Full Length Research Paper

Nutrients content and lipid characterization of seed pastes of four selected peanut (*Arachis hypogaea*) varieties from Ghana

Guy Eshun[1]*, Emmanuel Adu Amankwah[2] and John Barimah[2]

[1]Department of Home Economics Education, Faculty of Science Education, University of Education, Winneba, Ghana.
[2]Department of Food Science and Technology, Faculty of Biosciences, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana.

The proximate nutrients, calorific value, mineral nutrients and lipid characteristics of the seed pastes of four (4) peanut (*Arachis hypogaea*) varieties namely: *Sinkarzie*, *F-mix*, *JL 24* and *Manipintar* were investigated. Crude protein values ranged between 23.62% (±0.34) in *Sinkarzie* to 28.88% (±0.24) in *JL 24*. Crude fat ranged between 38.11% (±0.47) in *JL 24* to 48.79% (±0.20) in *Sinkarzie*. Carbohydrate content ranged between 11.54% (±0.18) for *Sinkarzie* to 19.65% (±0.55) in *JL 24*. The energy content in kCal/100 g sample ranged between 537.06 in *JL 24* to 581.54 in *Manipintar*. Calcium contents (mg/100 g) ranged between 23.14 (±0.49) in *Manipintar* to 128.25 (±2.90) in *F-mix*. At room temperature (25°C), all the oils from the four groundnut varieties were pale yellow coloured liquids with nutty odour. Saponification value (mg KOH/g oil) ranged from 144.70 (±0.63) in *JL 24* to 208.97 (±0.58) in *Sinkarzie*. Iodine value (mg/100 g) ranged from 79.10 (±0.15) in *Sinkarzie* to 86.93 (±0.26) in *F-mix*. Percentage free fatty acids (% FFA) ranged from 8.09% (±0.20) in *Manipintar* to 14.21% (±0.10) in *F-mix.* The results indicate that while the groundnut seeds could be used in fighting malnutrition, the oils obtained from the seeds could also be used for domestic and industrial purposes.

Key words: Ghana, peanut, proximate analysis, lipid characterization.

INTRODUCTION

Groundnut is a major annual oilseed crop and a good source of protein (Asibuo et al., 2008). The oil is mainly used as cooking oil and for the production of soap, margarine and cosmetics (Ong et al., 1995 as cited by Anyasor et al., 2009). Literature has reported many health benefits associated with the consumption of peanuts including cancer inhibition (Awad et al., 2000 as cited by Adjou et al., 2013).

To improve the nutritional quality of cereal-based traditional diets in Africa, the use of peanut flour as a protein supplement has often been suggested (Singh and Singh, 1991). Peanut can be roasted or fried to serve as a snack and the paste is used as margarine or butter (Atasie et al., 2009). The paste is also used as a thickener in soups and stews. It can also be consumed in the form of peanut cake (*kulikuli*) which is made from peanut after oil extraction (Adjou et al., 2012). Peanut 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 majority of people. The seed has several uses as 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

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*Corresponding author. E-mail: guyeshun@gmail.com. Tel: + 233 24 7261794.

considerable amounts of mineral elements to supplement the dietary requirements of humans and other farm animals (Asibuo et al., 2008).

The chemical composition of groundnut seeds has been evaluated in some countries. However, studies on the chemical composition of groundnut cultivars grown in Ghana have not been conducted (Asibuo et al., 2008). This study was therefore carried out to find the chemical composition of the seeds and the physicochemical properties of the oils of four (4) peanut (*A. hypogaea*) varieties namely: *Sinkarzie*, *F-mix*, *JL 24* and *Manipintar* to enable peanut users make an informed decision for a specific use for the peanut variety they have.

MATERIALS AND METHODS

Source of raw materials

The seeds of peanut used in this study were obtained from the Savannah Agricultural Research Institute, Tamale in the Northern region of Ghana. Four varieties of peanut (*Sinkarzie*, *F-mix*, *JL 24* and *Manipintar*) which were in their shells and stored at room temperature at the Savannah Agricultural Research Institute were collected for the study.

Sample analysis

Proximate nutrients determination

The peanut shells were removed and the seeds were milled with a laboratory miller (Tecator 1093 Sample mill, Sweden) and proximate nutrient analyses were carried out on the milled peanut sample.

Moisture content

Moisture content was determined by the method of the Association of Official Analytical Chemists (AOAC, 1990) by drying the sample in a thermostatically controlled oven to constant weight. Five grams (5.0 g) of the sample was accurately weighed into a previously cleaned, dried and weighed glass crucible. The crucible with its content was put into the oven at 103°C for 12 h. The sample was then cooled in a desiccator and weighed. The loss in weight expressed as a percentage of the initial weight of the sample gives the moisture content of the sample.

Ash content

Ash was determined by the method of Association of Official Analytical Chemists (AOAC, 1990). A 2.0 g sample was weighed into a previously dried and weighed porcelain crucible. The crucible with its content was placed in a furnace preheated to 600°C for 2 h. The sample was allowed to cool in the furnace to 250°C. The crucible and the ash were then transferred into an oven at 100°C for 30 min cooling. After this period, the crucible with its content was cooled in a desiccator. The crucible with its content was weighed. The weight of the ash was expressed as a percentage of the initial weight of the sample.

Crude protein content

Crude protein was determined by the method of the Association of

Official Analytical Chemists (AOAC, 1990). Two grams (2.0 g) of the sample was weighed into a digestion flask and 0.5 g of selenium catalyst was added. Twenty five (25) ml of concentrated H_2SO_4 was added and the flask was shaken to mix the contents. The flask was then placed on a digestion burner for 8 h and heated until the solution turned green and clear. The sample solution was then transferred into a 100 ml volumetric flask and made up to the mark with distilled water.

Twenty five millilitres (25 ml) of 2% boric acid was pipetted into a 250 ml conical flask and two drops of mixed indicator (20 ml of bromocresol green and 4 ml of methyl red) solution was added; and into the decomposition chamber of the distillation apparatus was added 15 ml of 40% NaOH solution. Ten millilitres (10 ml) of the digested sample solution was then introduced into a Kjedahl flask. The condenser tip of the distillation apparatus was then dipped into the boric acid contained in the conical flask. The ammonia in the sample solution was then distilled into the boric acid until it changed completely to bluish green. The distillate was then titrated with 0.1 N HCl solution until it became colourless. The percent total nitrogen and crude protein were calculated using a conversion factor of 6.25.

Crude fat content

Crude fat was determined based on the Sohxlet extraction method of AOAC (1990). A 250 ml quickfit round bottom flask was washed and dried in an oven at 103°C for 25 min and allowed to cool to room temperature before it was weighed. Two grams (2.0 g) of the sample was weighed into a muslin thimble. This was inserted into the extraction column with the condenser connected. Two hundred millilitres (200 ml) of the extracting solvent (petroleum ether, boiling point 40 to 60°C) was poured into the round bottom flask and fitted into the extraction unit. The flask was then heated with the aid of electrothermal heater at 60°C for 2 h.

Losses of solvent due to heating were checked with the aid of the condenser so that it cooled and refluxed the evaporated solvent. After extraction, the thimble was removed and the solvent salvaged by distillation. The flask containing the fat and residual solvent was placed on a water bath to evaporate the solvent followed by a further drying in an oven at 103°C for 30 min to completely evaporate the solvent. It was then cooled in a desiccator and weighed. The fat obtained was expressed as a percentage of the initial weight of the sample.

Crude fibre content

Crude fibre was determined by the method of the Association of Official Analytical Chemists (AOAC, 1990). The defatted sample (from crude fat determination) was transferred into a 750 ml Erlenmeyer flask and 0.5 g of asbestos was added. Two hundred millilitres (200 ml) of boiling 1.25 % H_2SO_4 was added and the flask was immediately set on a hot plate and condenser connected to it. The content was brought to boil within 1 min and the sample was digested for 30 min.

At the end of the 30 min, the flask was removed and the content was filtered through a linen cloth in a funnel and subsequently washed with boiling water until the washings were no longer acidic. The sample was washed back into the flask with 200 ml boiling 1.25 % NaOH solution. The condenser was again connected to the flask and the content of the flask was boiled for 30 min. It was then filtered through the linen cloth and thoroughly washed with boiling water until the washings were no longer alkaline. The residue was transferred to a clean crucible with a spatula and the remaining particles washed off with 15 ml ethanol into the crucible.

The crucible with its content was then dried in an oven overnight and cooled in a desiccator and weighed. The crucible with its content was then ignited in a furnace at 600°C for 30 min, cooled and reweighed. The loss in weight gave the crude fibre content

and was expressed as a percentage of the initial weight of the sample.

Carbohydrate content

Total percentage carbohydrate was determined by the different method as reported by Onyeike et al. (1995). This method involves adding the total values of crude protein, crude fat, crude fibre, moisture and ash constituents of the sample and subtracting it from 100. That is:

Percentage carbohydrate = 100 - (% moisture + % ash + % crude protein + % crude fat + % crude fibre)

Minerals determination

Calcium, iron and magnesium

Calcium, iron and magnesium were determined by Atomic Absorption Spectrophotometry (Agte et al., 1995). One gram (1 g) of the sample was dry ashed in a muffle furnace at 550°C for 5 h until a white residue of constant weight was obtained. The minerals were extracted from the ash by adding 20.0 ml of 2.5% HCl, heated to reduce the volume to 7.0 ml, and this was transferred quantitatively to a 50 ml volumetric flask. It was diluted to the mark (50 ml) with distilled water, stored in clean polyethylene bottles and magnesium content determined using atomic absorption spectrophotometer.

Phosphorus

The phosphorus determination was done based on the method described by Jackson et al. (1974). Two grams of the sample was ashed in muffle furnace preheated to 600°C for 2 h. The ash was dissolved in 5 ml of 5 M H_2SO_4. Four milliliters (4 ml) of 2% ascorbic acid and 4 ml of 4% ammonium molybdate were added to the resulting solution and shaken for uniform mixing. The absorbance of each sample was determined with a UV spectrophotometer.

Characterization of peanut oil

Extraction of peanut oil

The peanut seeds were milled with a laboratory miller (Tecator 1093 Sample mill, Sweden) and dried to constant weight in a thermostatically controlled oven at 105°C. The dried paste was transferred into a thimble and oil extraction carried out using petroleum ether with Soxhlet apparatus. The extracting solvent (petroleum ether) was evaporated leaving the concentrated oil sample for analysis.

Physical parameters of peanut oil

Colour and state of the oils

At room temperature (25°C), all the oils from the four peanut varieties were liquids with nutty odour. They were pale yellow coloured liquids. They were bright and clear with a light consistency.

Specific gravity

Specific gravity of the oil was determined according to AOCS method Cc 10a-25 (1993). The specific gravity bottle was placed in a water bath maintained at 25°C and filled with distilled water. It was removed, wiped dry (outside the bottle) and weighed. The bottle was emptied, dried and again placed in water bath at 25°C. The bottle was refilled with the oil and made to stay in the water bath for 30 min. It was then removed, cleaned and wiped (outside the bottle) completely dry and weighed. The specific gravity at 25°C was calculated as follows:

Specific gravity at 25/25°C $=$

$$\frac{weight\ of\ bottle\ and\ oil\ at\ 25°C\ - weight\ of\ bottle\ at\ 25°C}{weight\ of\ bottle\ at\ 25°C}$$

Refractive index

Refractive index of the oil was determined according to the AOCS method Cc 7-25 (1993). Several drops of the oil were placed on the lower prism of an Abbe refractometer (Model: Bellingham + Stanley Limited, 60/70 ABBE Refractometer, England) which was also adjusted to the same temperature as that of the sample. The prisms were closed and tightened firmly with the screw head, ensuring that the sample came to the same temperature of the instrument. The instrument was adjusted until the most distinct reading possible was obtained and the refractive index read.

Chemical parameters of groundnut oil

Percentage free fatty acid

Percentage free fatty acid was determined using the recommended method of the American Oil Chemists' Society (AOCS, 1993). One point four grams (1.4 g) of oil was weighed into a flask containing 15 ml of hot neutralized alcohol and 0.4 ml of phenolphthalein indicator was then added. The content was titrated with 0.5 N NaOH. Percentage free fatty acid value was calculated (as oleic acid) using the formula:

$$FFA\ (as\ oleic) = \frac{V \times N \times 28.2}{W}$$

Where, V = volume (ml) of NaOH solution, N = normality of NaOH solution, W = weight of oil sample.

Iodine value

Iodine value was determined according to AOCS method (1993). An amount of 0.2 g of the oil was accurately weighed into a 500 ml flask. Fifteen millilitres (15 ml) of carbon tetrachloride was added to the sample and swirled to ensure that the sample completely dissolved in it. Twenty five millilitres (25 ml) of Wij's solution was then pipetted into the flask containing the sample. The flask was stoppered and swirled to ensure complete mixing.

The sample was then placed in the dark for 30 min at room temperature. The flask was removed from storage and 20 ml of 10% KI solution added, followed by 150 ml of distilled water. The mixture was titrated with 0.1 N $Na_2S_2O_3$ solution, adding gradually and with constant and vigorous shaking until the yellow colour had almost disappeared. One and half millilitres (1.5 ml) of starch indicator solution was added and the titration was continued until the blue colour disappeared. A blank determination was conducted simultaneously.

The iodine value was calculated using the formula:

$$Iodine\ value = \frac{(B - S) \times N \times 12.69}{Weight\ of\ oil}$$

Table 1. Proximate and energy composition of raw peanut (fresh weight basis).

Constituent	Sinkarzie	F-mix	JL 24	Manipintar
Moisture (%)	7.54[bc] (±0.39)	8.99[a] (±0.61)	7.99[b] (±0.15)	7.13[c] (±0.05)
Ash (%)	2.96[a] (±0.09)	2.45[c] (±0.02)	2.68[b] (±0.05)	2.77[b] (±0.10)
Crude protein (%)	23.62[d] (±0.34)	25.51[c] (±0.14)	28.88[a] (±0.24)	26.71[b] (±0.26)
Crude fat (%)	48.79[a] (±0.20)	47.56[b] (±0.36)	38.11[d] (±0.47)	46.71[c] (±0.32)
Crude fibre (%)	5.55[a] (±0.06)	3.25[b] (±0.06)	2.69[d] (±0.06)	3.10[c] (±0.04)
Carbohydrate (%)	11.54[d] (±0.18)	12.24[c] (±0.29)	19.65[a] (±0.55)	13.58[b] (±0.06)
Energy (kCal/100 g)	579.72[a] (±1.84)	579.07[a] (±3.97)	537.06[b] (±2.62)	581.54[a] (±1.71)

Values are means ± standard deviations of triplicate determinations. Values in the same row having the same superscript letters are not significantly different (p > 0.05).

Where, B = blank titre value, S = sample titre value and N = normality of $Na_2S_2O_3$.

Saponification value

Saponification value was determined according to AOCS (1993). Two grams (2.0 g) of the oil was weighed into a flask. Twenty five millilitres (25 ml) of alcoholic KOH was pipetted and allowed to drain for about 1 min into the mixture. A blank determination was prepared and determined simultaneously with the sample. A condenser was connected to the flask and the mixed sample was allowed to boil gently and steadily for 45 min for complete saponification. The flask and condenser were then cooled but not sufficient to form a gel. The condenser was disconnected and 1 ml of phenolphthalein indicator was added to the content of the flask. The solution was titrated with 0.5 N HCl until the pink colour just disappeared. The saponification value was calculated using the formula:

$$Saponification\ value = \frac{(B - S) \times 56.1 \times N}{weight\ of\ oil\ sample}$$

Where, B = Blank titre value, S = sample titre value and N = normality of HCl.

Statistical analysis

All determinations were done in triplicates and the data analyzed by analysis of variance (ANOVA) at 5% level of significance using the programme ASSISTAT Version 7.5 beta (2011). Means were separated using the Duncan's multiple range statistical test.

RESULTS AND DISCUSSION

Proximate nutrients composition and calorific values of peanut

Table 1 presents results of proximate analyses and calorific (energy) values of raw peanuts. The moisture contents of the peanut varieties ranged from 7.13% (±0.05) in *Manipintar* to 8.99% (±0.61) in *F-mix*. Significant differences (p < 0.05) were observed among the four peanuts varieties for moisture content. Ash was highest in *Sinkarzie* with a value of 2.96% (±0.09) and lowest in *F-mix* with a value of 2.45% (±0.02). *JL 24* and

Manipintar did not differ significantly (p > 0.05) in ash contents. However, the ash contents of *JL 24* and *Manipintar* differed significantly (p < 0.05) from the other peanut varieties. The ash content obtained fell within the range of ash content for nuts (0.8 to 3.5%) (Aurand et al., 1987 as cited by Nagre et al. (2012). Crude protein values for the four peanut varieties ranged from 23.62% (±0.34) in *Sinkarzie* to 28.88% (±0.24) in *JL 24*. The values obtained fell within the range of crude protein values (18.92 to 30.53%) for groundnut given by Asibuo et al. (2008).

The values for crude protein obtained are in close agreement with the value of 26.40% obtained by Onyeike and Oguike (2003). The figures are however lower than the 33.88% reported by Adjou et al. (2013). The crude protein content of the peanut varieties differed significantly (p < 0.05) from each other. *Sinkarzie* had the highest crude fat content of 48.79% (±0.20) and *JL 24* had the lowest crude fat content of 38.11% (±0.47). All four peanut varieties were significantly different (p < 0.05) in their crude fat contents. The crude fat values obtained lie within the range of crude fat values between 33.6 to 54.96% reported by Asibuo et al. (2008).

The fat content is important in diets as it promotes fat soluble vitamin absorption. It is a high energy nutrient and does not add to the bulk of the diet (Atasie et al., 2009). The high crude fat values obtained give indication that the peanut varieties could be used in improving palatability of foods in which they are incorporated. The high crude fat values also signify that these peanut varieties are viable sources of oil and will be suitable for commercial production of oil.

Crude fibre values for the peanut varieties ranged from 2.69% (±0.06) for *JL 24* to 5.55% (±0.06) for *Sinkarzie*. Crude fibre is a measure of the quantity of indigestible cellulose, pentosans, lignin and other components of this type present in food (Aurand et al., 1987). These fibres protect the body against colon cancer, diabetis and cardiovascular illnesses (Ponka et al., 2005). It provides bulk to food to relieve constipation (Appiah et al., 2011). Diet low in crude fibre is undesirable as it could cause constipation and such diets have been associated with diseases of the colon like piles, appendicitis and cancer

Table 2. Iron, calcium, magnesium and phosphorus contents of raw peanuts.

Constituent (mg/100 g)	Sinkarzie	F-mix	JL 24	Manipintar
Fe	2.71[d] (±0.03)	4.45[c] (±0.05)	6.72[b] (±0.25)	7.69[a] (±1.54)
Ca	47.96[c] (±1.34)	128.25[a] (±2.90)	85.46[b] (±2.49)	23.14[d] (±0.49)
Mg	8.40[b] (±0.24)	8.46[a] (±0.43)	8.42[b] (±0.34)	7.57[c] (±0.54)
P	161.96[c] (±3.67)	433.09[a] (±4.26)	288.59[b] (±3.08)	78.14[d] (±2.13)

Values are means ± standard deviations of triplicate determinations. Values in the same row having the same superscript letters are not significantly different (p > 0.05).

(Atasie et al., 2009). All four peanut varieties differed significantly (p < 0.05) from each other in their crude fibre contents. The values of crude fibre obtained indicate that the peanut varieties have the ability to give bulk to foods in which they are incorporated to maintain gut distension for normal peristaltic movement of the gut. Carbohydrate values for the four peanut varieties ranged from 11.54% (±0.18) in Sinkarzie to 19.65% (±0.55) in JL 24. Carbohydrates are the main source of energy for all animals, including human beings. In most parts of the world, 80% of the kilocalories consumed by humans are in the form of carbohydrates (Mehas and Rodgers, 1997). The values of carbohydrate obtained suggest that peanuts could be used to manage protein energy malnutrition since it also contains good amounts of protein and fat. Values of carbohydrate obtained for the four peanut varieties differed significantly (p < 0.05) from each other.

Calorific value was highest in Manipintar with a value of 581.54 kCal/100 g (±1.71) and lowest in JL 24 with a value of 537.06 kCal/100 g (±2.62). Sinkarzie, F-mix and Manipintar did not differ significantly (p > 0.05) in their calorific values. These however differed significantly (p < 0.05) from the calorific value of JL 24. The high calorific values obtained indicate that peanuts could constitute a major source of energy for many of the world's poor and least privileged people.

Mineral composition of peanuts

The mineral (iron, calcium, magnesium and phosphorus) content of the peanuts are shown in Table 2. Mineral analysis showed a significant difference (p < 0.05) in iron contents among the four peanut varieties. Iron is an important element that is necessary in the haemoglobin of the red blood cells and myoglobin in the muscle (Thomas, 2002). According to Mehas and Rodgers (1997), iron is a vital part of red blood cells that carry and release oxygen. The values for iron ranged from 2.71 mg/100 g (±0.03) in Sinkarzie to 7.69 mg/100 g (±1.54) in Manipintar. Calcium contents ranged from 23.14 mg/100 g (±0.49) in Manipintar to 128.25 mg/100 g (±2.90) in F-mix. The calcium contents of the four peanut varieties differed significantly (p < 0.05) from each other. Calcium

is one of the main components of teeth and bones. It also plays a role in blood clotting (Mehas and Rodgers, 1997). Magnesium contents ranged from 7.57 mg/100 g (±0.54) in Manipintar to 8.46 mg/100 g (±0.43) in F-mix. These values differed significantly (p < 0.05) from each other except for Sinkarzie and JL 24 where there was no significant difference (p > 0.05) in magnesium contents. The magnesium contents of Sinkarzie and Manipintar significantly differed (p < 0.05) from the other peanut varieties. Magnesium is involved in making proteins and releasing energy, and helps hold calcium in the enamel of the teeth (Mehas and Rodgers, 1997). Magnesium helps in keeping the muscles relaxed and the formation of strong bones and teeth. It also helps to control blood pressure and is a nerve transmitter (Kolawole et al., 2007).

Phosphorus contents ranged from 78.14 mg/100 g (±2.13) in Manipintar to 433.09 mg/100 g (±4.26) in F-mix. All the peanut varieties differed significantly (p < 0.05) in phosphorus content from each other. Phosphorus is closely linked with calcium. The two minerals combine to form calcium phosphate, which give bones their strength and rigid structure (Mehas and Rodgers, 1997).

Physical parameters of peanut oil

The studied physical properties for peanut oil are presented in Table 3. At room temperature (25°C), all the oils from the four peanut varieties were liquids with nutty odour. They were pale yellow coloured liquids. They were bright and clear with a light consistency. The specific gravity of the oils at 25°C ranged between 0.89 (±0.00) for Sinkarzie and F-mix to 0.90 (±0.00) for JL 24 and Manipintar, indicating that the oils are less dense than water. The specific gravity values obtained are well in line with the observation of Singh and Singh (1991) who determined the density of peanut edible oil to be 0.885 g/ml. No significant difference (p > 0.05) was observed for the specific gravity values for the four peanut varieties. Refractive index at 25°C ranged between 1.459 (±0.00) for Manipintar to 1.461(±0.00) for F-mix. No significant difference (p > 0.05) was observed for the refractive indices for Sinkarzie and JL 24. The refractive

Table 3. Physical properties of peanut oil from four different peanut varieties.

Variety	Specific gravity (at 25°C)	Refractive index (at 25°C)	State at 25°C	Colour	Odour
Sinkarzie	0.89[a] (±0.00)	1.460[ab] (±0.00)			
F-mix	0.89[a] (±0.00)	1.461[a] (±0.00)			
JL 24	0.90[a] (±0.00)	1.460[ab] (±0.00)	Liquid	Pale yellow	Nutty
Manipintar	0.90[a] (±0.00)	1.459[b] (±0.00)			

Values are means ± standard deviations of triplicate determinations. Values in the same column having the same superscript letters are not significantly different ($p > 0.05$).

Table 4. Chemical indices of peanut oil.

Property	*Sinkarzie*	*F-mix*	*JL 24*	*Manipintar*
Saponification value (mgKOH/g oil)	208.97[a] (±0.58)	189.34[c] (±0.52)	144.70[d] (±0.63)	194.25[b] (±0.57)
% Free fatty acids (% FFA)	9.70[c] (±0.30)	14.21[a] (±0.11)	12.80[b] (±0.11)	8.09[d] (±0.21)
Iodine value (mg/100 g)	79.10[c] (±0.15)	86.93[a] (±0.26)	80.37[b] (±0.15)	86.61[a] (±0.26)

Values are means ± standard deviations of triplicate determinations. Values in the same row having the same superscript letters are not significantly different ($p > 0.05$).

indices for *Sinkarzie* and *JL 24* however differed significantly ($p < 0.05$) from the refractive indices for the other peanut varieties. The refractive indices obtained for the peanut varieties are close to the value of 1.449 reported by Atasie et al. (2009) for peanut oil. Refractive index is used as a measure of purity and a means of identification of fats and oils, since each substance has a characteristic refractive index (Nielsen, 1994). Studies have shown that refractive index increases by a value of 0.001 as rancid odour is noticeable (Rosell, 1984).

Chemical parameters of peanut oil

The chemical parameters of the studied oils are shown in Table 4. The results indicate that the iodine values ranged from 79.10 mg/100 g (±0.15) in *Sinkarzie* to 86.93 mg/100 g (±0.26) in *F-mix*. The iodine values obtained in this study are consistent with that obtained by other workers like Onyeike and Oguike (2003) who obtained iodine value of 87.6 mg/100 g for groundnut oil from raw groundnut seeds. Asibuo et al. (2008) indicated that the iodine values of groundnut oils studied from twenty (20) peanut varieties ranged from 85.77 to 98.43 mg/100 g. Since the iodine values of the peanut oils from this study fell below 100, they could be classified as non-drying oils and this non-drying attribute qualifies them to be used in the paint industry (Akubugwo and Ugbogu, 2007). The iodine values obtained in this study indicate that the oils contain appreciable level of unsaturated bonds. Studies have revealed that the higher the degree of unsaturation (high iodine value), the greater the tendency of the fat to go through oxidative rancidity (Joseph, 1977). The oils should therefore be stored in such a way as to protect

them from oxidative deterioration. The saponification values ranged from 144.70 mg KOH/g oil (±0.63) in *JL 24* to 208.97 mg KOH/g oil (±0.58) in *Sinkarzie*. Statistical analysis revealed a significant difference ($p < 0.05$) in saponification value for all the four peanut varieties. These saponification values indicate that the oils contain a large number of fatty acids of low molecular weight and hence useful in the soap industries and in the manufacture of lather shave creams (Onyeike and Oguike, 2003). The saponification value is only of interest if the oil is going to be used for industrial purposes as it has no nutritional significance (Asiedu, 1989).

Percentage free fatty acid (% FFA) ranged from 9.70% (±0.20) for *Sinkarzie* to 14.21% (±0.10) for *F-mix*. The statistical analysis revealed significant difference ($p < 0.05$) in percentage free fatty acid values for all the four peanut varieties. The free fatty acid value is used as a measure of oil deterioration. According to Bassir (1971), it is desirable that the free fatty acid content for a dietary lipid should lie within the limits of 0.0 to 3.0%. Free fatty acids (FFAs) are not present to any significant level in healthy plant cells but FFA levels of up to 15% (more in very bad cases) is usually found in commercial crude vegetable oils whether pressed or solvent extracted. These FFAs are present as a consequence of cell damage in vegetable tissue during harvesting, storage, transportation and must be removed during refining (Harmond, 1993 cited by Afolabi, 2008). This explains the very high % FFA values for the solvent extracted peanut oils which were studied. The oils were not refined after solvent extraction before carrying out the analysis of the oil. The physicochemical properties of the studied peanut oils indicate that the oils could be used for both domestic and industrial purposes.

Conclusion

The study has established the nutritive value of the peanut seeds which could be considered as good sources of protein and oil. They can therefore be used to fight against malnutrition, especially protein energy malnutrition. The study also identified peanut varieties with various quality attributes which could be used by manufacturers of peanut products to select the varieties with desirable quality attributes for their products. For soap-making, it will be beneficial to use the oil from *Sinkarzie* because of its high saponification number. When products which require high protein contents are to be developed, *JL 24* will be useful because of its high protein content. The presence of calcium, magnesium and phosphorus is good indication that the peanut varieties studied are rich in the minerals for bone formation. The studied chemical properties of the peanut oils indicated that the oils have potential for development for use as domestic and industrial oils. The oils are non-drying and this qualifies them to be used in the paint industry. The large saponification values obtained indicate that the oils will be useful in the soap industries and in the manufacture of lather shave creams.

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