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Full Length Research Paper

Evaluation of nutrient composition of African melon oilseed (*Cucumeropsis mannii* Naudin) for human nutrition

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Protein deficiency is prevalent among children and even adults in developing countries, especially in African countries and contributes to immune dysfunction, opportunistic infections and mortality. The goal of this project is to search for a cheaper and sustainable plant based source of protein that can be incorporated in the diet to prevent protein deficiency and other essential nutrients. African melon oil seeds (*Cucumeropsis mannii* Naudin) collected from Cameroon-West Africa were analyzed to determine their nutrient composition and whether they could serve as a sustainable source of protein, essential amino acids and polyunsaturated fatty acids for consumers in developing countries, especially in African countries. Nutrient data obtained shows that *Cucumeropsis mannii* Naudin has crude protein content of 31.4% and all essential amino acids. Total fat content in the seeds was 52.5% and the fatty acids that were in abundance were: linoleic (62.42%), oleic (15.90%), palmitic (10.27%), and stearic (10.26%). Mineral and vitamin analysis indicated that the seed contains important macro and micro minerals, and vitamins. Nutrient composition shows that *Cucumeropsis mannii* Naudin is a rich source of protein, essential amino acids, essential fatty acids, minerals and vitamins making it a nutritive food for consumers in developing countries, especially in West Africa where it is widely cultivated. The high content of polyunsaturated fatty acids and essential amino acids, demonstrate that *Cucumeropsis mannii* Naudin has potential health benefits. Our results suggest that African oilseed is a potential food source that can be incorporated in many African/Western diets, and/or used in poultry and animal feed.

Key words: African melon oilseed, protein, amino acids, fatty acids, mineral, vitamin.

INTRODUCTION

Accumulated body of information from the WHO Global Database on Child Growth reports the prevalence of protein-energy malnutrition among children under 5 years old in developing countries, specifically in Africa (Keller and Fillmore, 1983). It is also reported that protein deficiency and lack of other essential nutrients in the diet contributes to the incidence of kwashiorkor and widespread infectious diseases. Protein deficiency also contributes to underweight, growth retardation, poor hair color, anemia, atrophy of tissues and organs of the body and wasting of muscle among children under the age of 5 (WHO working group, 1986). The major reason for lack of adequate protein in most African diet is due to economic constraints. Meat and fish contain high quality protein for people of all age groups but it is quite expensive (about $2 per pound) for most African consumers who live on a monthly income of about $100 with an average family size of six (personal experience).

Epidemiological evidence have shown that consumption of diet high in saturated fatty acids contributes significantly to the risk of developing cardiovascular disease, some form of cancer and atherosclerotic heart disease in humans (Romero-Corral et al., 2006).

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Maintaining a healthful diet that is low in saturated fatty acids and high in mono- and polyunsaturated fatty acids offers the greatest potential of all known approaches in reducing the risk for cardiovascular disease (Laidlaw and Holub, 2003; Okuda et al., 2005).

It is widely documented that most diets in developing countries are high in carbohydrate and significantly low in high quality protein and essential fatty acids (Krivanek et al., 2007). Most developing countries depend on starch-based foods as the main staple food for the supply of both energy and protein. This accounts in part for protein deficiency which prevails among children and adults as recognized by Food and Agricultural Organization (Ladeji et al., 1995; Akubugwo et al., 2007). Most of the dietary protein consumed by a majority of children and adults in developing countries is deficient in one or more essential amino acids (Jansen and Howe, 1964; Krivanek et al., 2007). With less than one percent of the known plant species being used for food, there is need to increase the supply of high quality food through exploring novel compounds with potential for providing nutritious food with high quality protein and polyunsaturated fatty acids. Thus, there is a renewed effort from researchers (Movahedian et al., 2006; Prasad, 2005) to identify plant sources rich in essential amino acids, essential fatty acids and phytochemicals necessary for improvement of human health. Many of the local vegetable materials like *Cucumeropsis mannii* Naudin are under-exploited because of inadequate scientific knowledge of their nutritional potentials.

Cucumeropsis mannii Naudin is cultivated widely in West African countries, specifically in Cameroon (Fomekong et al., 2008; Achigan-Dako et al., 2008). *Cucumeropsis mannii* is a species of melon native to tropical Africa where it is grown for food and as a source of oil. These seeds are known as Mann's *Cucumeropsis* and white-seed melon. The plant produces climbing vines up to 4 meters long. The plant bears small yellow male and female flowers with petals under a centimeter in length. The fruits are egg-shaped or an elongated ovate shape, up to about 19 centimeters long and 8 wide, and cream in color with green streaks (Loukou et al., 2007). The plant adapts well in sandy soil and in hot environment. The plant is usually grown during the raining season (March-September). After the seeds are planted, it usually takes 3-4 months to mature for harvesting. The cultivation technique is widely established by small scaled farmers in most villages in West African countries. All the farmers practice organic farming because they rely on manure from compost to enrich the soil for the next planting season. When the fruits are matured, the seeds of *Cucumeropsis mannii* Naudin are usually harvested from the fruits and dried, then manually shelled to collect the seeds. The seeds are ground and used for soup/vegetable and serves as an ingredient for seasoning baked meats and fish. The oilseed is an economical and valuable agricultural plant in West Africa, especially in Cameroon. The major objective of this project is to evaluate the nutrient composition of *Cucumeropsis mannii* Naudin and to determine whether it could serve as a major source of protein, specifically essential amino acids and potential rich source of nutrients that can be incorporated in many African/ Western diets, and/or used in poultry and animal feed.

MATERIALS AND METHODS

Seventy-two grams of dried African melon oilseeds were obtained from limited resource farmers in eight villages (3 farmers per village) in Manyu Division, South West province of Cameroon. We bought 3 g of the oilseeds from each farmer. The dried seeds were shelled manually and stored at room temperature prior to being transported to the United States. Twenty-four hours prior to arrival in the United States, the melon oilseeds were placed in Ziploc bags and in boxes for a sixteen hours flight to the United States. Upon receipt in our lab, the melon seeds were stored at 4°C until used for nutrient analysis. Before analysis, composites of seeds were ground to a meal with the aid of a blender. The ground composite samples were divided into triplicate samples prior to analysis and results were expressed on the basis of dry matter (DM).

Mineral and vitamin analysis

A gram of the ground oilseed from each of the triplicate samples was used for analysis of selected minerals. The concentration of calcium, phosphorus, sodium, potassium, magnesium, iron, manganese, zinc and copper in the ground oilseeds were determined by inductive couple plasma atomic emission spectroscopy as described by Winge et al. (1985). Selenium concentration was determined by measuring selenide gas using a spectrophotometer as described by Szydlowski and Dunmire (1979). Another gram of the ground oilseeds was used to analyze vitamins A and E levels. Vitamin A concentration was determined using High Liquid Chromatography (HPLC) as described by Klimes and Jedlicka (2002), while vitamin E was measured as tocopherol acetate using HPLC as described by Klimes and Jedlicka (2002), and McMurray et al. (1980).

Protein, amino acids and fatty acids analysis

A gram of the ground oilseed from each of the triplicate samples was used for analysis of crude protein and amino acids. Crude protein content in the ground oilseeds was measured using the Buchi Kjeldahl Line Digestion Unit (Buchi B324, Switzerland) for digestion of samples, and the Buchi Distillation Unit for the distillation and titration of digested samples. Amino acids profile excluding tyrosine and tryptophan was determined by performic acid oxidation with acid hydrolysis-sodium metabisulfite method (AOAC, 1994). One gram of each ground triplicate sample was used to analyze total fat and fatty acid profile. Total fat content in the ground oilseeds was determined using the method described by Sukhija and Pamquist (1988). Fatty acid methyl esters were prepared as described by Dodds et al. (2005) and Schreiner (2005). Fatty acid methyl esters were separated and quantified with gas chromatography equipped with J&W DB 23-column (30 m x 0.32 mm ID, 0.25 µ film) with the following conditions: initial oven temperature at 75 and 210°C, respectively; helium as carrier gas (2 ml/min, set at 25°C), detector temperature at 280°C, injection temperature at 240°C and split ratio of X200 and with an FID detector. Identification and quantification of fatty acids were performed by comparing the retention data and the areas of the

Table 1. Minerals and Vitamins composition of African melon oil seed based on dry matter (DM).

Nutrients	AMOS[1]	Corn[2]	Peanut[2]
Minerals		**Values per 100 g**	
Sodium, Na	3.61 mg	43 mg	2 mg
Potassium, K	601.1 mg	350 mg	187 mg
Calcium, Ca	75.65 mg	7 mg	`15 mg
Phosphorus, P	827.1 mg	294 mg	101 mg
Magnesium, Mg	359.3 mg	155 mg	50 mg
Manganese, Mn	4.38 mg	0.61 mg	0.59 mg
Iron, Fe	6.45 mg	4.21 mg	0.64
Zinc, Zn	4.35 mg	2.22 mg	0.94
Copper, Cu	1.73 mg	0.235 mg	0.19 mg
Selenium, Se	12.2 ug/100 g	18.9 mg	2.1 mg
Vitamins			
Vitamin A-retinol	<66.1 IU A/100 g	261 IU	Nd
Vitamina E (tocopherol acetate)	0.89 mg/100 g	0.51 mg	1.6 mg

[1]Africa melon oilseed. [2]Obtained from USDA National Nutrient Database. nd= not detected.

peaks of standards with samples as described by Dodds et al. (2005) and Schreiner (2005).

RESULTS AND DISCUSSION

Minerals and Vitamins content

The mineral and vitamin content in African melon oil seeds are shown in Table 1. Data from nutrient analysis showed that *Cucumeropsis mannii* Naudin is a rich source of minerals such as sodium, potassium, phosphorus, calcium, magnesium, manganese, iron, zinc, copper, and selenium with important health benefits. These minerals have important health benefits for the human body. Some of the most important functions of these minerals in the human body are: bone mineralization and energy transfer from phosphorus; bone development and growth from calcium; cardiac and smooth muscle contractibility from magnesium; contraction of smooth, skeletal and cardiac muscle from potassium; nerve transmission and regulation of fluid balance from sodium; cofactor of some enzymes involve in carbohydrate metabolism from manganese; synthesis of hemoglobin and myoglobin from Iron; antioxidant defense function and synthesis of DNA/RNA from zinc; immune system and antioxidant defense function from copper, and thyroid hormone synthesis and antioxidant defense function from selenium (Byrd-Bredbenner et al., 2007).

Our results also showed that African melon oilseeds have some amount of vitamin A and E. Vitamin A is important for night and color vision, and maintenance of mucus-forming cells throughout the body while vitamin E protects against fatty acid oxidation and cell damage from free radicals (Byrd-Bredbenner et al., 2007). The content of selected minerals and vitamins observed in African melon oilseeds are similar to those in corn and peanut (Table 1). Diets consumed in most African countries are low in minerals such zinc, copper and specifically iron because meat which is a good source for heme iron is rarely included in the diet (Byrd-Bredbenner et al., 2007). A majority of the population cannot afford to include meat in their daily diet because it is very expensive. The average cost of meat or fish is about $2 per pound for most African consumers who live on a monthly income of about $100 with an average family size of six (personal experience). In addition, consumption of essential nutrients like vitamin A and E are inadequate because most consumers in African countries rarely eat green leafy vegetables (Byrd-Bredbenner et al., 2007). This result has shown that African melon oilseed can serve as a source of vital minerals and vitamins that are marginal or lacking in the diet of children and some young adults in developing countries.

Protein content and amino acid composition

Protein and amino acids content in the seeds are shown in Table 2. Results has shown that *Cucumeropsis mannii* Naudin is rich in protein (31.4% dry matter basis, DM) and essential amino acids (0.73% histidine, 1.11% isoleucine, 1.63% leucine, 0.90% lysine, 0.78% methionine, 0.34% cysteine, 1.47% phenylalanine, 0.78% tyrosine, 0.79% threonine, 0.39% tryptophan, 1.42% Valine). Loukou et al. (2007) reported *Cucumeropsis mannii* Naudin has a protein content of 36±2.17% which is higher than that of peanut (*Arachis hypogae* L.) 24.79±0.44%. Our data has shown that the composition of essential amino acids in the African melon oil seeds are similar or superior to sweet corn which is widely

Table 2. Crude protein and amino acids content in African melon (*Cucumeropsis mannii* Naudin) based on dry matter (DM).

Nutriments	AMOS[1]	Sweet Corn[2]
	Concentration (%)	
Crude Protein	31.4	16.1
Amino Acids		
Alanine	1.74	np
Arginine	4.07	0.79
Aspartic acid	2.67	np
Cystine	0.34	np
Glutamic acid	4.51	np
Glycine	1.96	np
Histidine	0.73	0.41
Isoleucine	1.11	0.61
Leucine	1.63	1.74
Lysine	0.90	0.61
Methionine	0.78	0.26
Phenylalanine	1.47	0.98
Tryptophan	0.39	0.081
Serine	1.23	np
Threonine	0.79	0.67
Tyrosine	0.78	np
Valine	1.42	1.07
Proline	0.94	np

[1]African melon oilseed; [2]Analysis performed by Kennerer and Acosta (1949). np = not performed.

consumed in African countries as a staple food crop (Table 2). It has been documented that most diets in developing countries are deficient in protein, especially essential amino acids (Ladeji et al., 1995). Several studies have documented that children and adults consume less than 10% protein per day which is lower than the recommended daily requirement of 16% protein (Jansen and Howe, 1964, Byrd-Bredbenner et al., 2007). Result from this study confirms that protein in *Cucumeropsis mannii* Naudin is of high quality because it has all the essential amino acids; indicating that this oilseed has the potential of meeting the protein needs of children and adults in developed and developing countries.

Total fat and fatty acid profile

The fatty acid profile of the African melon oilseed is shown in Table 3. Nutrient analysis revealed that African melon oil seeds are high in fat (52.5% DM) and fatty acids such as palmitic (10.27%), stearic (10.26%), oleic (15.90%), and linoleic (62.42%). From these results, we observed that the content of saturated fatty acids, monounsaturated fatty acids and polyunsaturated fatty acids in the oilseed was 21.2, 16.1 and 62.42%, respectively. Our data showed that the composition of fatty acids in African melon oil seed is similar to those found in some of the edible **v**egetable Oils (Table 3) present in the market place. Result from this study indicates that African melon oil seed can serve as a potential source for cooking oil because of the high content of monounsaturated and polyunsaturated fatty acids. Foods containing monounsaturated (oleic, C18:1) and polyunsaturated fatty acids are receiving increased attention due to their functionality in disease prevention. Monounsaturated and polyunsaturated fatty acids are associated with low incidence of cardiovascular diseases probably, in part through its hypolipidemic and hypocholesterolemic effect (Simopoulis, 1991).

There is compelling evidence that consumption of monounsaturated and polyunsaturated fatty acids lowers total plasma cholesterol and low density lipoprotein (LDL) cholesterol levels in human subjects (Eristsland 2000). In addition, the polyunsaturated fatty acids observed in African melon oilseed are predominantly omega-6 fatty acids (ω-6). These ω-6 (C18:2) fatty acids are essential fatty acids because they cannot be synthesized by humans and must be obtained from the diet (Goodnight et al, 1982; Nordoy, 1991; Gropper et al., 2009); therefore, intake of relatively small amounts of these fatty acids can prevent deficiencies and diseases that are associated with deficiency of ω-6 fatty acids (Nakamura, 2000). Dietary polyunsaturated fatty acids (PUFAs) of the ω-6

Table 3. Percentage of fatty acids in commercial vegetable oil and *Cucumeropsis mannii* Naudin.

Fatty Acids	Safflower[1]	Canola[1]	Soybean[1]	Corn[1]	Sunflower[1]	Peanut[1]	Olive[1]	AMOS[2]
Myristic (C14:0)	nd	0.75	0.1	nd	nd	0.1	nd	0.04
Pentadecanoic (C15:0)	nd	nd	nd	nd	6.50	10.0	11.0	0.04
Palmitic (C16:0)	5.0	4.0	10.80	11.40	4.50	2.30	2.20	10.27
Palmitelaidic (C16:0, cis)	nd	nd	nd	nd	nd	nd	nd	0.10
Heptadecanoic (C17:0)	nd	nd	nd	nd	nd	nd	nd	0.08
Stearic (C18:0)	2.0	1.60	4.0	1.9	nd	nd	nd	10.26
Arachidic (C20:0)	nd	0.5	nd	nd	nd	nd	nd	0.36
Behenic (C22:0)	nd	0.4	nd	nd	nd	nd	nd	0.09
Triocosanoic (C23:0)	nd	nd	nd	nd	nd	nd	nd	0.02
Total saturated fatty acids	7.0	7.25	15.1	13.3	11.0	17.8	13.5	21.2
Palmitoleic (C16:1)	nd	0.25	0.2	nd	nd	0.1	0.8	nd
10-Heptadecanoic (C17:1)	nd	nd	nd	nd	nd	nd	nd	0.03
Oleic (C18:1, cis)	77.0	61.0	23.8	25.3	18.5	47.1	75.8	15.90
11-Transeicosenoic (C20:1)	nd	1.50	0.20	nd	nd	1.40	0.30	0.11
Erucic (C22:1)	nd	nd	nd	nd	nd	nd	nd	0.01
Mono-unsaturated fatty acids	77.0	63.0	24.30	25.3	20.4	48.6	77.1	16.1
Linoleic (C18:2, cis)	15.0	23.5	53.3	60.7	68.8	33.6	8.3	62.42
Alpha Linolenic (C18:3)	nd	11.50	7.10	0.70	nd	nd	0.60	0.16
11-14-Eicosandienoic (C20:2)	nd	nd	nd	nd	nd	nd	nd	0.01
Docosahexaenoic (C22:6)	nd	nd	nd	nd	nd	nd	nd	0.07
Poly-unsaturated fatty acids	15.0	25.0	60.60	61.40	68.80	33.60	8.80	62.7
Total Fat per serving								52.5

[1]Data provided by Erasmus (1993). [2]African melon oilseed (*Cucumeropsis mannii* Naudin).

type have been associated with alterations in atherogenic indexes such as plasma lipoproteins, thrombosis, and blood pressure (Castelli et al., 1986; Iacono and Dougherty, 1990).

Several studies have reported that linoleic acid (LA) serves as a precursor to arachidonic acid *in vivo* (Byrd-Bredbenner et al., 2007). A primary function of these essential fatty acids is the production of prostaglandins, which regulate body functions such as heart rate, blood pressure, blood clotting, fertility, conception, and play a role in immune function by regulating inflammation and encouraging the body to fight infection (Nakamura, 2000). These essential fatty acids are also needed for proper growth in children, particularly for neural tube development and maturation of sensory systems (Gropper et al., 2009). Epidemiological studies have reported that most diets in African and developing countries are significantly low in ω-6 fatty acids because their diets depend on starch-based foods and less on food sources that provide omega-6 essential fatty acids like safflower, sunflower, sesame, hemp, pumpkin, soybean, walnut and wheat germ (Byrd-Bredbenner et al., 2007). The American Heart Association recommends consumption of 2–4 table spoon of vegetable oil per day to prevent diseases associated with ω-6 fatty acids (linoleic acid, C18:2) deficiency (Castelli et al., 1986; Byrd-Bredbenner et al., 2007). Result from this study indicates that African melon oilseed is a good source for omega-6 fatty acids; suggesting that consumption of these oilseeds can prevent potential deficiency of ω-6 fatty acids.

Conclusion

High quality protein that contains all the essential amino acids is lacking in the diet of children and adults in developing countries, especially in Africa where consumers rely heavily on starch-based foods. Plant-based protein and cheaper sources of amino acids like those obtained from *Cucumeropsis mannii* Naudin can be incorporated in the diet to help meet protein and essential amino acid needs of children and adults in Developing countries. The average cost of African melon oilseed is about $1.00 per pound of melon seeds compared to $2.00 per pound of beef (personal experience). In addition, intake of polyunsaturated fatty acids, especially essential fatty acids are also very low in developing countries; indicating that inclusion of African melon oilseeds in the diet would

be a noble approach to prevent essential fatty acids deficiency and diseases associated with these nutrients. Animal and poultry producers are constantly searching for feed ingredients that are rich in essential amino acids, minerals and vitamins to incorporate in animal and poultry feed in order to improve feed efficiency and production. Our data suggests that incorporation of *Cucumeropsis mannii* Naudin especially in poultry feed may provide essential nutrients and improve growth and development of chicks and the quality of meat products. To the best of our knowledge, no data has ever been reported about toxicity resulting from consumption of African melon oilseeds by healthy humans. Africans have eaten these oilseeds for years without any reported adverse health problem. Currently, there is no information about changes in nutrient composition of African melon oilseeds using different cooking methods. Therefore, extensive research is required to examine the level of anti-nutritional or toxic compounds in African melon oilseeds and potential changes to nutrient composition using different cooking methods.

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