African Journal of Food Science Vol. 5 (2), pp. 40 - 44 February 2011
Available online http://www.academicjournals.org/ajfs
ISSN 1996-0794 ©2011 Academic Journals

Full Length Research Paper

Studies on chemical compositions and functional properties of thorn apple (*Datura stramonium L*) *Solanaceae*

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Accepted 28 December, 2010

The fruits of thorn apple (*Datura stramonium L*) were separated into seed coat, seeds and whole seeds, the various parts were analyzed for proximate composition, anti-nutrients, minerals and functional properties. The physicochemical properties of the oil were also studied. The results obtained showed that, protein and ash were highly distributed in the seed coat than the seed; in contrast the fat, carbohydrate and fiber contents of the seed were higher than the coat. In addition, the seeds also contained higher concentration of phytate, tannin and oxalate than the coat. All the minerals analyzed except calcium, iron, potassium, sodium and phosphorus were higher in the seed coat than the seed. The percentage water absorption and foaming capacities and least gelation were higher in the coat than the seed. Oil absorption and emulsion capacities of the seed coat were higher than the seed. The result of the physicochemical properties indicates that, oil of thorn apple could be utilized for industrial purposes.

Key words: Seed coat, nutrients distribution, antinutrients, elemental composition, acid value, foaming capacity.

INTRODUCTION

Datura is a genus of nine species of vespertine flowering plant belonging to the family *Solanaceae* and genus *Datura*. Its precise and natural distribution is uncertain, owing to its extensive cultivation and naturalization throughout the temperate and tropical regions of the globe. Its distribution within the Americas, however, is most likely restricted to the United States and Mexico, where the highest species diversity occurs, however, some South American plants formerly thought of as *Daturas* are now treated as belonging to the distinct genus *Brugmansia* (Hawkes et al., 1991). Thorn apple is also known as Devil's apple because of its dangerous qualities and the peculiar effects that follows its administration. *Datura* belongs to the classic "witches weeds," along with deadly nightshade, henbane and mandrake. Most parts of the plants contain toxic hallucinogens and *Datura* has a long history of use for causing delirious states and death. It was well known as an essential ingredient of love potions and witches' brews (Preissel and Hans-George, 2002). All *Datura* plants contain atropane alkaloids such as scopolamine, hyoscy-amine and atropine, primarily in their seeds and flowers. Because of the presence of these substances, *Datura* has been used for centuries in some cultures as a poison and hallucinogen (Preissel and Hans-George, 2002; Adams et al., 2005). There can be a 5:1 toxin variation across plants and a given plant's toxicity depends on its age, where it is growing and the local weather conditions. This variation makes *Datura* exceptionally hazardous as a drug. In traditional cultures, a great deal of experience with and detailed knowledge of *Datura* was critical, in order to minimize harm (Preissel and Hans-George, 2002). Many tragic incidents result from modern recreational users ingesting *Datura*. For example, in the 1990s and 2000s, the United States media contained stories of adolescents and young adults dying or

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becoming seriously ill from intentionally ingesting *Datura* (CDC, 2002; Leinward, 2006). There are also several reports in the medical literature of deaths from *Datura stramonium* and *Datura ferox* intoxication (Michalodimitrakis and Koutselinis, 1984; Steenkamp et al., 2004). Children are especially vulnerable to atropine poisoning and their prognosis is likely to be fatal (Taha, 1984; Djibo and Bouzou, 2000). In some parts of Europe and India, *Datura* has been a popular poison for suicide and murder. From 1950 to 1965, the State Chemical Laboratories in Agra, India, investigated 2,778 deaths that were caused by ingesting *Datura* (Preissel and Hans-George, 2002). The U.S. Centers for Disease Control and Prevention reported accidental poisoning resulting in hospitalization for a family of six who inadvertently ingested *Datura* used as an ingredient in stew (Bontayan, 2010). In some places, it is prohibited to buy, sell or cultivate *Datura* plants (Preissel and Hans-George, 2002). The most common *Datura* spp. noxious to the farm animals are *D. stramonium* (atropine alkaloid) and *D. ferox* (scopolamine, 98 to 100% of total alkaloids) mainly present in Europe and South America, respectively (Piva and Piva, 1995). The presence of alkaloids from *Datura* seeds in feeding stuffs may be responsible for chronic and/or subclinical toxic effects; acute poisoning from *Datura* seeds is rare. Pigs are the most sensitive animals to *Datura* poisoning, followed by cattle, horses and chickens (Piva and Piva, 1995). Sheep and rabbits are indifferent to atropine presence in food because they synthesize the atropine esterase enzyme (Piva and Piva, 1995). The progressive atropine poisoning in pigs leads to a reduction of feed intake and growth, gastrointestinal motility and secretory activity, extreme mouth dryness, increased respiration and cardiac rate, pupil dilation, etc. Clinical symptoms are partly similar among different species (Piva and Piva, 1995). Toxic effects from *Datura* alkaloids presence in feeds showed possible variability of alkaloids content tolerated by pigs. It was also reported by Piva and Piva (1995) that, the threshold limit in pigs (20 to 60 kg live weight) was 1.5 mg alkaloids/kg of feed (1.21 mg alkaloids/kg live weight). The aim of this work is however, is to examine the proximate, antinutrient composition, mineral composition, protein functional properties and physicochemical properties of extracted oil of thorn apple seed with the view to look into possible ways of maximizing the potential usefulness.

MATERIALS AND METHODS

Materials

The fruits of thorn apple (*D. stramonium L*) were collected from Ido-Osun area of Osogbo in Osun State of Nigeria (geographical location). The fruits were separated into seed coat, seeds and whole seeds, which were sun dried and the samples were later ground to powder with the Marlex Excella laboratory blender. The powdered samples were kept in an air-tight polythene bags and placed in a refrigerator at 4℃ until the analysis.

Methods

Proximate analysis

Proximate analysis of the samples; moisture content, ash, ether extract and crude fiber contents were done using the method reported by AOAC (1990). Nitrogen was determined by the micro-Kjeldahl method (Pearson, 1976) and crude protein content was subsequently calculated by multiplying the nitrogen content by a factor of 6.25. Carbohydrate content was estimated by subtracting the sum of the percentages of protein, moisture, fiber, ether extract and ash from 100 according to AOAC (1990).

Functional properties analysis

The modified method of Adeyeye et al. (2002) was used to determine the foaming capacity, emulsion stability and least gelation capacity of the sample. The method reported by Beuchat (1977) was used to determine the oil absorption and water absorption, while the emulsion capacities and the emulsion stability of the sample were determined according to Yasumatsu et al. (1992).

Mineral analysis

Minerals were analyzed by the method reported by Oshodi (1992). Minerals were analyzed by dry-ashing 1 g of the sample at 550℃ in a furnace. The ash obtained was dissolved in 10% HCl, filtered with filter paper and made up to standard volume with deionised water. Flame photometer was used to determine sodium and potassium contents of the sample, while Ca, Fe, Mg, Zn, Cu, Pb, Ni and Cr were determined using atomic absorption spectrophotometer (AAS), as phosphorus content was determined by the Vanado Molybate method as reported by AOAC (1990).

Anti-nutrient analysis

The method of Wheeler and Ferrel (1971) was used to determine the phytate contents of the samples. Oxalate content was determined according to the procedure of Day and Underwood (1986), while tannin content was determined by the method of Marker and Goodchild (1996).

Statistical analysis

The results obtained were statistically analyzed and reported as Mean ± standard deviation of triplicate data.

RESULTS AND DISCUSSION

Proximate analysis

The result of proximate composition of thorn apple (*D. stramonium L*) from Table 1 showing percentage moisture, ash, crude fat, crude protein and carbohydrate contents of the seed coat, seed and whole seed of thorn apple fruit. The result showed that, the seed coat had higher moisture content than the seed. The result shows

Table 1. Proximate composition of thorn apple *Datura* spp.

Parameter	Percentage Composition		
	Seed coat	Seeds	Whole seed
Moisture	8.65 ± 0.5	5.30 ± 0.5	8.50 ± 0.6
Ash	15.70 ± 0.6	4.00 ± 1.5	8.70 ± 0.6
Fiber	24.00 ± 0.3	25.10 ± 1.5	23.70 ± 0.5
Fat	9.00 ± 0.0	19.90 ± 1.5	16.60 ± 0.6
Protein	20.00 ± 0.0	15.90 ± 0.2	16.20 ± 0.4
Carbohydrate	22.65 ± 0.3	29.80 ± 0.3	26.20 ± 0.5

Table 2. Anti nutrients composition of thorn apple.

Parameters	Seed coat	Seeds	Whole seeds
Phytic acid (mg/g)	24.22 ±0.29	29.19 ± 0.40	16.75 ± 010
Tannin (µg/g)	4.00 ± 0.10	6.00 ± 0.10	8.00 ± 0.10
Oxalate (mg/g)	3.75 ± 0.13	7.13 ± 0.21	7.77 ± 0.05

that, the seed has 5.30 percent moisture content which is however, lower than that obtained for the seed of *Haemtostaplus barteri* reported by Amoo and Lajide (1999). The low moisture content of thorn apple seeds indicates a good shelf life and their low susceptibility to microbial deterioration. The seed coat was observed to contain high ash content which indicate mineral composition of the sample since ash is the inorganic residue left after organic component of a sample has been burnt-off; however, the study revealed the seed coat to be richer in mineral elements than the seed. Fat content is higher in seed (19.9%) than in seed coat (9.00%). These values are higher than (5.20%) those reported for *Bahuhinia recemosa* seeds (Amoo and Moza, 1999) and those obtained for *Mucuna Ghana* 6.89%; *Mucuna preta* 7.62% and *Mucuna veracruz mottle* 7.24%, as reported by Amoo et al. (2009). The analysis showed that, the coat (24%) and the seed (25%) have a high proportion of fiber content, this value is however higher than those reported by Amoo et al. (2009) for three species of Mucuna and Oshodi (1992) for *Adenophus breviflorus*. However, the digestibility of a food substance is inversely proportional to the quantity of fiber present in it. The study also revealed that, coat (20.00%) is richer in proteins than the seed (15.90%). The carbohydrate content was 30 and 23% for seed and coat, respectively, these values are however, lower than those reported by Amoo et al. (2009) for the seeds of three species of *Mucuna.*

Anti nutrients

The seed and the coat of thorn apple fruit contained high amount of oxalate with the seed having almost twice the proportion found in the coat (Table 2). Since oxalate form insoluble precipitate with nutrients such as sodium and potassium causing renal calculi and at the acute state of renal failure, consumption of thorn apple can therefore, result in metallic oxalates poisoning. Both seed coat and seed contains high phytic acid content. Phytic acid chelates minerals such as zinc and calcium thereby, reduces the minerals available to the body, act as acid chelating the vitamin niacin, resulting in pellagra. Eating thorn apple may therefore, reduce vitamin niacin, cause mineral deficiency and cause vitamin deficiency diseases. It may however, be good food for cancer patients due to the anticancer properties of phytate. Tannin content of thorn apple fruit is high. Tannin inhibits absorption of certain minerals such as iron and zinc through protein resulting in anaemia. Tannin's high proportion in thorn apple makes the apple a good ingredient in the process of tanning leather (Wikipedia, 2009).

Mineral content

Thorn apple is rich source of magnesium, calcium and phosphorus. The coat has highest magnesium constituent of 399.2 mg/g whereas, seed has 344.07 mg/g. Seed has higher calcium and phosphorus concentration than seed coat. In contrast, copper and zinc were higher in seed coat than in seed. Iron proportion is almost the same in the seed and coat with 6.93 and 6.9 mg/g, respectively. Lead and chromium were observed to be low in the seed with lead (0.32 mg/g in coat, 0.29 mg/g in seed); chromium (0.6 mg/g in both seed and coat) as revealed in Table 3; indicating that, the seed is rich in nutritionally valuable minerals and low in poisonous

Table 3. Mineral content of thorn apple.

	Mineral concentration (mg/g)		
	Seed coat	**Seeds**	**Whole seeds**
Magnesium	399.20	344.07	307.49
Calcium	57.00	426.50	295.10
Lead	0.32	0.29	0.95
Chromium	0.60	0.60	2.85
Iron	6.92	6.93	5.63
Copper	10.36	6.22	8.07
Manganese	5.13	4.11	8.49
Zinc	8.25	3.23	0.51
Phosphorus	190.00	275.00	220.00
Potassium	1.93	2.04	2.50
Sodium	2.02	2.86	2.50

Table 4. Functional properties of thorn apple.

Parameters (%)	Properties		
	Seed coat	**Seeds**	**whole seeds**
Water absorption capacity	876.67 ± 5.00	206.67 ± 5.00	193.33 ± 11.00
Oil absorption capacity	533.67 ± 10.00	543.00 ± 5.00	571.00 ± 20.00
Foaming capacity	11.33 ± 1.00	8.13 ± 0.20	9.73 ± 0.20
Emulsion capacity	39.10 ± 0.80	49.00 ± 2.00	55.10 ± 1.60
Bulk density	0.30 ± 0.12	0.39 ± 0.01	0.42 ± 0.05
Least gelation	6.00 ± 0.50	2.00 ± 0.30	4.00 ± 0.50

Table 5. Physicochemical properties of the extracted oil of thorn apple *Datura* spp.

Properties	Results
Color of extracted oil	Brownish yellow
Specific gravity	0.98 ± 0.001
Refractive index	1.48 ± 0.001
Saponification value	204.84 ± 11.00
Free fatty acid mg/g	0.41 ± 0.01
Peroxide value mg/g	1.76 ± 0.04
Iodine value mg/g	12.49 ± 1.10
Acid value mg/g	7.84 ± 0.01
Smoke point °C	60.33 ± 0.58
Flash point °C	109.33 ± 1.20
Fire point °C	161.67 ± 0.57

heavy metals which can well be compared with observation of Amoo et al. (2009) for *Mucuna* species.

Functional properties

The values obtained for water absorption and oil absorption capacity are very high for the coat and the seed as shown in Table 4. The water absorption capacity is however, remarkably higher than that of oil absorption for seed coat. The values are also higher than that obtained from pigeon pea flower (225%) as reported by Oshodi and Ekperigin (1989). High oil absorption capacity is an indication of presence of non-polar hydrocarbon chain in the oil structure. It may therefore, be good for use in oil absorption at difference production works. The bulk density is 0.30 for coat, 0.39 for seed and 0.42 for seed and coat. The least gelation in 6.00% in coats, 2.00% in seed and 4.00% in seed and coat, which implies that, the gelation is least in seed. Foaming capacity was generally low; 11.33% for coat, 8.13% for seed and 9.73% for seed and coat. The values are lower than 66.0% reported by Lin et al. (1974). Despite low composition of foaming active substance, it could still be a good material for soap production and harnessed in other industrial processes. However, the results obtained in this study are higher than those obtained by Amoo et al. (2009) for three species of *Mucuna* seeds.

Physicochemical properties of extracted oil

Specific gravity of the oil is almost similar to water (Table 5). Saponification value of the oil is 204.84. The refractive index of 1.478, is close to 1.4637and 1.4637 obtained for the seed oil of two sunflower lines when subjected to water stress at different growth stages reported by Qasim et al. (2009). Iodine value was found to be 12.49 mg/g. Iodine value is useful in placing oil into a particular group such as animal fat, waxes, drying oil, etc. Less unsaturated fat have low iodine value and are solid at room temperature, while more unsaturated are liquid at room temperature. The iodine value therefore, reflects the degree of unsaturation and tendency of the oil to go rancid. Free fatty acid (FFA) content of the oil is 0.41 mg/g. FFA is an identity of the oil condition. FFA of between 0.5 to 1.5% becomes noticeable to the mouth palate. The FFA of the oil analyzed is however, very low. Acid value is 7.084 mg/g. This value is higher than that of soybeans (0.6 and 4.0 mg/g) of *Arachis hypogeal* reported by Pearson (1976). Peroxide value is very low; 1.7°C flash point 109°C and fire point of 161°C. Smoke point refers to temperature at which a cooking fat or oil begin to break down, smokes, burns and gives the food unpleasant taste. The smoke point is a key factor of consideration in frying as a reflection of temperature of oil and to what purpose the oil could be used for. The thorn apple oil extract being analyzed has a low smoke point. Flash and fire points are useful in determining temperature and fire stability of oil. Oil with low flash point of below 38°C will require special precaution for safe handling. The oil of thorn apple has relatively high flash and fire point. The results obtained for the physicochemical properties in this study are however, in consonance with other researchers for various oil seeds Anwar et al. (2006) for *Moringa oleifera* seed and Qasim et al. (2009) for sunflower seed.

Conclusions

The present study has shown from the obtained data for proximate composition that, anti-nutrients, minerals, functional properties and physicochemical properties of the oil studied for the seed of thorn apple is a good source of protein, nutritionally valuable minerals, good functional properties status and good oil physicochemical properties that can be of high industrial benefits. However, the high phytic acid contents can be reduced through other processing methods.

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