fastigiata	1216	23	55	349
9. Broni nkatee	,,	1286	40	86	349
10. Afu	,,	1183	29	53	325
11. Nkoranza local	,,	1354	19	76	384
12. Atebubu local	,,	1458	24	134	456
13. Aprewa	,,	1180	20	71	390
14. Kintampo local	,,	1193	24	96	420
15. Shitaochi	,,	1374	48	131	405
16. Broni	,,	1188	29	80	325
17. Kamaloo	,,	1306	26	48	320
18. Kofi Nsarko	,,	1313	29	61	411
19. Kowoka	,,	1344	28	44	336
20. Broni fufuo	,,	1310	29	60	390
Mean		1359	29	78	364
Cv (%)		1.1	2.3	3.3	1.1
SED		32	1.5	5.7	9.3

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