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Research Paper

Estimation of nutritional and anti-nutritional factors in *Aloe vera* L. gel powder

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ABSTRACT : *Aloe vera* has marvelous medicinal properties. All the nutrients present in *Aloe vera* work together in a synergistic way to create healing and health giving benefits. Biological activities of *Aloe vera* include promotion of wound healing, antifungal activity, antidiabetic effects, anti-inflammatory, anticancer, immuno-modulatory and gastro-protective properties. Keeping in view the beneficial effects of *Aloe vera*, the present study was undertaken to analyze the nutritional and anti-nutritional factors in *Aloe vera* L. gel powder. *Aloe vera* L. gel powder was analyzed chemically for proximate composition, available carbohydrates, mineral content, dietary fibre constituents and anti-nutritional factors like tannins, saponins and phytic acid. It was found that *Aloe vera* L. gel powder had 11.9 per cent moisture, 5.8 per cent crude protein, 0.9 per cent crude fat, 0.4 per cent crude fibre, 4.8 per cent ash, 76.2 per cent carbohydrates and provided 336 kcal of energy. It had 1.20 per cent total sugars, 0.62 per cent reducing sugars, 0.58 per cent non-reducing sugars and 0.59 per cent starch. The concentrations of minerals zinc, chromium and iron were 2.35mg per cent, 0.09 mg per cent and 1.46 mg per cent, respectively. In dietary fiber constituents, *Aloe vera* L. gel powder had 0.4 per cent neutral detergent fibre, 0.3 per cent acid detergent fiber, 0.1 per cent hemicelluloses, 0.3 per cent cellulose and 0.4 per cent pectin. The amounts of antinutritional factors like saponins, tannins and phytic acid content in *Aloe vera* L. gel powder was 0.01 per cent, 0.01 per cent and 0.08 per cent, respectively.

KEY WORDS : *Aloe vera* L., Proximate composition, Available carbohydrates, Mineral content, Dietary fiber constituents, Anti-nutritional factors

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Aloe plant is a native of the parts of Africa, especially South Africa's Cape Province and the mountains of tropical Africa. It is also grown in subtropical and tropical locations including South America and Caribbean. *Aloe barbadensis* Miller is the only plant that is known to have legendary medicinal reputation dating back to thousands of years ago (Yebpella *et al*., 2011). With the recent resurgence of herbal products as a part of 'green movement', *Aloe vera* is witnessing a new renaissance across the world. Emphasis on agricultural diversification has led to a search of alternatives that are profitable and environment friendly. Global market data reveal that the opportunities are expanding in the herbal sector with market growth rate of 15 per cent per annum in India and 7 per cent per annum in the world. Total production of aloe in India is estimated to be about 1, 00,000 tones (Anonymous, 2006).

Indian farmers have been looking for some better alternative to diversify from traditional agriculture due to gradual reduction in profitability owing to decline in productivity, increased incidence of diseases and pest attack in traditional crops. Therefore, contingent upon their hardy nature and higher returns, medicinal plant cultivation (like *Aloe vera*) may be considered a better option (Gulia *et al*., 2009).

The aloe leaf can be divided into two major parts namely, the outer green rind, including the vascular bundles, and the inner colorless parenchyma containing the aloe gel. *Aloe vera* gel has got the potential to be used as a food preservative, as

a substitute of sulphur dioxide in preserving fruit and vegetables. It contains a number of nutrients such as vitamins, fatty acids, amino acids, sugars, minerals, enzymes therefore dried powder can be used in formulations as a functional ingredient for health benefits. Aloe leaf powder, which contains antioxidants, dietary fibre, iron, etc., may find its usage in number of ayurvedic medicines (Newton, 2004).

More than 200 chemical components have been identified from the leave pulp and exudates of *Aloe vera* plant (Ni and Tizard, 2004). The raw pulp of *Aloe vera* contains approximately 98.5 per cent water, while the mucilage or gel consists of about 99.5 per cent water (Eshun and He, 2004). The remaining 0.5 – 1 per cent solid material consists of a range of compounds including water-soluble and fat-soluble vitamins, minerals, enzymes, polysaccharides, phenolic compounds and organic acids (Boudreau and Beland, 2006). It has been hypothesized that this heterogeneous composition of the *Aloe vera* pulp may contribute to the diverse pharmacological and therapeutic activities which have been observed for aloe gel products (Talmadge *et al*., 2004).

The chemical composition of the leaf pulp and exudates was summarised to include anthraquinones/ anthrones, carbohydrates, chromones, enzymes, inorganic compounds, miscellaneous organic compounds and lipids, non-essential and essential amino acids, proteins, saccharides and vitamins (Hamman, 2008). The therapeutic properties of *Aloe vera* gel such as anti-inflammatory effects, wound healing effects, antibacterial, antiviral, antifungal, antidiabetic, anti-neoplatic activities and antioxidant effects are the function of the polysaccharide constituent (Ni and Tizard, 2004 and Ramachandra and Srinivasa, 2008). Other biological and physiological activities exhibited by the *Aloe vera* pulp include inhibition of AIDS virus by accemannan and inhibition of the prostaglandin synthesis by anthraquinone-type compound (Hassanuzzaman *et al*., 2008). Bozzi *et al*. (2007) studied the quality and authenticity of commercial aloe gel powders and came out with the findings that out of nine analyzed, only three products contained satisfactory amount of acemannan—a major carbohydrate fraction of *Aloe vera* gel and known to have antiviral and antitumoral activities *in vivo*. Gautam and Awasthi (2007) standardized process of making of *Aloe vera* leaf powder and evaluated nutritional and physico-chemical characteristics of the leaf powder.

Aloe vera has marvelous medicinal properties. It contains treasures of nutritional and antipathogenic compounds. They all work together in a synergistic way to create healing and health giving benefits. The composition of the plant has been a subject of considerable scientific research. Keeping in view the beneficial effects of *Aloe vera*, the present study was undertaken to analyze the nutritional as well as anti-nutritional factors in *Aloe vera* L. gel powder.

■ RESEARCH METHODS

Method to prepare *Aloe vera* L. gel powder:

Matured leaves of *Aloe vera* L. were initially washed in a water solution (200 ppm solution of sodium hypochlorite) and then further rinsed with a dilute solution of sodium hypochlorite (20 ppm). If leaves were extremely muddy then they were pre-washed with deionised water. In order to avoid contamination of internal fillet with the yellow sap, the traditional hand-filleting method of processing aloe leaves was developed. In this method, the lower 1 inch of the leaf base (the white part attached to the large rosette stem of the plant), the tapering point (2-4 inch) of the leaf top and the short, sharp spines located along the leaf margins were removed by a sharp knife, then the knife, was introduced into the mucilage layer below the green rind avoiding the vascular bundles and the top rind was removed. The bottom rind was similarly removed and the rind parts, to which a significant amount of mucilage remains attached, were discarded. The inner fillet was washed again ensuring that there was no possibility of bacterial contamination, after which, the fillet was cut in to pieces and dried in a hot air oven at a temperature of 50°C for a period of 12 h. The dried fillet then ground and stored for further study (Gulia *et al*., 2009).

Estimation of proximate composition:

Moisture, crude protein, crude fat, crude fibre and total ash of *Aloe vera* L. gel powder were determined in accordance with the method of the Association of Official Analytical Chemists (AOAC, 2000). The nitrogen free extract (NFE) was calculated by subtracting the sum of crude protein, crude fat, moisture and total ash content out of hundred. The energy content was calculated by factorial method.

Estimation of available carbohydrates:

Sugars and starch were extracted based on the methodology reported by Chow and Landhausser (2004).

Total soluble sugars:

The method reported by Yemen and Wills (1954) was used for the estimation of total soluble sugars. Briefly, 10 ml of freshly prepared anthrone reagent was pipetted in test tubes for sample, standard and blank and kept the test tubes in ice-cold chilled water. A 1.0 ml of sample extract and 0.2 to 1.0 ml of standard sugar solution (20-100 µg) were taken on 10 ml anthrone reagent in the test tube for preparation of standard curve layer. After 3-5 minutes, the contents were shaken, still the test tubes immersed in ice-cold water. The contents of test tube were heated vigorously in boiling water bath for 10 minutes and then cooled immediately in cold water. The absorbance was read at 625 nm against a blank. The standard curve was prepared and the concentration of total sugar in sample was calculated.

Reducing sugars:

Reducing sugars in *Aloe vera* L. gel powder were determined as per Somogyi (1945) method. A 1.0 ml sample extract was taken in a blood sugar test tube graduated at 25 ml and 0.2 to 1.0 ml of standard sugar solution (20-100 µg) and was taken for preparation of standard curve in series of test tube and water was added to make 1.0 ml. A 1.0 ml of mixed copper reagent was added to each of tubes and heated for 20 minutes in a boiling water bath. After that, 1.0 ml arsenomolyhdate reagent was added and contents were mixed thoroughly and diluted to 25 ml with water. The absorbance was read at 520 nm against a blank. The standard curve was prepared and the concentration of reducing sugars in sample was calculated. The amount of non-reducing sugars was calculated by taking the difference between total soluble sugars and reducing sugars.

Starch:

The content of starch was determined as per Clegg (1956) method. Five ml of water was added to residue which was left in centrifuge tube in the extraction of sugars and starch and 6.5 ml of 52 per cent perchloric acid was added while stirring the contents. The contents were stirred continuously for five minutes and then occasionally for next 15 minutes. Centrifugation was done after addition of 20 ml water. The supernatant was collected in 100 ml volumetric flask and again 5 ml of water was added to residue and repeated for next 30 minutes. The contents of tube were washed into volumetric flask containing first extract and volume was made up to 100 ml with distilled water. The extract was filtered and to 0.5 ml of dilute extract, cold anthrone sulphuric acid reagent (5 ml) was added. The test tubes were heated in boiling water bath for 8 minutes and were cooled to room temperature. The absorbance was read at 620 nm. The standard curve was prepared using glucose in the range of 10-100 µg. The content of starch was calculated by multiplying value of the concentration of glucose by a factor 0.9.

Estimation of mineral content:

Zinc:

For determination of zinc, 0.5 g of sample was digested using diacid mixture (HNO_3 : $HClO_4$: : 4 : 1) as per method given by Page *et al.* (1982) and their contents in the digests were determined after proper dilution. The digested material after cooling was diluted to 25 ml with deionised water and filtered through whatman filter paper No. 1. For estimation of Zinc content, the concentration of this micronutrient was measured on an atomic absorption spectrophotometer (AA240 FS-Varian model).

Chromium and iron:

For determination of chromium and iron, 0.5 g of sample was digested in a microwave sample preparatory systems (MSPS) using high purity concentrated nitric acid as per method given by Association of Official Analytical Chemists (AOAC, 2000). The digestion was completed within one hour. The digested samples were clear and found to be free from any suspended particles. The known volumes were prepared using A- class volumetric flasks. Standards of known concentration were prepared and calibration graph was plotted automatically on AAS. 0.20 micro litre of sample was injected in graphite furnace of AAS and concentrations were observed in micrograms per litre or ppb after 3 minutes.

Estimation of dietary fibre constituents:

Dietary fibre constituents were determined by Van Soest and Wines (1967) methods.

Estimation of anti-nutritional factors:

Tannins:

The method given by Singh and Jambunathan (1981) was used for the estimation of tannins. One gram of sample was taken in flask. 40 ml of 10 per cent methanol was added to it and refluxed for 1-2 hour in hot water bath with occasional shaking. Contents were then filtered and final volume was made 50 ml with methanol. For estimation, 0-10 ml aliquots of standard tannic acid solution and one ml of sample were pipetted into 100 ml volumetric flasks containing 75 ml water. To this, 5 ml Folin-Denis reagent and 10 ml saturated sodium carbonate solution were added and, diluted to volume with water. The absorbance was determined after 30 minutes at 760 nm. The amount of tannin was calculated from the standard curve.

Saponins:

Saponins were estimated as per Fenwick and Oakenfull (1983) method. Two grams of sample was homogenized in acetone (10 ml) for 24 hrs and then the solvent was removed. The above procedure was repeated by using methanol (10ml) as solvent. The methanol extract was allowed to cool and made to 50 ml with methanol. One ml of sample was taken in test tube and kept in boiling water bath at 100°C in order to remove alcohol and after cooling 2 ml of ethyl acetate was added. To this 1 ml of reagent A and 1 ml of reagent C were added. After stirring, the test tubes were kept in water bath maintained at 60°C for 20 min and then allowed to cool for 10 min at room temperature. The intensity of red color developed was measured at 430 nm. The amount of saponins was calculated from the standard curve using saponin (0-100µg) as standard.

Phytic acid:

The method given by Sadasivan and Manickam (1992) was used for the estimation of phytic acid. For extraction, 0.5g sample was extracted with 20 ml of 0.5 M nitric acid for 3-4 hour with continuous shaking. For estimation, 0.2-1.0ml of

the filtrate or standard sodium phytate solution was diluted with distilled water to a final volume of 1.4 ml to which 1.0 ml of a solution of ammonium ferric sulphate containing 50 µg iron was added. After mixing, stopper was placed on the test tubes and was kept in boiling water bath for 20 minutes. The test tubes were cooled to room temperature and 5 ml amyl alcohol was added to each test tube followed by 0.1 ml of a solution of ammonium thiocyanate. The contents of the test tube were immediately mixed by inversion and shaking. After centrifuging for a short time at low speed, the intensity of the colour in the amyl layer was determined at 465 nm using a spectrophotometer against an amyl alcohol 'blank' exactly 15 minute after addition of the ammonium thiocyanate solution. The amount of phytic acid was calculated from the standard curve.

Statistical analysis:

Samples for each estimation were taken in triplicates. Results were expressed as mean ± standard error (SE) (n = 3) for each determination on dry weight basis.

■ RESEARCH FINDINGS AND DISCUSSION

Aloe vera L. gel powder was analyzed chemically for proximate composition, available carbohydrates, mineral content, dietary fibre and anti-nutritional factors by using standard methods. The values had been calculated for 100 g of *Aloe vera* L.gel powder. *Aloe vera* L.gel powder had 11.9 per cent moisture, 5.8 per cent crude protein, 0.9 per cent crude fat, 0.4 per cent crude fibre, 4.8 per cent ash, 76.2 per cent carbohydrates and provided 336 kcal of energy (Table 1). Gautam and Awasthi (2007) also reported that *Aloe barbadensis* leaf powder contained 4.8 per cent crude protein, 2.2 per cent crude fat, 14.0 per cent total ash, 18.5 per cent crude fibre, 48.0 per cent carbohydrate and 231 kcal energy value. The results are in similar line with the reported value of the crude fat 2.1 per cent, crude protein 4.6 per cent and ash content 15.0 per cent (Gulia *et al*., 2009). *Aloe vera* gel powder had 1.20 per cent total sugars, 0.62 per cent reducing sugars, 0.58 per cent non-reducing sugars and 0.59 per cent starch (Table 1). Gautam and Awasthi (2007) reported that *Aloe barbadensis* leaf powder contained 0.76 per cent of reducing sugars as well as non-reducing sugars. Sirohi *et al*. (2009) found that *Aloe barbadensis* contained 2.28 per cent of total sugars.

The concentrations of minerals zinc, chromium and iron in *Aloe vera* L. gel powder was 2.35 mg per cent, 0.09 mg per cent and 1.46 mg per cent, respectively (Table 1). Rajendran *et al*. (2007) reported that concentration of zinc in *Aloe vera* leaf gel was more than 10 mg and concentrations of iron was 0.93 mg to 1.078 mg. Zinc is versatile, which has been well known to be an important trace element in diabetes as a cofactor for insulin. Abnormal zinc metabolism has been suggested to play a role in the pathogenesis of diabetes and /or its complications. Patients with diabetes mellitus tend to have low serum zinc and increased urinary excretion. Zinc has numerous targets to modulate insulin activity, including its antioxidant capacity. Zinc enhances the effectiveness of insulin. Zinc has a relatively low order of toxicity compared with most other trace elements. Chromium is considered to be an essential trace element for animals and humans. It acts as a cofactor in maintaining the normal metabolism of glucose. An insufficient dietary chromium intake could lead to impaired lipid metabolism and is thought to be associated with diabetes and/or cardio vascular disease (Garcia *et al*., 2001). Iron has several vital functions in the body, which mainly is involved in oxidation-reduction reactions (ETC), hemoglobin-oxygen transport and also a co-factor for numerous other enzymes (Lozak *et al*., 2002). *Aloe vera* L.gel powder had 0.4 per cent neutral detergent fibre, 0.3 per cent acid detergent fibre, 0.1 per cent hemicellulose, 0.3 per cent cellulose and 0.4 per cent pectin (Table 1).

In anti-nutritional factors, *Aloe vera* L. gel powder had 0.01 per cent tannins, 0.01 per cent saponins and 0.08 per cent phytic acid (Table 1). Similar to findings of the present study, Sirohi *et al*. (2009) also found that *Aloe barbadensis* contained

Table 1 : Chemical composition of *Aloe vera* L. gel powder

Proximate composition[c]	
Moisture %	11.9 ±0.02
Crude protein %	5.8±0.03
Crude fat %	0.9±0.01
Crude fiber, %	0.4±0.01
Ash %	4.8±0.02
NFE %	76.2±0.02
Energy (Kcal)	336±0.01
Available carbohydrates[c]	
Total soluble sugars %	1.20±0.05
Reducing sugars %	0.62±0.02
Non reducing sugars %	0.58±0.03
Starch %	0.59±0.02
Mineral content[c]	
Zinc mg%	2.35±0.01
Chromium mg%	0.09±0.03
Iron mg%	1.46±0.05
Dietary fibre constituents[c]	
Neutral detergent fiber, %	0.4±0.01
Acid detergent fiber, %	0.3±0.01
Hemicellulose, %	0.1±0.03
Cellulose %	0.3±0.01
Lignin, %	0.0±0.00
Pectin, %	0.4±0.02
Anti-nutritional factors[c]	
Tannins, %	0.01±0.02
Saponins, %	0.01±0.03
Phytic acid, %	0.08±0.02

Values represent Mean±SE [c] On dry weight basis

0.16 per cent of total tannins and 0.01 per cent of total saponins. The phytochemical screening done by Yebpella *et al*. (2011) revealed that tannins and saponins were present in *Aloe vera* extracts.

Conclusion:

This work on estimation of nutritional and anti-nutritional factors in *Aloe vera* L. gel powder showed that *Aloe vera* L. gel powder contained good amount of available carbohydrates, and mineral content like iron, zinc and chromium. Dietary fibre constituents were present in very less amount in *Aloe vera* L. gel powder. The presence of anti-nutritional factors like tannins, saponins and phytic acid was negligible.

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■ REFERENCES

Anonymous (2006). Database on important medicinal and aromatic plants. (Ministry of Commerce Directorate General of Foreign Trade, Government of India, New Delhi).

AOAC (2000). Official methods of analysis of AOAC (17th Ed.). Gaithersburg, MD: AOAC International.

Boudreau, M.D. and Beland, F.A. (2006). An evaluation of the biological and toxicological properties of *Aloe barbadensis* Miller, *Aloe vera*. *J. Environ. Sci. Health*, **24** : 103-154.

Bozzi, A., Perrin, C., Austin, S. and Arce, F. (2007). Quality and authenticity of commercial aloe gel powders. *Food Chem.*, **103** : 22–30.

Chow, S.P. and Landhausser, M.S. (2004). A method for routine measurements of total sugar and starch content in woody plant tissues. *Tree Physiol.*, **24**: 1129 –1136.

Clegg, K.M. (1956). The application of anthrone reagent to the estimation of starch in cereals. *J. Sci. Food Agr.*, **7** : 40.

Eshun, K. and He, Q. (2004). *Aloe vera*: a valuable ingredient for the food, pharmaceutical and cosmetic industries – A review. *Crit. Rev. Food Sci. Nutr.*, **44**: 91-96.

Fenwick, D. and Oakenfull, D. (1983). Saponin content of food plants and some prepared foods. *J. Sci. Food Agr.*, **34** :186-191.

Garcia, E., Cabrera, C., Lorenzo, L.M., Lopez, C.M. and Sanchez, J. (2001). Estimation of chromium bioavailability from the diet by an *in vitro* method. *Food Add. & Contam.*, **18** : 601-606.

Gautam, S. and Awasthi, P. (2007). Nutrient composition and physico-chemical characteristics of *Aloe vera* (*Aloe barbadensis*) powder. *J. Food Sci. Technol.*, **44** : 224–225.

Gulia, A., Sharma, H.K., Sarkar, B.C., Upadhyay, A. and Shitandi, A. (2009). Changes in physico-chemical and functional properties during convective drying of *Aloe vera* (*Aloe barbadensis*) leaves. *Food Bioprod. Process*, **30** : 1-4.

Hamman, J.H. (2008). Composition and application of *Aloe vera* leaf gel. *Molecules*, **13**: 1599-1616.

Hassannuzzaman, M., Ahmed, K.U., Khilequzzaman, K.M., Shamsuzzaman, A.M.M. and Nahr, K. (2008). Plant characteristics, growth, and leaf yield of *Aloe vera* as affected by organic manure in pot culture. *Aust. J. Crop Sci.*, **2** : 158-163.

Lozak, A., Soltyk, K. and Ostapczuk, P. (2002). Determination of selected trace elements in herbs and their infusions. *Sci. Total Environ.*, **289** : 33-40.

Newton, L.E. (2004). Aloes in habitat. In Reynolds, T. (Ed.), *Aloes: The Genus Aloe*. Boca Raton : C.R.C. Press, pp. 3-36.

Ni, Y. and Tizard, I.R. (2004). Analytical methodology: the gel-analysis of aloe pulp and its derivatives. In Reynolds, T. (Ed.), *Aloes: The Genus Aloe*. Boca Raton:CRC Press. pp. 111-126.

Page, A.L., Miller, R. H. and Keeney, D. R. (1982). *Methods of soil analysis*. (2nd Ed.). American Society of Agronomy, Madison, WI, USA.

Rajendran, A., Narayanan, V.and Gnanavel, I. (2007). Study on the analysis of trace elements in *Aloe vera* and its biological importance. *J. App. Sci. Res.*, **3**: 1476-1478.

Ramachandra, C.T. and Srinivasa, R.P. (2008). Processing of *Aloe vera* gel: A review. *Res. J. Agric. & Biol. Sci.*, **3**:507-510.

Sadasivam, S. and Manickam, A. (1992). *Biochemical methods*, New Age International (P) Limited Publishers, New Delhi, pp. 205-206.

Singh, U. and Jambunathan, R. (1981). Studies on desi and kabuli chickpea cultivators. The level of protese inhibitors, level of phenolic compounds and *in vitro* digestibility. *J. Food Sci. Technol.*, **46**:1364.

Sirohi, K.S., Pandey, N., Goel, N., Singh, B., Mohini, M., Pandey, P. and Chaudhary, P.P. (2009). Microbial activity and ruminal methanogenesis as affected by plant secondary metabolites in different plant extracts. *Internat. J. Environ. Sci. Tech.*, **1**: 52-58.

Somogyi (1945). A new reagent for the detergent of sugars. *Biol. Chem.*, **160**: 61-68.

Talmadge. J., Chavez, J., Jacobs, L., Munger, C., Chinnah, T., Chow, J.T., Williamson, D. and Yates, K. (2004). Fractionation of *Aloe vera* L. inner gel, purification and molecular profiling of activity. *Internat. Immunopharmacol.*, **4** : 1757-1773.

Van Soest, P.J. and Wines, R.H. (1967). Use of detergents in the analysis of fibrous feeds. IV. Determination of plant cell-wall constituents. *J. Assoc. Offic. Anal. Chem.*, **50**: 50–55.

Yebpella, G.G., Adeyemi, H.M.M., Hammuel, C., Magomya, A. M., Agbaji, A. S. and Okonkwo, E. M. (2011). Phtyochemical screening and comparative study of antimicrobial activity of *Aloe vera* various extracts. *Afr. J. Microbiol. Res.*, **5** : 1182-1187.

Yemen, E.W. and Willis, A.J. (1954). The estimation of carbohydrates in plant extracts by anthrone. *Biochem. J.*, **57** : 508-514.

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