

See discussions, stats, and author profiles for this publication at: <https://www.researchgate.net/publication/320237119>

Nutritional and Phytochemical Screening of Aloe barbadensis

Article · February 2012

CITATIONS

65

READS

4,789

4 authors, including:



[Feyisara Banji Adaramola](#)

Babcock University

24 PUBLICATIONS 385 CITATIONS

SEE PROFILE

Nutritional and Phytochemical Screening of *Aloe barbadensis*

A.O. Adesuyi, O.A. Awosanya, F.B. Adaramola and A.I. Omeonu

Department of Chemical and Environmental Sciences, School of Science and Technology,
Babcock University, Ilishan-Remo, Nigeria

Abstract: The aim of this research study is to analyse qualitatively and quantitatively the *Aloe barbadensis* for Proximate, Anti-Nutrient and Phytochemical composition. The Proximate, Anti-Nutrient composition and Phytochemical screening of *Aloe barbadensis* were determined. The Proximate composition involves the Moisture content, Crude protein, Crude fibre, Crude Fat, Ash content and Carbohydrate. The Anti-Nutrients involved Oxalate, Tannins and Phytate while the Phytochemicals determined were the Saponins, Phenols, Alkaloids and Flavonoids. *Aloe barbadensis* was found to be rich in Carbohydrate (73.07%), so it can be used as a good source of Carbohydrate. The Protein and Fat content were found to be relatively low, (4.73 and 0.27%) respectively. But *Aloe barbadensis* can still be used as a source of Protein and Fat. Qualitatively, Tannin, Oxalate and Phytate were found in trace amount. Tannin, Phytate and Oxalate contents were 0.155 g/100 g, 0.683 g/100 g, and 0.524 g/100 g, respectively. This could affect the availability of Minerals in *Aloe barbadensis*. It was also discovered that Phytochemicals are present in quantities of 0.232 g/100 g, 5.651 g/100 g, 2.471 g/100 g and 3.246 g/100 g for Phenols, Saponins, Alkaloids and Flavonoids, respectively. This is an indication of Cosmetic and medicinal Value of *Aloe barbadensis*. The Sample was also found to be a rich source of minerals. Sodium and Potassium content (5280 and 10670 PPM), respectively indicates the tendency of *Aloe barbadensis* to be able to regulate or control the osmotic balance of the body fluid as well as body pH. *Aloe barbadensis* is also found to be rich in Phosphorus (6657 PPM), which is essential for bone formation. Lead occur in traces. Magnesium (325.8 PPM) is also present, which could help to lower the blood pressure. The overall data suggest that *Aloe barbadensis* has some Nutritional and Medicinal Properties.

Key words: *Aloe barbadensis* antinutrients, mineral medicinal, nutritional, phytochemicals, proximate

INTRODUCTION

Plants have been of importance to medicine for thousands of years. Even today the World Health Organization (WHO) estimates that up to 80% of people still rely on traditional remedies such as herbs for their medicine (Arunkumar and Muthuselvam, 2009). One of such herbs is *Aloe barbadensis* which has caught the global commercial interest in the world of Science, particularly medical science for their proposed health benefits despite little or no scientific evidence justifying the anecdotal claims accompanying many of its products (Botes *et al.*, 2008). *Aloe barbadensis*, also known as Aloe vera is part of the *Liliaceae* or *asphodelaceae* plant family. It is cactus like plant with green dagger-shaped leaves that are fleshy, tapering, spiny, marginated and filled with a clear viscous gel. It has thick leaves that grow in a rosette shape. Many species of Aloe appear to be stem-less, with the rosette growing directly at ground level; other varieties may have a branched or unbranched stem from which the fleshy leaves spring. They vary in color from grey to bright-green and are sometimes striped or mottled.

Some Aloe natives to South Africa are arborescent. The parenchyma cells of the leaves contain large quantities of pulp. It is a monocotyledon and a member of the lily family. It is an evergreen plant. *Aloe barbadensis* can grow up to three feet tall, although most specimens are between one and two feet tall. It is native to East and South Africa and is grown in most subtropical and tropical locations, including Latin America and the Caribbean. The plant has many common names and is often referred to as burn plant, first-aid plant, or medicine plant. Its name is most likely derived from the Arabic word "Alloeh", meaning "shining bitter substance". It is cultivated almost everywhere in the world, both as a houseplant and for its medicinal qualities. It grows best in full sunshine and does not require much water. It does not grow well at temperatures below 32°F (0°C).

Aloe species primarily inhabit relatively dry, warm climates, but has been introduced successfully in the southern United States and Australia as well. These climates tend to have warm, dry summers and cool, moist winters, with more precipitation occurring during the winter. Fires occur frequently in summers, and the species

that survive are those that tolerate fire and drought well. Nutrient density is low in these regions, and thus the habitat cannot support large predators. Smaller animals and especially plants predominate. These habitats have a wide variety of species that have adapted to these unique ecological conditions, such species of Aloe, are endemic. *Aloe albida*, for example, is found in the wild only in South Africa. Aloe is a perennial and takes 4-5 years to mature. Plants can live and reproduce for up to 25 years. Its tubular flowers, yellow to red in color, grow in arrow-shaped clusters on spikes that are up to 3 feet tall. It flowers in springtime. Its fruits are small and not particularly significant. In addition to propagating via seeds, it can reproduce by offsets, which may take root up to 6 feet away from the plant and grow into new plants. There are over 500 species of Aloe, including *Aloe perryi* from Socotra Island or Zanzibar and *Aloe ferox* from Africa.

Aloe vera leaf contains more than 200 different constituents. Some constituents are:

- Acemannan
- Aloe-Emodin
- Aloins
- Enzymes
- Mucopolysaccharides
- Galactomannans

Acemannan: This is a D-isomer mucopolysaccharide that is extracted from aloe vera leaves with mannoacetate as the monomer linked by β -1,4- glycosidic linkages. Glycosidic bond (3,6). This polymer is hydrophilic: 50 hydrogen bond acceptors, 19 hydrogen bond donors and log P of -3.27. Therefore, its permeability (and hence bioavailability) has been scored to be 1 according to Lipinsky's rule of five. Acemannan as an immunostimulant has been demonstrated to induce macrophages to secrete interferon (INF), tumor necrosis factor- (TNF- α) and interleukins (IL-1) - which might help in preventing or abrogating viral infection. These three cytokines are known to cause inflammation and interferon is released in response to viral infections and other polysaccharides boost T-lymphocyte cells which help promote skin healing and neutralize many of the enzymes responsible for damaging the mucosal wall.

Aloe-emodin: of IUPAC nomenclature of 1,8-dihydroxy-3-(hydroxymethyl)-9,10-anthracenedione and chemical formula, $C_{15}H_{10}O_5$, is an anthraquinone present in aloe latex, an exudate from the aloe plant which has a strong stimulant-laxative action.

Aloins: also known as "Barbaloin" is a bitter, yellow-brown colored compound noted in the exudates of at least 68 Aloe species at levels from 0.1 to 6.6% of leaf dry

weight making between 3 and 35% of the total exudates, and in another 17 species at indeterminate levels (Reynolds, 1995). It is used as a stimulant-laxative, treating constipation by inducing bowel movements. The compound is present in what is commonly referred to as the aloe latex that exudes from cells adjacent to the vascular bundles, found under the rind of the leaf and in between it and the gel. When dried, it has been used as a bittering agent in alcoholic beverages.

Enzymes: They act as biochemical catalysts that break down the proteins we eat into amino acids. The enzymes turn the food we eat into fuel for every cell in our body, enabling the cells to function and work efficiently. "The main enzymes found in Aloe vera include Amylase (breaks down sugars and starches), Bradykinase (stimulates immune system, analgesic, anti-inflammatory), Catalase (prevents accumulation of water in the body), Cellulase (aids digestion-cellulose), Lipase (aids digestion-fats), Oxidase, Alkaline Phosphatase, Proteolytiase (hydrolyses proteins into their constituent elements), Creatine Phosphokinase (aids metabolism), and Carboxypeptidase.

Galactomannans: (Long chain sugars derived from plants), are polysaccharides consisting of a mannose backbone with galactose side groups (more specifically, a (1-4)-linked α -D-mannopyranose backbone with branch points from their 6-positions linked to α -D-galactose, i.e. 1-6-linked α -D-galactopyranose).

Minerals: Some minerals like Sodium, potassium, calcium, magnesium, manganese, copper, zinc, chromium and iron are also Constituents of *Aloe barbadensis*.

Vitamins: Vitamins like B1, B2, B6, C, β -carotene, choline, folic acid, α -tocopherol are also Aloe Constituents.

Mucopolysaccharides [MPS] (Long-chain sugars): Mucopolysaccharides [MPS] or glycosaminoglycans (GAGs) are long unbranched polysaccharides consisting of a repeating disaccharide unit. The repeating unit consists of a hexose (six-carbon sugar) or a hexuronic acid, linked to a hexosamine (six-carbon sugar containing nitrogen). They are found in every single cell in the body. The human body stops manufacturing its own mucopolysaccharides around puberty and from then on must rely on outside sources. Some examples of glycosaminoglycan uses in nature include heparin as an anticoagulant, hyaluronan as a component in the synovial fluid lubricant in body joints, and chondroitins, which can be found in connective tissues, cartilage, and tendons.

Mucopolysaccharides work in the body in the following ways:

- As an anti-coagulant, heparin
- By facilitating absorption of water, electrolytes and nutrition in the gastrointestinal tract and maintaining fluid movement
- By lining the colon to keep out toxic waste from the body
- By lubricating the joints, hyaluronan which act as a component in the synovial fluid lubricant in body joints, and chondroitins, which can be found in connective tissues, cartilage, and tendons
- By protecting teach cell from microbial invasion (especially viruses)

Aloe latexcontains:

- Anthraquinone glycosides (these molecules are split by the normal bacteria in the large intestines to form other molecules called aglycones), the main one beingaloin.

Usage of aloe vera: The bitter yellow juice found between the gel and the outer skin of the leaf is dried and used as a laxative.

Medicinal part used: The leaves, the fresh leaf gel and latex:

- Aloe latexis the sticky residue left over after the liquid from cutAloe leaveshas evaporated.
- Aloe vera extractis made by pulverizing the wholeleavesof the plant.
- Aloe juiceandgelis made from the inner leaf (most commonly used for minor cuts and burns).

Proximate analysis: Proximate analysis, also known as Weende analysis is a chemical method of assessing and expressing the nutritional value of a feed, which reports the moisture, ash (minerals), crude fibre, crude fat and crude protein (total nitrogen) present in a fuel as a percentage of dry fuel weight. Carbohydrate (nitrogen-free extract) is determined by difference. The proximate analyses gives the overall nutritional composition of the sample in question, this is briefly complemented by Antinutrient and Mineral composition of the sample.

Phytochemicals: Phytochemicals (from the Greek word “phyto”, meaning plant) are biologically active compounds, found in plants in small amounts, which are not established nutrients but which nevertheless seem to contribute significantly to protection against degenerative disease (Dreosti, 2000). The term does not apply to

compounds used in relation to treating an established acute disease, but rather to substances that are protective at low levels against the development of degenerative diseases over a lifetime (Dreosti, 1998). They are natural bioactive compounds found in plant foods that interplay with nutrients and dietary fibre to protect against diseases. It is also well known that plants produce these chemicals to protect themselves, but recently research demonstrates that they can protect humans against diseases as well as assisting in risk reduction for a variety of chronic and inflammatory conditions.

Objectives of the study:

- To investigate qualitatively the Nutritional content of *Aloe barbadensis*.
- To investigate quantitatively the Nutritional content of *Aloe barbadensis*.
- To investigate quantitatively the photochemical content of *Aloe barbadensis*.

MATERIALS AND METHODS

***Aloe barbadensis* leaves, nutritional and phytochemical analyses:** This research study was carried out in April, 2011 at the Department of Chemical and Enviromental Sciences. School of science and technology, Babcock University, Ilishan-Remo, Nigeria.

Aloe barbadensis plant were obtained from a local garden in Lagos, Shomolu District, who grows them for individual use and as an ornamental plant. The plant leaf was identified by Mr. Odewo, a herbarium caretaker at university of Lagos, Akoka. The leaves were plucked off the stem, rinsed, cut at the lateral section to have a larger surface area and placed on clean polythene Bag. The plant materials were air dried under the sun for one week and were later pulverized into fine powder using a kitchen blender and stored in a clean Polythene bag and was kept in a cool place prior to Laboratory Analyses.

Nutritional property analyses:

Proximate analysis of aloe barbadensis powder: Proximate analysis is a system of analysis of nutrients also termed “conventional analysis”, in which the gross components rather than the individual nutrients amino acids, fatty acids, monosaccharides e.t.c. are determined (Onyeike and Osuji, 2003). The following are constituent parameter: moisture, ash, crude protein, fat, crude fibre and carbohydrate.

All of these were carried out using the Method of analyses described by Onyeike and Osuji (2003).

Mineral analyses: The atomic Absorption spectrophotometer (AAS) was used for the analyses of the following metals: Mg, Zn, Fe, Mn, Cu, Pb and P while the Flame Photometer was used in the analyses of K & Na.

Using AAS, a known amount of the sample was placed in a dish and heated with burnsen burner in a fume cupboard until there was no smoke emitted. This was transferred to the dessicator in other for it to cool after which 0.1m HCl solution was added to the ash. The resulting solution was filtered and diluted. Suitable salts of the metals in questions were used to make their standards, lamps were fixed and the analyses was done. Using the flame photometer, the Diluents of sample was aspirated into the jenway Digital flame photometer using the filter corresponding to each mineral element. All of these were carried out using the method of analyses described by Oshodi (1992).

Phytochemical analyses: Phytochemical analyses includes the Phenol determination, determination of Saponin, determination of Alkaloids and Flavonoids determination. All of these were determined based on methods of analyses described by AOAC (1990).

RESULTS

The Proximate composition of the Sample is shown in Table 1. The values represent the Mean triplicates + Standard error.

The qualitative Anti-Nutrient Screening of *Aloe barbadensis* is shown in Table 2.

The quantitative Anti-Nutrient Screening of *Aloe barbadensis* is shown in Table 3. Values are Mean Triplicate + Standard Error. 0.683+0.00

The quantitative Phytochemical Screening is shown in Table 4. Values are Mean Triplicate + Standard Error. Table 5 shows the Mineral Composition of *Aloe barbadensis*.

DISCUSSION

Table 1 shows the proximate analysis of *Aloe barbadensis*. The average carbohydrate content (73.08%), which is the highest parameter will be a good source of Carbohydrate. Carbohydrates provide readily accessible fuel for physical performance and regulate nerve tissue (Whitney and Rolfes, 2005).

Average moisture content (11.71%) was the second highest Parameter noted. Too much of moisture in any sample has been proved to cause caking especially in flour and can also determine the Storage/Shelf life and the viability of microorganisms' growth (Adeyeye and Ayejuyo, 2000). Average crude fibre (7.84%) was the third highest parameter noted, this implies that they can serve as a source of dietary fibre (Agostoni *et al.*, 2001) and can be employed in the treatment of diabetes, obesity and gastrointestinal tract diseases. Its also an indication

Table 1: Proximate composition of *Aloe barbadensis*

Parameters (%)	
Moisture Content	11.71+0.02
Crude Protein	4.73+0.01
Crude Fibre	7.84+0.01
Ash	2.36+0.01
Crude Fat	0.27+0.01
Carbohydrate	73.08+0.04

Table 2: Qualitative anti-nutrient screening

Parameters	
Tannin	+
Oxalat	+
Phytate	+

(+): Trace Amount Present; (+)(+): Abundant Amount Present; (-): No Amount Present

Table 3: Quantitative anti-nutrient screening

Parameters (g/100g)	
Tannin	0.155+0.00
Oxalate	0.448+0.04
Phytate	

Table 4: Quantitative phytochemical screening

Parameters (g/100g)	
Phenol	0.232+0.00
Saponin	5.651+0.00
Alkaloids	2.471+0.00
Flavonoids	3.246+0.00

Table 5: Mineral composition

Elements	(PPM)	(%)
Mg	325.7	0.033
Zn	71.5	0.007
Fe	28.8	0.003
Mn	128	0.013
Cu	15.3	0.002
Pb	1.7	0.00017
P	6650.1	0.665
Na	5170	0.517
K	10615	1.062

that it contains a proportion of Cellulose, Hemicellulose and Lignin (Saldanha, 2003).

The lowest parameter noted was average crude fat content (0.27%), which are universally stored forms of energy in living organisms. They are major structural elements of biological membranes as phospholipids and sterols (Nelson and Cox, 2008).

Average ash content (2.36%) is a reflection of the mineral contents preserved in the leaves. Minerals are essential for the proper functioning of tissues and act as second messengers in some biochemical cascade mechanisms (Antia *et al.*, 2006).

Average crude protein (4.73%), would serve as enzymatic catalyst, mediate cell responses, control growth and cell differentiation (Whitney and Rolfes, 2005).

Table 2 and 3 show qualitative and quantitative anti-nutrients of *A. barbadensis*. Tannins (0.155 g/100 g), which were found in the plant, are known to be effective in the treatment of sore throat, diarrhoea and haemorrhage.

Tannins are known for their abilities to precipitate with iron and other metals, thereby reducing their absorption.

Oxalates (0.448 g/100 g) affects calcium and magnesium metabolism and react with proteins to form complexes which have an inhibitory effect in peptic digestion (Akande *et al.*, 2010).

Phytic acid (0.683 g/100 g) (inositol hexaphosphate) in plants binds calcium in the intestinal lumen, preventing its absorption as well other minerals, including zinc, are also chelated by phytate.

Table 4 shows phytochemical screening of *Aloe barbadensis* indicating the amount of saponins, alkaloids, phenols and flavonoids. These compounds are known to be biologically active and therefore aid the antimicrobial activities of *Aloe barbadensis* (Igbinosa *et al.*, 2009).

Alkaloids (2.471 g/100 g), a secondary metabolite compound observed in the extract of *Aloe barbadensis* has the biological property of toxicity against cells of foreign organisms. Its activities have been widely studied for their potential use in the elimination and reduction of human cancer cell lines (Nobori *et al.*, 1994). Alkaloids which are one of the largest groups of phytochemicals in plants have amazing effects on humans and this has led to the development of powerful pain killer medications (Kam and Liew, 2002).

Saponin (5.651 g/100 g) found to be present in *Aloe barbadensis* extracts and has supported the usefulness of this plant in managing inflammation. Just *et al.* (1998) revealed the inhibitory effect of saponins on inflamed cells.

Flavonoids (3.246 g/100 g), another constituent of *Aloe barbadensis* extracts are large compounds occurring ubiquitously in food plants. They at times occur as glycosides and contain several Phenolic hydroxyl groups on their ring structure. Some flavonoids are antioxidants and has been proved to exhibit a wide range of biological

activities like antimicrobial, anti-inflammatory, anti-angionic, analgesic, anti-allergic, cytostatic and antioxidant properties (Hodek *et al.*, 2002).

Phenols (0.232 g/100 g) also found present in plant sources are major group of compounds acting as primary antioxidants or free radical scavenger.

Table 5 shows a great deal of mineral composition of *Aloe barbadensis*. It's a proved fact that Potassium is the most abundant mineral in Nigerian agricultural products (Oshodi *et al.*, 1999). This is shown in the table. The next mineral to Potassium in terms of value is Phosphorus, which is vital in bone formation (Adetuyi and Akpambang, 2005), followed by sodium. *Aloe barbadensis* can be used as a source Sodium and Potassium. Since High amount of Potassium and Magnesium may help to lower blood pressure (Otsuki *et al.*, 2010), *Aloe barbadensis* can be used as a source of these minerals. Iron is vital in the formation of

haemoglobin and normal functioning of central nervous system (Otsuki *et al.*, 2010), this sample contain considerable amount of iron and can therefore be used as a source. The presence of lead could be due to bioaccumulation. Micro minerals like copper, Manganense and Zinc are present too

CONCLUSION

The analyses carried out on *Aloe barbadensis* indicates its Nutritional and Phytochemical composition. The Proximate analysis shows a high level of Carbohydrate and crude fibre with a little bit of Protein. The mineral analysis indicates that *Aloe barbadensis* contain macro/major elements which are needed in high quantity in meals, Potassium been the highest. Sodium and Magnesium were also found to be abundant in this sample. Micro elements were also found to be present. These are all good indication of high nutritive value. Despite the presence of some Anti-nutrient that could serve as mineral inhibitors, *Aloe barbadensis* can still be used as sources of these minerals. The Phytochemical content also is an indication that this sample has potential protective vices against degenerative diseases.

REFERENCES

- Adetuyi, A.O. and O.E. Akpambang, 2005. The Nutritional value of *Sorghum Bicolor L.* Stem Flour used for infusion Drinks in Nigeria. Pak. J. Sci. Indus. Res., 49: 276.
- Adeyeye, E.I. and O.O. Ayejuyo, 2000. Chemical composition of Cola Gluminate and *Garcinia kola* seeds grown in Nigeria. J. Food Sci., 45: 223-230.
- Agostoni, C., B. Carratu, C. Boniglia, E. Riva and E. Sanzini, 2001. Free amino acid content in standard infant formulas: Comparison with human milk. J. Am. College Nutr., 19: 434-438.
- Akande, K.E., U.D. Doma, H.O. Agu and H.M. Adamu, 2010. Major anti-nutrients found in plant protein sources: Their effect on nutrition. Pak. J. Nut. 9: 827-832.
- Antia, B.S., E.J. Akpan, P.A. Okon and I.U. Umoren, 2006. Nutritive and anti-nutritive evaluation of sweet potatoes (*Ipomoea batatas*) leaves. Pak. J. Nut., 5: 166-168.
- AOAC, 1990. Official Methods of Analysis. 15th Edn., Association of Official Analytical Chemistry. Washington D.C., USA.
- Arunkumar, S. and M. Muthuselvam, 2009. Analysis of phytochemical constituents and antimicrobial activities of *Aloe vera L.* against clinical pathogens. World J. Agric. Sci., 5: 572-576.

- Botes, L., F.H., Van der Westhuizen and D.T. Loots, 2008. Phytochemical contents and antioxidant capacities of two *Aloe greatheadii* variants *davyana*. Extracts, 13: 2169-2180.
- Dreosti, I.E., 2000. Recommended dietary intake levels for phytochemicals: Feasible or Fanciful? Asia Pacific J. Clin. Nut. 9: 119-122.
- Dreosti, I.E., 1998. An antioxidant RDI: Feasible or fanciful? Nutr. Soc., 22: 26-28.
- Hodek, P., P. Trefil and M. Stiborova, 2002. Flavonoids- Potent and versatile biologically active compounds interacting with cytochrome P450. Chemico-Biol. Inter. J., 139: 1-21.
- Igbinosa, O.O., E.O. Igbinosa and O.A. Aiyegoro, 2009. Antimicrobial activity and phytochemical screening of stem bark extracts from *Jatropha curcas* (Linn). Afr. J. Pharm. Pharmacol., 3: 58-62.
- Just, M.J., M.C. Recio, R.M., Giner, M.J., Cueller, S., Manez, A.R. Bilia, *et al.*, 1998. Anti-inflammatory activity of unusual lupine saponins from *Bupleurum Fruticescens*. Planta Med., 64: 404-407.
- Kam, P.C. and A. Liew, 2002. Traditional Chinese herbal medicine and anaesthesia. Anaesthesia, 57: 1083-1089.
- Nelson, D.L. and M.M. Cox, 2008. Lehninger Principles of Biochemistry. 5th Edn., W.H. Freeman and Company. Madison Avenue, New York, pp: 343.
- Nobori, T., K. Miurakm, D.J. Wu, L.A. Takabayashik and D.A. Carson, 1994. Deletion of the cyclin-dependent kinase-4 inhibitor gene in multiple human cancers. Nature, 368: 753-756.
- Onyeike, E.N. and J.O. Osuji, 2003. Research Techniques in Biological and Chemical Sciences. Springfield Publishers Ltd., Owerri, Nigeria. pp: 403.
- Oshodi, A.A., 1992. Proximate Consumption, Nutritionally valuable Minerals and Functional properties of *Adenopus breviflorus* benth seed and Protein concentrate. Food Chem. 45: 79-83.
- Oshodi, A.A., H.N. Ogungbenle and M.C. Oladimeji, 1999. Chemical composition, nutritionally valuable minerals and functional properties of benni seed (*Sesamum radiation*). Peal millet (*Pennisetum typhoides*) and guninoa (*Chenopodium quinoa*) flours. Int. J. food Sci. Nutrition, 50: 325-331.
- Otsuki, N., N.H. Dang, E. Kumagai, A. Kondo, S. Iwata and C. Morimoto, 2010. Aqueous extract of Carica papaya leaves exhibit anti-tumor activity and Immunomodulatory effects. J. Ethnopharmacol., 127: 760-767.
- Reynolds, T. 1995. Comparative chromatographic patterns of leaf exudate components from shrubby aloes. Botanical. J. Linnean Soc. 102: 273-285.
- Saldanha, L.G., 2003. Fibre in Diet of U.S Children: Results of National Survey. Pediatrics, 96: 994-996.
- Whitney, E.N. and S.R. Rolfes, 2005. Understanding Nutrition. 10th Edn., Thomson/Wadsworth Publishing Company, Belmont, CA., pp: 132-137.