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# Chemical composition and nutritive value study of the seed oil of Adenanthera pavonina L. (Fabaceae) growing in Democratic Republic of Congo

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**Abstract:** The seed oil of *Adenanthera pavonina* L. (Fabaceaea) collected in Kinshasa, Democratic Republic of Congo was analyzed for its proximate, lipids, mineral fatty acid and amino acid profiles, carbohydrate, mineral elements starch and fiber compositions. The mean values of various nutrients for proximate composition (%) were: moisture 7.36 ± 1.08%, crude proteins 31.04 ± 2.30, crude lipids or fats 11.03 ± 1.41, total fiber dietary 7.84 ± 0.04, carbohydrates 52.04 ± 1.06, starch 41.13 ±1.04. The calculated energy was 1953.60 kJ/100 g. These results indicated that the studied oil contained higher amounts of proteins, lipids, carbohydrates, ash, and starch compared with most of the commonly consumed legumes or seeds. Mineral elements (mg/100g) included: sodium (842.30), potassium (1284.22, iron (11.71, aluminium (9.65) and magnesium (4.63).The fatty acid profile revealed that linoleic acid was the most abundant fatty acid (52.6%) followed by oleic acid (18.7%), palmitic acid 7.5%) and gadolic acid (7.3%). The seed proteins of this oil contained higher levels of the essential amino acids such as arginine, leucine, lysine, phenylalanine and valine (4.5 to 11.5%) and non-essential amino acid such as glutamic acid, aspartic acid, glycine, proline and serine (4 to 23%). The comparison of these parameters with known oils showed that *A. pavonina* oil, to some extent, resembles oils that are processed for food and could be serve as a source of good edible oil for human and animal.

**Keywords**: *Adenanthera pavonina* L, amino acids, glucides, proteins, minerals, lipids.

## 1. Introduction

The developing countries know some problems related to the increase population pressure, amino acids, fats and protein depletion of nature source in their daily diet, poverty and low agricultural production. They do not produce enough food of the right nutritional reality needed by the population for their growth (1).

It is also well documented on the hunger and protein malnutrition. In these countries, the net effect of this protein deficit is manifested in the prevalence of various forms of protein calorie malnutrition (PCM) diseases such as Kuashiorkor, marasmus and mental deficiencies (2). Several reports have indicated protein deficiency as the common state of malnutrition mainly for children and infants in the developing countries, and mainly in the regions where diets are based on roots and tuber crops (3).

In view of the prevalent food shortages, attention is currently being focused on the exploitation and use of lesser known and traditional and non-traditional plant sources which are currently used by people (4, 5, 6, 7). Food legumes and seeds of some plant species constitute a major source edible of nutrients such as proteins, lipids, carbohydrates, mineral elements, fatty acids and amino acids, and other important substances such as fiber and vitamins (8) which have some importance for health human and animal.

Among the wild seeds, those of the genus *Adenathera pavonina* is widespread in tropical and sub-tropical areas of word and can be considered as an alternative nutrients source of animal and human diet. This plant is known as food tree because its seeds and young leaves are eaten by people. For this, seeds and leaves are roasted, eaten and are said to taste like soybean. The two plant parts are eaten in Melanesia and Polynesia and in Democratic Republic of Congo by some people. Nutritional study has previously proven one quarter the seed to be a oil source with high percentage of proteins without reference to other important nutrients present this oil (9). In addition, the seeds are known to have nourishing qualities and have combined to scatter the plant. (10, 11).

Although the physiochemical and composition of the seed oil of *A. pavonina* growing in other countries such Sri Lanka (12) and Nigeria (5) had been previously reported, there is very little information reported on its nutritional value in the literature. Thus, the present investigation is undertaken on the evaluation of the nutritive value of the seed oil of *A. pavonina* growing in Democratic Republic of Congo by the identification and quantification of some important chemical nutrients.

## 2. Materials and methods

### *2.1 Plant material*

Mature seeds of *A. pavonina* were collected in Kinshasa in September 2011. The plant was identified by Mr Nlandu of the Institut National d'Etudes et de Recherches en Agronomie (INERA), Faculty of Sciences, University of Kinshasa where a voucher specimen AP 00432011 was deposited in the herbarium of this institute.

### 2.2.–a: *Extraction of oil*

150 g of powdered seeds were submitted to a Soxhlet extraction with petroleum ether (1000 ml) for 1 h. The extract was filtrated and evaporated in vacuo yielding oil which become white translucent in solid state at room temperature (26.55 g, 17.70%).

### 2.2.–*b:Reagents*

Ethanol, methanol were of HPLC quality and purchased form Fisher Scientific UK Limited, Bishop Meadow Road, Loughborough, Leicestershire, LE11 5RG, UK. Petroleum ether, acetonitrile, n-hexane, diethyl ether and acetic acid were of HPLC grade and obtained from Acros Organics, New Jersey, USA. Standard amino acids included Aspartic acid, Glutamic acid, Alanine, Aspargine, Cysteine, Glutamine, Glycine, Histidine, Leucine, Lysine, Methionine, Phenylalanine, Proline, Serine, Threonine, Tyrosine and Valine in addition to the eluting solvents and derivatization agent were all purchased from Sigma Aldrich Laboratories, Seeize, Germany. Hightly purified water (milli-Q-Millipore) was used throught for preparation of all buffers and reagents. Addtionally, the internal standard l-norvaline was obtained from Sigma Chemicals Co (St Louis, MO, USA).

### *2.3. TLC analysis of lipids*

Total lipids from *A. pavonina* seeds were extracted by Soxhlet extraction using diethyl ether as solvent (13). They were analyzed by TLC on silica gel (Merck) plates (0.25 mm thickness layer) using benzene diethyl ether/*n*-hexane/acetic acid: 80:20:2 as mobile phase. The separated fractions of the total lipids were visualized by exposure the plates to iodine vapor after drying. All lipid fractions were identified on TLC by comparing their Rf values with those of known available lipid standards. For the quantitative analysis, different lipid fractions were scanned using Shimadzu TLC scanner (C-S-910). The area of each peach was measured by the triangulation method (14). The percentage of each class was calculated using the following formula:

% lipids = Area of each peach/Total peaks area x 100. (15)

***Fatty acids analysis***

***2.4.1. Sample preparation***

An amount of 7.1 g of oil was solubilized in 1 ml *n*-hexane. From this stock solution, 100 µL was transferred into a tube an *n*-hexane was evaporated under nitrogen to dryness. The dried residue was solubilized in 50 µL methanol, vortexed for 20 seconds for dissolution and, 50 µL of dimethylsilyldiazomethane 0.1 M in n-hexane was added. The mixture was vortexed for 20 seconds and then kept at 60°C for 30 minutes. After cooling at room temperature, the solvent was evaporated under nitrogen to dryness and the residue redissolved in 1 ml *n*-hexane which was transferred to a GC injection vial for analysis.

***2.4.2. GC-MS analysis***

It was performed on an Agilent 6890-5973 GC-MS apparatus operated in electron ionization (EI) mode, equipped with a DD-5 capillary column of 30 m x 0.25 mm x 0.25 µm (JC W Scientific), and a flame ionization detector. The ion source, quadrupole and interface temperatures were at 250, 150 and 300°C respectively. Helium was used as a carrier gas at constant flow (1.0 ml/min). The electron multiplier voltage was set at 2000 V. Once, 10 µL of the methylated sample was injected in pulsed split less mode (injector temperature 300°C, pressure pulse 20 psi, pulse time 4.50 min, splites time 1.50 min). The temperature of the DD-5 capillary column was programmed from 90°C (1.50 min) to 300°C at the sak of 5°C/min, stay for 10 min. Full scan EI spectra (m/z 50-750) were acquired during the whole analysis time. The fatty acids were identified by their m/z compared to those reported in the literature (16).

***2.5. Determination of proteins and carbohydrates***

This was carried out by determining nitrogen content by the standard micro-Kjedahl method using a digestion apparatus (Kjeldathern System KT 40) and titration system (17), Crude protein content was calculated as N% x 6.25.

For carbohydrates, proteins were removed from the ethanolic solution of the oil after treatment with lead acetate. Carbohydrates were determined using the anthron method as follows: 1 ml of the treated oil as described above was incubated with 5 ml anthron solution (0.12 g anthron in 100 ml 6.5 M $H_2SO_4$) at 90°C for 10 min. The absorbance of the green product resulting was measured at 630 nm. Glucose equivalents were calculated from a standard curve obtained with pure analytical grade glucose. The identification of individual sugars was made by TLC on silica gel plates (Merck, thickness layer 0.25 mm) using methanol/ ethyl acetate/ acetic acid/water (1:6:5:1. Sugars were identified by spraying the plates with a solution of 50% diphenylanine in aniline, 100 ml acetone and 15 ml phosphoric acid. Spots were revealed after heating plates at 110°C for 10 min. Glucose, rhamnose, galactose, sucrose and fructose with high analytical grades were used as reference sugars (18).

***2.6. Determination of amino acids*: *Derivatization and analysis***

Amino acids were determined according to the procedure previously described by Montano (19) briefly, dried sample (20 mg proteins) was hydrolyzed with 1 ml HCl 6 M in a glass tube and was put under nitrogen for 1 min to remove air. The hydrolysis was then carried out at 110°C for 24 h and then filtered through a 0.45 µm filter. An aliquot of 100 µL was evaporated to dryness under nitrogen. The dried residue was vortexed into 20 µL of 20 ml HCl 20 mM containing L-α-amino-*n*-butyric acid as an internal standard. The sample of amino acids was subjected to HPLC analysis after derivatization with 6-aminoquinolyl-N-hydroxysuccinimethyl carbonate (AQC). Then 60 µL of borate buffer 200 mM and 20 µL of ACCQ-Fluor reagent were added. The mixture was vortexed for 2 min. The vial was heated in a heating block at 550°C for 10 mim. For standard amino acids, 10 µL of the solution was combined with 70 µL of borate buffer and 20 µL of ACCQ-Fluor reagent. They were future treated in the same conditions described above. Then, 10 µL of sample and 5 µL of standard amino acid solutions were injected into HPLC.

The analysis of amino acids was conducted on a HPLC system with Muth λ fluorescence detector (Water, Milford, Massachussetts, USA) equipped with a $C_{18}$ column (4 µm x 150m x 3.90 mm) helded at 37°C, was used for the analysis (excitation at 250 nm and emission at 395 nm). The system of eluents Constituted with 3 solvents: A: acetate-phophate buffer, B: acetonitrile and C: Milli-Q-watter. The separation program was follows:
0 min A-100%, B-0%, C-0%; 0.5 min: A-99%, B-1%, C-0%; 18 min: A-95%, B-5%, C-0%; 19 min: A-91%, B-9%, C-0%, 29.5 min: A-83%, B-17%-C-0%; 33 min: A-0%, B-60%, C-40%; 36 min: A-100%, B-0%, C-0%. The HPLC peaks were identified by comparing the retention time data obtained from the standard amino acids or reported in the literature (20).

Sulfur containing amino acid were identified after performic acid oxidation as described by Moore (21) while tryptophan was colorimetrically determined after alkaline hydrolysis (4.2 M NaOH) according the method previously described by Basha and Roberts (22).

***2.7. Mineral analysis***

5 mg of *A. pavonina* seeds oil was incinerated at 450°C for 12 hrs in a moufle furnace. The acid digest was prepared by oxiding the sample with nitric/perchlori acids (2:1). Sodium (Na) and potassium (K) amounts were evaluated by flame photometer (Flame Photometer model-EEC). The minerals, such as calcium (Ca), magnesium (Mg), zinc (Zn), iron (Fe), copper (Cu) and manganese (Mn) were determined with an atomic absorption spectrophotometer (Perkin-Elmer Model 5000) while phosphorus (P) was determined by phosphovanado-molybdate (yellow) method according to AOAC (1990)(17). All mineral were quantified against standard solutions of known concentrations that were currently analyzed (23).

***2.8. Determination of starch and total dietary fiber* (TDF)**

The determination of total ash was carried out by heating 2 g of dried sample in a silica dish in a oven at 600 °C for 6 hours (17). Total dietary fiber (TDF) was estimated by the non-enzymatic-gravimetric method described by Li and Cardozo (24).

**Table 1. Proximate composition of seed oil of *Adenanthera pavonina***

| Components | Quantity (g/100 g) |
|---|---|
| Moisture | 7.36 ± 1.08 |
| Crude proteins | 31.04 ± 2.30 |
| Crude lipids or fats | 11.03 ± 1.41 |
| Total dietary fiber | 7.84 ± 0.04 |
| Carbohydrates | 52.04 ± 1.06 |
| Starch | 41.13 ± 2.65 |
| Free fatty acids | 1.46 ± 0.05 |
| Energy kJ/100 g | 1953.60 |

**Table 2. Composition and amounts of mineral elements (mg/100 g) identified in the oil of *A. pavonina* seeds.**

| Composés | *A. pavonina* | Graine de soya* |
|---|---|---|
| Ash (g/100 g) | 4.47 ± 1.04 | - |
| Sodium | 842.35 | 10.0 |
| Potasssium | 1284.22 | 192.0 |
| Iron | 1.71 | - |
| Copper | 2.04 | - |
| Zinc | 4.21 | - |
| Magnésium | 4.63 | 4.3 |
| Calcium | 04 | |
| Manganèse | 2.41 | - |
| Phosphourus | 5.02 | - |
| Aluminium | 9.65 | - |

* FAO (1982). Food composition tables for the Near East. Food and Nutrition paper 26, FAO/UN, Rome. -: not available.

**Table 3. Composition and amounts of crude proteins, crude lipids, free fatty acids and lipid classes in the oil of *A. pavonina* seeds.**

| **Classes** | **Quantity (%)** |
|---|---|
| Crude proteins | 31.04 ± 2.3 |
| Crude lipids | 11.03 ± 1.4 |
| Free fatty acids | 1.46 ± 0.02 |
| Phospholipids | 37.3 ± 1.7 |
| Monoglycérides | 1.3 ± 0.2 |
| Dithylglycerols | |
| 1,2-diglycerides | 0.6 ± 0.2 |
| 2 ,3-diglycerides | 0.4 ± 0.1 |
| 1,3-diglycerides | 0.3 ± 0.1 |
| Triclycerides | 34.6 ± 1.2 |
| Monoethylglycerols | 3.4 ± 0.4 |
| Stérols | 2.0 ± 0.6 |

**Table 4. Composition and amounts of fatty acids (%) identified in the oil of *A. pavonina* seeds**

| Fatty acids | ***A. pavonina*** | **Graine de Soya** |
|---|---|---|
| 1. Palmitic acid | 7.5 | 10.6 |
| 2. Margaric acid | 1.6 | - |
| 3. Linoleic acid | 52.6 | 53.7 |
| 4. Oleic acid | 18.7 | 23.3 |
| 5. Elaidic acid | 0.2 | - |
| 6. Stearic acid | 2.6 | 4.0 |
| 7. Unidentified acid | 0.8 | - |
| 8. Cis-10-nonadécanoïc acid | 1.4 | - |
| 8a. unidebtified acid | 0.3 | - |
| 8b. Unidentified acid | 0.1 | - |
| 9. Gadolic acid | 7.3 | - |
| 10. Arachidic acid | 0.6 | - |
| 10a. Unidentified acid | 0.1 | |
| 11. Erucic acid | 2.3 | - |
| 12. Behenic acid | 0.2 | 0.3 |
| 13. Nevornic acid | 2.2 | - |
| 14. Lignocéric acid | 2.7 | - |
| 14a. Unidentified acid | 0.2 | - |
| 14b. Unidentified acid | 0.1 | |
| 15. Cerotic acid | 0.2 | |
| 16. Myristic acid | - | 0.1 |
| 17. Palmitoleic acid | - | 0.1 |
| 18. Eicosadien acid | - | - |
| 19. Linolenic acid | - | |
| **Total fatty acids (TFA)** | **99.7** | |
| **Saturated fatty acids (SFAs)** | **16.2** | |
| **Insaturated fatty acids (USFAs)** | **83.5** | |

- not available or not identified.

**Table 5. Composition and amount of amino acids identified in *A. pavonia* seed oil**

| Amino acids | A. pavonina (%) | FAO/WHO | Enfant | Adulte |
|---|---|---|---|---|
| ***Essential amino acids*** | | | | |
| Arginine | 11.33 | | | |
| Histidine | 2.30 | 1.9 | 1.90 | 1.60 |
| Isoleucine | 3.94 | 2.8 | 2.80 | 1.30 |
| Leucine | 9.48 | 6.8 | 6.60 | 1.60 |
| Lysine | 4.54 | 5.8 | | |
| Methionine | 2.64 | 3.2 | | |
| Phenylalanine | 4.46 | 4.1 | | |
| Threonine | 1.70 | 3.4 | 3.40 | 0.90 |
| Valine | 3.53 | 3.5 | | |
| **Total** | **45.92** | | | |
| ***Non essential amino acids*** | | | | |
| Alanine | 3.57 | | | |
| Glutamic acid | 22.26 | | | |
| Aspartic acid | 8.76 | 2.5 | | |
| Cysteïne | 0.17 | | | |
| Glutamine | 1.70 | | | |
| Glycine | 4.84 | | 5.80 | 1.60 |
| Proline | 4.61 | | | |
| Serine | 5.10 | | | |
| Tyrosine | 4.52 | 6.3 | | |
| **Total** | **53.83** | | | |

*Requirement for children and adult according to FAO / WHO (1991) : Protein quality evaluation. Report of Joint FAO/WHO expert consultation. Food and Nutrition Paper, No. 51. Rome.

## 3. Results and discussion

The proximate composition of the seed oil of *A. pavonina* collected in Kinshasa (Democratic Republic of Congo) is presented in Table 1. The moisture of the oil was 7.36 ± 1.08 and was lower compared to that seen for other seed oils such as that from *Mucuna puriens* var. *utilis* white coloured seed coat (11.25 ± 0.11) and *M. deesingiana* (9.60 ± 0.04) (25), *Canavalia gladiata* whole seed and cotyledon oils (11.2 ± 0.04 and 10.5 ± 0.01 respectively) (26), and other seed oils from different plant species (27). It was however higher compared to that of cashew nut flour oil (5.7) (28), *Mangifera indica* seed oil (5.30 ± 0.05) and *Mucuna utilis* seed oil (6.02 ± 0.11) (29) and flected pumpkins seed oil (5-5.50 g/100 g) (30). The level of moisture was in close agreement with the reported mean values of moisture ranging between 7 to 11% for some legumes (Arkroyed and Doughty, 1964) (31).

Crude proteins (31.04 g/100 g) in this oil was lower compared to that found in soybean oil (36.70 g:100 g) and other edible oils such as watermelon seed kernel and pumpkin seed kernel flour oils (35.7 and 36.5 g/100g respectively, but higher than seen in Paprika seed oil (24.4 g/100 g) (7), cowpea, maize (23.1 and 8.9 g/100 g respectively), the pulse crops commonly consumed such as pigeon pea and chick pea (23-33 g/100 g) (32), cashew nut (25.25 ± 0.20 g:100 g) and some cultivated legume oils (33). The content was almost similar to that of *Pinus pinea* seed oil (31.6 g: 100 g) (34). In addition, regarding the recommended daily allowance from proteins for children ranges from 23.0-36.0 g and for adult 44-56 g, it can be considered that the seed oil of this plant can supply the recommended daily intake of this nutrient particularly for children. The protein quality is known as the nutritional value of a food depending on its amino acid content and on the physiological utilization of specific amino acids after ingestion, absorption and obligatory minimal rates of oxidation. The proteins are also well known as a source of amino acids and can play an important role in the organoleptic properties of food, and hence their nutritional quality can be evaluated basically by the content, proportion and availability of their amino acids (35).

Crude lipids or fats (18. 34g/100 g) was comparable to that of *A. pavonina* seed oil from Nigeria (17.99 g:100g) (5), but lower compared to that of soybean oil (20.10 g/100 g) and higher to that

of cowpea and maize (15.0 and 3.9 g:100 g respectively) . Fats are important in diet because they promote fat soluble vitamin absorption and are high energy nutrient.(36) Moreover, the effort to reduce the amount of calories consumed as fat in some countries such the United States accentuates the significance of understanding the lipid components of food (37).

To meet protein and lipid demands in developing countries where animal and human proteins and lipids are grossly inadequate and missing, more attention is being paid to less consumed protein and lipids sources such as legumes and seeds (38) which are considered as their source. The content of crude proteins and lipids of the studied seed oil suggested its usefulness as alternative source of both nutrients.

The total dietary fiber (TDF) of the oil was 7.84 ± 0.04 g/100 g and was found to be higher compared to that of *Dolichos tribalus, Vigna radiate* var. *Sublobata* and *V. unguiculata* sunsp. *Cylindica* and mean values of some edible legumes ranging from 5-6% (28). It is well known that the dietary fiber plays an important role in the maintenance of internal distention intestinal tract as its physiological effect. Adequate consumption of dietary fibers from a variety of foods will help the protection against colon cancer and also help normalize blood lipids, thereby reducing the risk of cardiovascular diseases. Fibers help prevent the constipation and diverticular diseases. It is an essential component of a well-balanced diet that will help minimize some common health problems. Some type of fibers can also slow D-glucose absorption and reduce insulin secretion, which is of great importance for nondiabetics as well (37). Thus, it is important to avoid consumption of poor foods in fibers.

Carbohydrate level obtained in the present study for the oil from *A. pavonina was* 52.0 ± 1.06 g/100 g. This level was favorably comparable with on acceptable range mean values of legumes, 20-60% of dry weight (31). The carbohydrate level was higher compared to that of *A. pavonina* seed oil from Nigeria and soybean (50.30 and 33.95 g/100 g respectively), *Mucuna utilis seed* oil (42.98 g/100g) (29), some clones of *Theobroma cacao* seed oil (1.3-13.4 g/100 g) and soybean oil (FAO, 1982 (5). Simple sugars identified by TLC on silicagel plates (Merck, thickness layer 0.25 mm) in the oil were glucose, fructose and sucrose in the presence of standards sugars. To our knowledge, the detection of simple sugars in *A. pavonina* seeds oil is reported here for the first time. The carbohydrate content gave an indication that the seed oil studied here can be considered as a rich source of energy and was able for supplying the daily energy requirements of the body in children and adult. On the other hand, carbohydrates are easily digested, they provide the necessary and need calories in the diet of most people, promote the use of dietary fats and reduce waste of proteins (29).

The present study revealed that the ash content of the *A. pavonina* seed oil was 4.1 ± 1.04 g/100 g and would be important to the extent that it contains nutritional mineral elements presented in Table 2. Moreover, the level of the ash of this oil was higher to that of *Mucuna utilis* sed flour (3.60 ± 0.01 g/100 g) (29), wartmelon seed kernel (3.60 g/100 g) and pumkin seed kernel (3.12 g/100 g) oils (7), *A. pavonina* seed oil from Nigeria, cowppea and maize oils (2.37, 3.4 and 1.2 g/100 g respectively) (5). It was however lower compared to that of *Mucuna deeringiana* (5.54 ± 0.04 g/100 g) and *M. pruriens* var. *utilis* balck coloured seed coat (2.12 ± 0.01 g/100 g) (25) and mngifera indica seed oil (67.9 ± 0.6). However, the level of the ash was favourably comparable to that of Paprika seed oil (4.32 g/100 g) (7) and *Mucuna pruriens* var. *utilis* white coloured seed coat (4.12 ± 0.09) (25). Moreover, Pomeranz and Chifton (39) have recommended that ash content in nuts, seeds and tubers should fall in the range of 1.5-2.5% in order to be suitable for animal feeds. That reported here is higher compared to the recommended values and suggested that this oil is a rich source of ash.

The starch content of the seed was found to be 41.13 ± 1.04 g/100 g comparable to that *A. pavonia* seed oil from Nigeria (41.95 g/100 g) (5). It was lower compared to that of *Mangifera indica* seed oil (94.4 ± 1.8 g/100 g) and higher to the starch level of *Canvalia gladiata* cotyledon and whole seed oils (36.02 ± 0.03 and 30.7 ± 0.01 g/100 g respectively) (26). The high level of the starch indicated that it is a good source of mineral elements presented in Table 2. As other sugars, the starch is known to be a source of energy in human body and various indispensable mineral elements (37)

The free fatty acids (FAs) of the studied oil, 1.51 ± 2.6%) was favorably comparable to that of *A. pavonina* seed oil from Nigeria (1.4%) and higher compared to that soybean oil (0.5%) (5). However, the presence of high FAs content may have resulted from the extraction method and storage conditions of the seed oil after harvest (40) and leads to take more precautions to avoid destruction or denaturation of the oil.

The calculated metabolizable energy was 1953.60 kJ/100 g and showed that this oil was a concentrated source of energy. According to Paul and Stanthgate (41) who had reported the energy of different cereals ranging from 1.3 to 1.6 Mj/100 g, the energy of the studied oil has energy

concentration higher compared to those of these cereals. In this context, protein quality and quantity are major concerns in human diets. This energy was comparable to that reported on *A. pavonia* seed oil from Nigeria (19.20 kJ/g or 1920kJ/100g (5). It was higher to that Mucuna utilis seed flour oil (1703.95 kJ:100g) (29), *Canavalia gladiata* whole seed flour and cotyledon flour oils (1108.2 and 1492.3 kJ/100 g), *Mucuna pruriens* var. *utilis* white coloured seed coat and balck coloured seed coat (1641.78 and 1652.8 kJ/100 g respectively) and M. deeringiana seed (15.90.39 kJ/100 g) oils.(25)

The levels of mineral elements (mg/100g) of the seed oil of *A. pavonina* studied here were shown in Table 2. Potassium (K) was found to be the most abundant element (1284.22 mg/100g). This was in agreement with other authors who had already demonstrated that this mineral element is abundant in some studied seed oils of some plant species and legumes.(42,26,7,5,28,23,29) This level of potassium was comparable with the Recommended Dietary Allowance value (RDA) of infants and children (< 1500 mg) in their daily diet (43). The high level of this mineral element in this oil as for other vegetal sources can be utilized beneficially in the diets of people who take diuretic medicines for the treatment of hypertension and suffer from excessive of K through the body fluid (44). Sodium (Na) was also found in an appreciable amount (842.35 mg/100g) in this studied seed oil. This mineral element is a macronutrient constituting 2% of the total mineral content of the human body. It is vital in maintaining the bood fluid volume, osmotic and acid-base equilibrium. The deficiency of Na occurs during hot wheater or as a result of heavy work in hot climate leading to take precautions in these regions (29). Other mineral elements are important in the human body although they were found in low amount in the seed oil of *A. pavonina* seed oil here and in the oils of other vegetals such as melon, pumpkin and grourd seeds (7,23,29,). The level of Na was favourably comparable to that of Na in seed oil of *A. pavonina* from Nigeria (5). Calcium, phosphorus, magnesium and manganese are involved in bone formation . These results revealed that the oil of A. pavonina seeds provide a sufficient amount of mineral elements to meet the human mineral requirement (43).

Neutral lipids from the seed oil of *A. pavonina* were dominated by phospholipids and triglycerides accounting for 37.3 ± 1.7 and 34.6 ± 1.2% respectively as predominant components. The significant amounts of diethylglycerides derivatives presented in Table 3 and were comparable to that of *Vigna radiate (*Desi chickpea) seed oil (23). The phospholid content was quite higher compared to that of other polar lipid components. Similar reports or findings had been previously described by El-Adawy and Taha, (7) on the nungbean seeds. The levels of monoglycerides and diglyceride derivatives were found to be higher compared to those of watermelon seed kernel, pupkin seed kernel and paprika seed oils having a mean value ranging from 0.35 to 1.35% (7). They were however lower to that of nungbean cultivar oil (5.6-9.3% (15). To our knowledge, this is the first report of some classes of lipids in *A. pavonina* seed oil. Like many other lipid-containing molecules, phospholipids can be broken down in the body and utilized for energy. They can be split by enzymes to form signaling molecules called chemokines, which are instrumental in regulating cellular migration, enzyme production and many other cellular processes. The fats taken in as part of the diet are triglycerides. They are also storage fats that keepted in adipose tissues for periods of fasting. Burned dietary triglycerides for energy and contain nine calories per gram. The triglycerides are also made from excess proteins and carbohydrates that are consumed. While the caloric content of saturated and unsaturated fat is identical, saturated fat is less heart healthy than unsaturated. The physiological significance of carbohydrates and lipids is well documented in the literature (45)

The composition and amounts of identified FAs in seed oil of *A. pavonina* are presented in Table 4.A total of fourtheen FAs were unambigously identified based mainly on their respective molecular ions (m/z) reported in the literature (16). They include 8 saturated fatty acids (SFAs) and 6 unsaturated fatty acids (UFAs) accouting for 57.14 and 42.85% respectively of the total FAs, but their amounts were found to be difference since the total amount of SFAs was lower compared to that of UFAS (Table 4). Palmitic acid (7.5%) was the abundant SFA followed by margaric acid and cis-10-nonadecanoic acid (1.4%). Linoleic acid was the dominating USFA (52.6%) followed by oleic acid (18.7%), gadolic acid (7.3%) and erucic acid (2.3%). These four USFAs represented 80.9% of the total amount of FAs and can explain the solid state taken immediately by the oil at room temperature. The level of other identified FAs ranged from 0.1 to 2.6% (Table 4).

From nutritional point au view, linoleic acid is required for the growth, physiological functions and maintenance. The activity of these prostaglandins Includes lowering of blood pressure and constriction of smooth muscle Its nutritional value is due to its metabolism at tissue levels which produce the hormone-like prostaglandins (46). In addition, the high amount of the essential FA linoleic acid suggests that it is highly nutritious due to its ability to reduce several cholesterol (23). From these observations, the predominance of linoleic acid

adds an extra dimension of the nutritional value of the seed oil of *A. pavonina*. The FA composition and high amount of UFAs make this oil as a special legume suitable for nutritional applications. The FAs composition of the present study was qualitatively comparable with some edible legumes such as *Cicer arientum*, *Vigna radiate* and *V. mungo* (47), *V. unguiculata* and *Praseolus* (23) and *A. pavonia* (5) seed *oils*. The antinutritional FA behenic acid was detected in the present study in low level of 0.2%. This acid was already detected in other plant species such as groundnut (48), winged bean (49); and *Entanda phraseoloides* oils. Its presence can not pose a problem for human health if the sample is properly processed. The importance of essential fatty acids in human health is well documented in the literature (50).

Table 5 shows the composition and amounts of amino acids (aas) identified in *A. pavonina* seed oil in the presence of amino acid standards. A total of 18 amino acids were unambiguously identified in the presence of amino acid standards. In the studied oil it was noted the presence of 9 essential aas (EAAs) and 9 non-essential aas (NEAAs). Among EEAs, arginine (11.33%) and leucine (9.48%) were the predominant followed by lysine (4.54%), phenyalanine (4.46%) and valine (3.53%), The level of these the total EAAs (45.92%) were higher compared to that of *A. pavonina* seed oil (32.39%) o (Ezeagu al., 2004) and those of FAO/WHO requirement pattern for children (33.96% and adult (12.70%) (51). The data in Table 5 indicated that all EAAs except S-containing types and tryptophan were present in low amounts in the studied oil. AAs profile showed histidine (2.30%), methionine (2.64%) and cysteine (0.17%) as the limiting aas. This observation suggested that some legumes and seed proteins are markely deficient in these aas (52). This was also true for *A. pavonina* seed oil studied in the present investigation. The amounts of NEAAs were ranged from 1.70 to 22.26% (Table 6). Glutamic acid was the most abundant (22.2.6%) followed by aspartic acid (8.76%), serine (5.10%, glycine (4.84% and tyrosine (4.52%). Cysteine was the lowerst NEAAs (0.17%). Althouh 50% of each type of aas was identified in this seed oil, a great difference was observed from their amounts since those of EAAs represented 45.92% and those of NEAAs 53.83% of the total amount of aas. Moreover, previous experiments had shown similar content of glutamic and aspartic acids accounting fro 15.1 to 27% compared to the present data. The levels of these aas were comparable to that of *A. pavonina* seed oil collected in Nigeria (0.06 to 20.24%) (5), Desi chickpea (*Cicer arietinum*) cultivar oil (1.1 to 17.8%) (23). AAs composition is generally used as an indicator of the nutritional value of protein source. AAs deficiency can be met by consuming large amounts of legumes or mixture of legumes or by using the complementarity that exist between high sulphur amino acid cereals and legumes, particularly the soybean. The importance of amino acids in nutrition is well documented in the literature (53).

Beside these nutrients reported in the present study, it is important to note that some antinutritional components were previously reported to be present in the seed oil of *A. pavonina*. They included trypsin/ chymotrypsin inhibitors isolated from *A. pavonia* seed from Indian (wood seeds) (54), iso-inhibitors of trypsin from *A. pavonia* seed from Brazil (55). trypsin inhibitor (ApTI), achitinase from *A. pavonina* seeds collected in open fields of Campos dos Coyhacazes, Rio de Janerio, Brazil (56), chitinase proteins possessing antifungal activity consisting mainly in of their capacity to act as chitine and play thus an important role in plant defense (56) and galactamannans from *A. pavonina* seeds collected in Porto, Portugal (57). Other compounds included steroidal lipids, stigmasterol (62%), sitosterol 10%), 24-methyl cholesterol (9%), 24-epiclerosterol (4%) and isofusterol (3%) were detected in *A. pavonina* seeds oil from Kandy district, Sri Lanka (58).

## Conclusion

Results from the present study show that the seed oil of *A. pavonina* is rich in lipids, crude proteins, carbohydrates, amino acids, ash, fatty acids and some mineral elements compared to some other seed, nut and legume oils. This study revealed that the studied oil has a high nutritional value which can be exploited and considered as an alternative source of these nutrients to reduce protein-energy-malnutrition among economically weaker categories of people in developing countries. The oil appears to have a positive effect on human health and resembles to oils that are processed for food and could serve as a source of good edible oil for human and animal.

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