Determination and Comparative Study of Mineral Elements and Nutritive Value of some Common Fruit Plants

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Owing to diverse agro climatic conditions, India is endowed with a wide variety of plants, both wild growing and domesticated, which contribute to the diet of its people. Nutritional contribution and nutritive value of fruits have been extensively studied but, there is practically no information on nutritive value of their bark which may contribute significantly to the nutrient intake of local population. Fruit plants viz; Phyllanthus emblica (Amla), Aegle marmelos (Bael) and Carica papaya (Papita) are very important fruit plants in all over India. These plants have great importance due to their economic value, nutritive value and major source of medicines as they have been found through out human history. The present course of study reveals the elements in bark of the fruits (Amla, Bael & Papaya) as well as the nutritive value of their bark. Macro and microelement contents of bark of three fruit plants (Phyllanthus emblica, Aegle marmelos and Carica papaya) were evaluated by the use of inductively coupled plasma (ICP-MS) technique. The plant parts showed sufficient mineral elements, most of which have been found to be common among them with good nutritive value and rich in carbohydrate, enough protein and fat content.

Keywords: *Phyllanthus emblica*, *Aegle marmelos* and *Carica papaya*. Mineral elements, Nutritive value.

1. INTRODUCTION

India is endowed with a wide variety of plants, both wild growing and domesticated, which contribute to the diet of its people. Depending upon certain factors like availability, socio economic condition, tradition, taste, and culture, some of these fruits are regularly consumed, others are taken rarely. Nutritional contribution and nutritive value of fruits have been extensively studied but, there is practically no information on nutritive value of their bark which may contribute significantly to the nutrient intake of local population. The present course of investigation reveals the elements in bark of the fruits (Amla, Bael & Papaya) as well as the nutritive value of their bark.

The knowledge of the elemental content of fruit plants is important because it may influence the production of their active constituents and their pharmacological action [1,2]. Active constituents of plant are metabolic products of plant cells and a number of trace elements play an important role in metabolism. Survey of the literature on the analysis of fruits plants reveals that studies on these plants pertain mainly to their organic contents, e.g., essential oils, vitamins, alkaloids, glycosides, and other active components and their pharmacological effects and a little is reported about their trace elemental composition. Hence, it is thought of interest to analyze the major, minor, and trace elemental content of bark of fruit plants commonly found in India [2].

Macro and microelement contents of bark of three fruit plants (*Phyllanthus emblica*, *Aegle marmelos* and *Carica papaya*) were evaluated by the use of inductively coupled plasma mass spectroscopy (ICP-MS) technique. The analytical method allows the determination of 82 elements in plant bark. ICP technique is well suited for the analytical detection of elements in order to ascertain the nutritional role of fruit plants and the daily dietary intake.

2. MATERIALS AND METHODOLOGY

The samples were collected from different regions of capital city New Delhi. Bark of Amla (*Phyllanthus emblica*) was collected from the premises of Shri Aurbindo Ashram, New Delhi, bark of Bael (*Aegle marmelos*) and bark of Papaya (*Carica papaya*), were from premises of R. K. Puram, New Delhi. They are stored in plastic sealing bags. The plant bark were washed with deionised water and disinfected with 0.1 % $HgCl_2$ solution for 5 min and dried in shade to prepare the sample for mineral analysis, the washed and dried materials were ground to fine powder with mortar and pestle, then used for dried ashing.

For analysis of elements the powdered plant shoot was taken in precleaned and constantly weighed silica crucible and heated in a muffle furnace at 400°C till there was no evolution of smoke. The crucible was cooled at room temperature in a desiccator and carbon-free ash was moistened with concentrated sulphuric acid and heated on a heating mantle till fumes of sulphuric acid ceased to evolve. The crucible with sulphated ash was then heated in a muffle furnace at 600°C till the weight of the content was constant (~2–3 h).

The samples were weighed before and after ashing to determine the concentration of ash present. The prepared ash sample was introduced in ICP-MS to determine elemental content of sample. The ICP-MS allows determination of elements with atomic mass ranges 7 to 250. This encompasses Li to U.

For determination of nutritive value, various parameters (Ash content, Moisture content, Percent Fat, Percent Protein & Percent Carbohydrate) were studied using the crushed plant material. For determination of moisture content, the sample materials were taken in a flat-bottom dish and kept overnight in an air oven at 100–110°C and weighed. The loss in weight was regarded as a measure of moisture content. Crude fat was determined by extracting 2 gm moisture free sample with petrol in a Soxhlet extractor, heating the flask on a sand-bath for about 6 h till a drop taken from the drippings left no greasy stain on the filter paper. After boiling with petrol, the residual petrol was filtered using Whatman no. 40 filter paper and the filtrate was evaporated in a pre-weighed beaker. Increase in weight of beaker gave crude fat.

The crude protein was determined using micro Kjeldahl method. Two grams of oven-dried material was taken in a Kjeldahl flask and 30 ml conc. H_2SO_4 was added followed by the addition of 10 gm potassium sulphate and 1 gm copper sulphate. The mixture was heated first gently and then strongly once the frothing had ceased. When the solution became colourless or clear, it was heated for another hour, allowed to cool, diluted with distilled water and transferred to an 800 ml Kjeldahl flask, washing the digestion flask. Three or four pieces of granulated zinc, and 100 ml of 40% caustic soda were added and the flask was connected with the splash heads of the distillation apparatus. Next 25 ml of 0.1 N sulphuric acid was taken in the receiving flask and distilled. When two-thirds of the liquid had been distilled, it was tested for completion of reaction. The flask was removed and titrated against 0.1 N caustic soda solution using methyl red indicator for determination of Kjeldahl nitrogen, which in turn gave the protein content.

2.1. Formulae

Percentage of carbohydrate was given by:

100 – (percentage of ash + percentage moisture + percentage fat + percentage protein).

Nutritive value is finally determined by:

Nutritive value = 4 X percentage of protein + 9 X percentage of fat + 4 X percentage of carbohydrate.

3. RESULTS AND DISCUSSION

Table 1: Concentration of various elements (in ppm) in bark of three plants.

ELEMENTS ↓	**PLANTS**		
	Phyllanthus emblica	***Aegle marmelos***	***Carica papaya***
Aluminium (Al)	11.611	5.46	3.42
Boron (B)	10.575	5.88	3.80
Bismuth (Bi)	0.414	0.210	1.33
Calcium (Ca)	18.45	18.71	16.95
Chromium (Cr)	0.414	0.63	0.380
Copper (Cu)	0.622	0.630	0.380
Iron (Fe)	17.21	12.19	12.762
Lithium (Li)	ND	0.210	ND
Magnesium (Mg)	1.036	1.051	0.952
Manganese (Mn)	7.05	3.57	4.762
Molybdenum (Mo)	ND	ND	0.190
Sodium (Na)	ND	44.14	ND
Nickel (Ni)	ND	1.26	0.190
Lead (Pb)	0.207	ND	ND
Strontium (Sr)	0.414	0.420	22.28
Titanium (Ti)	9.123	0.21	16.38
Zinc (Zn)	7.87	3.153	4.00

Results of various elements detected in all the three plant materials have been summarized in Table 1 and graphical representation of the common elements have been shown in Figure 1.

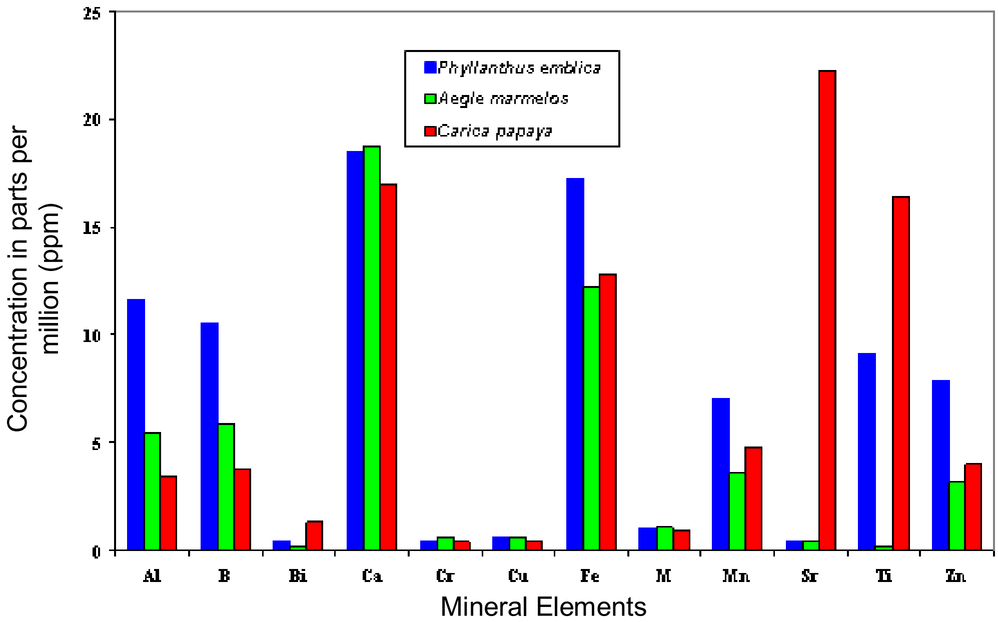

Fig. 1: Concentration of elements found to be common in all three plants in ppm.

Altogether 17 elements (Al, B, Bi, Ca, Cr, Cu, Fe, Li, Mg, Mn, Mo, Na, Ni, Pb, Sr, Ti, Zn) have been detected, out of which 12 elements (Al, B, Bi, Ca, Cr, Cu, Fe, Mg, Mn, Sr, Ti and Zn) were found to be common in all the plant material and 5 elements (Li, Mo, Na, Ni and Pb) were present in either one or more than one plant material. Lithium and Sodium was found to be present in only *Aegle marmelos,* similarly Molybdenum was found only in *Carica papaya*, Nickel was present in *Aegle marmelos* and *Carica papaya* and Lead was present only in *Phyllanthus emblica.*

Aluminium (Al) was found to be highest in *P. emblica* in comparison to other two materials. Intermediate range was present in *A. marmelos* and lowest in *C. papaya.* Aluminum has only recently been considered a problem mineral. Though it is not very toxic in normal levels, neither has it been found to be essential. It is present in only small amounts in animal and plant tissues. Recent investigations, however, implicate aluminum toxicity in Alzheimer's disease and other brain and senility syndromes. The evidence of aluminum's toxicity or essentiality is not conclusive as yet [3]. Most of this mineral is found in the lungs, brain, kidneys, liver, and thyroid. Our daily intake of aluminum may range from 10-110 mg, but the body will eliminate most of this in the feces, urine and some in the sweat. With decreased kidney function, more aluminum will be stored, particularly in the bones [4]. **Boron (B)** was also found to be present in the same order as that of Aluminium, i.e., highest in *P. emblica*, intermediate in *A. marmelos* and lowest in *C. papaya.* The range present in *P. emblica* was almost double and more than that in other two materials respectively [3]. In human body Boron (B) assists and improves retention of calcium, magnesium, and phosphorus; necessary for brain function, memory and alertness as well as for the activation of vitamin D [4]. **Bismuth (Bi)** was found to be present highest in *C. papaya* and lowest in *A. marmelos.* Bismuth is essentially nontoxic in ordinary amounts, but prolonged exposure or excessive use may lead to toxicity. This could cause mental confusion, memory loss, in co-ordination, slurred speech, joint pain, or muscle twitching and spasm. The human body contains about 3 mg. of bismuth [4]. It is present in almost trace amount in the plant material except in *C. papaya.* **Calcium (Ca)** was found in almost equal quantity in all the plant materials. Calcium play important role in building and maintaining strong bones and teeth also large part of human blood and extra cellular fluids [3]. It is also necessary for normal functioning of cardiac muscles, blood coagulation, milk clotting and regulation of cell permeability [5]. Calcium deficiency causes rickets, back pain, osteoporosis, indigestion, irritability, premenstrual tension and cramping of the uterus [4,5,6,7]. **Chromium (Cr)** has quite low percentage in all the studied materials. It was comparatively higher in *A. marmelos*. Chromium plays a vital role in metabolism of carbohydrates and its deficiency leads to diabetes in human body [4,8]. Deficiency of chromium results in hyperglycaemia, growth failure, neuropathy, cataract and atherosclerorsis [4,9,10,11]. **Copper (Cu)** was found to be in sufficient quantity in all the plant material, with highest in *A. marmelos*. Cu is a component of many enzyme systems such as cytochrome oxidase, lysyl oxidase and ceruloplasmin, an iron-oxidizing enzyme in blood [12]. The observation of anaemia in Cu deficiency may probably be related to its role in facilitating iron absorption and in the incorporation of iron into haemoglobin [4,7,13]. **Iron (Fe)** Iron was found to be sufficient in all studied plant materials, being highest in *P. emblica*. In human beings it make body tendons and ligaments, certain chemicals of brain are controlled by presence or absence of Iron, it is essential for formation of hemoglobin, carry oxygen around the body [4,14]. Iron deficiency causes anemia, weakness, depression, poor resistance to infection [15]. **Magnesium (Mg)** was found to be very less in all the plant materials. Lack of chlorophyll in stem was one of the main reasons for its absence. In humans, Mg is required in the plasma and extracellular fluid, where it helps maintain osmotic equilibrium [3]. It is required in many enzyme catalysed reactions, especially those in which nucleotides participate where the reactive species is the magnesium salt, e.g. $MgATP^{2-}$. Lack of Mg is associated with abnormal irritability of muscle and convulsions and excess Mg with depression of the central nervous system [4,16,17]. **Manganese (Mn)** was found to be in moderate quantity in all the plant materials. Highest reported in *P. emblica* and lowest in *A. mamelos*. Manganese is cofactor for some enzymes; because it is found with lecithin, it is involved in the synthesis of fatty acids and cholesterol; strengthens nerves and thought processes; element in body linings and connective tissues; helps with eyesight; enhances body's recuperative abilities and resistance to disease [4,18]. **Strontium (Sr)** was found to be in trace in *P. emblica* and *A marmelos*, but unexpectedly high in *C. papaya*. There is no evidence yet that strontium is an essential mineral. Our body contains about 300-350 mg, nearly 99 percent of it in the bones and teeth [3]. It closely resembles calcium chemically and can actually displace it. It forms strontium bone salts, which may actually be slightly stronger than those of calcium [4]. **Titanium (Ti)** was found to be high in *C. papaya* and *P. emblica* but in very less amount in *A. marmelos*. There is no known biological role for titanium [3]. There is a detectable amount of titanium in the human body and it has been estimated that we take in about 0.8 mg/day, but most passes through us without being adsorbed. It is not a poisonous metal and the human body can tolerate titanium in large doses [4]. **Zinc (Zn)** was found to be present in moderate amount in plant materials, highest in *P. emblica* and almost half of its amount in other two plant materials. Zn is a component of many metallo-enzymes, including some enzymes which play a central role in nucleic acid metabolism [4,12]. In addition, Zn is a membrane stabilizer and a stimulator of the immune response [4,19]. Its deficiency leads to impaired growth and malnutrition [20]. **Lithium (Li)** was only detected in *A. marmelos* and that also in trace amount. It is thought to stabilize serotonin transmission in the nervous system; it influences sodium transport; and it may even increase lymphocytic (white blood cell) proliferation and depress the suppressor cell activity, thus strengthening the immune system. There is also speculation that lithium is in some way involved in cancer genesis or prevention [3]. Deficiency of lithium is not really known. The theory that a deficiency of lithium can cause an increase in depression has not been adequately proved [4]. **Molybdenum (Mo)** was reported only in *C.papaya* in very less quantity. Molybdenum is a vital part of three important enzyme systems xanthine oxidase, aldehyde oxidase, and sulfite oxidaseand. So it has a vital role in uric acid formation and iron utilization, in carbohydrate metabolism, and sulfite detoxification as well [3]. In the soil and possibly in the body, as the enzyme nitrate reductase, molybdenum can reduce the production or counteract the actions of nitrosamines, known cancer-causing chemicals, especially in the colon [4]. **Sodium (Na)** was reported only in *A. marmelos* in very less quantity. Sodium take part in ionic balance of the human body and maintain tissue excitability. Because of the solubility of salts, sodium plays an important role in the transport of metabolites [4,21]. **Nickel (Ni)** was found to be present in *A. marmelos* and *C. papaya*. The biological function of nickel is still somewhat unclear. Nickel is found in the body in highest concentrations in the nucleic acids, particularly RNA, and is thought to be somehow involved in protein structure or function. It may activate certain enzymes related to the breakdown or utilization of glucose. Nickel may aid in prolactin production, and thus be involved in human breast milk production. Most of the information about nickel comes from testing with animals, and its relevancy to humans is still not proven [4]. **Lead (Pb)** was reported only in *P. emblica* in very much low amount. The heavy metal lead is the most common toxic mineral and the most abundant contaminant of our environment and our body. Lead is a neurotoxin and commonly generates abnormal brain and nerve function. It passes into the brain and can also contaminate the in-utero fetus and breast milk. It is very harmful to the human body [4].

Results of ash, moisture, fat, protein and carbohydrate percentage of all three plant materials have been analysed in Table 2 and comparatively represented in Figure 2, similarly nutritive value have been reported in Table 3 and comparatively analysed in Figure 3.

Table 2: Percentage of Ash, Moisture, Fat, Protein and Carbohydrate.

Plants ↓	Ash Content	Moisture Content	Crude Fat	Crude Protein	Crude Carbohydrate
P. emblica	16.71	34.29	2.46	38.87	7.67
A. marmelos	4.12	4.9	11.58	49.60	29.8
C. papaya	1.8	20.21	3.34	43.69	30.96

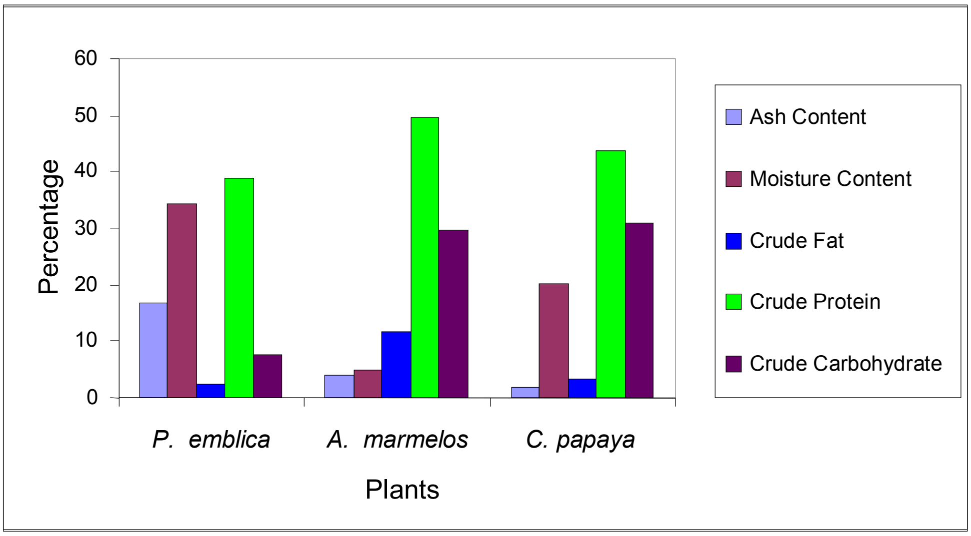

Fig. 2: Percentage of Ash, Moisture, Fat, Protein and Carbohydrate.

Nutritive value of shoots of *A. marmelos* was reported to be maximum followed by *C. papaya* and *P. emblica*; on a Dry Matter (DM) basis. These fruit plants have good nutritive value, which supports their use as food, medicine and good source of various important nutrients. The crude protein, fat and carbohydrate on DM basis shows variation in there content.

Comparing reports of all three plants the moisture content was found to be highest in *P. emblica* (34.29 %), followed by *C. papaya* (20.21 %) and *A. marmelos* (4.9 %). Dry nature of *A. marmelos* is further supported by its some what inclination towards xerophytic nature. Moisture content can also be compared with their nature of fruits.

Table 3: Nutritive Value of Plant Materials

S. No.	PLANTS	Nutritive Value [Cal/100 gm]
1	*Phyllanthus emblica*	208.30
2	*Aegle marmelos*	421.82
3	*Carica papaya*	328.66

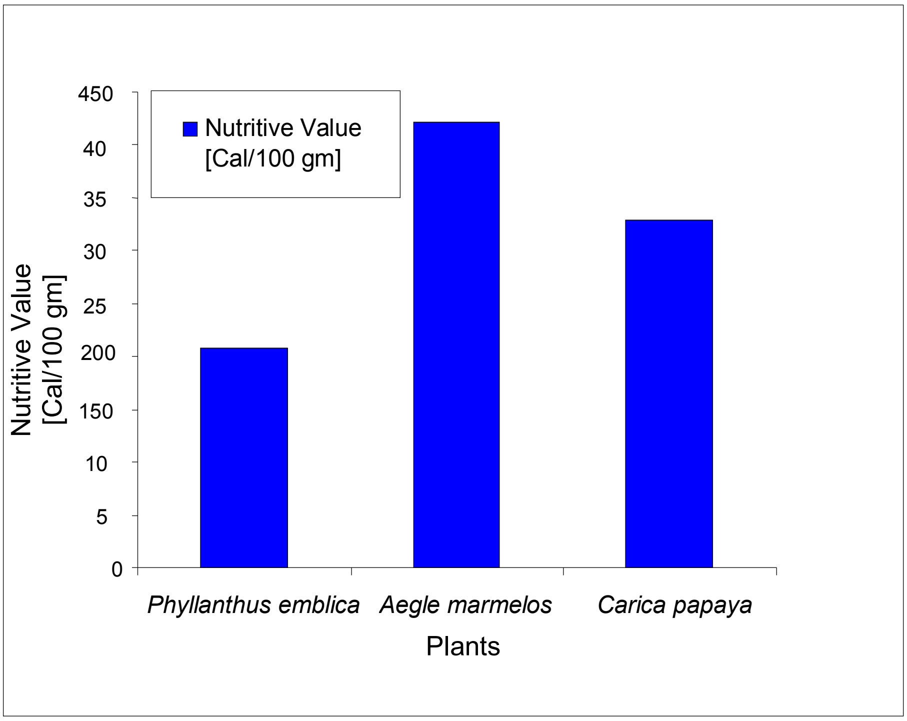

Fig. 3: Evaluation of Nutritive Value [Cal/100 gm].

Crude fat was found to be highest in *A. marmelos* (11.58%) followed by *C. papaya* (3.34%) and *P. emblica* (2.46%). In comparative analysis the fat content in the bark of *A. marmelos* was found to be very much higher in comparison to other two plant materials. It has also some co-relation with the moisture content. Fat content being hydrophobic in nature can be present in adequate amount only in absence of water.

Crude protein was also reported to be in the same sequence as that of crude fat, i.e., highest in *A. marmelos* (49.60%) followed by *C. papaya* (43.69%) and *P. emblica* (38.87%). Protein content in all the three plant materials do not show much variations making them equally nutritive for protein.

On calculating the carbohydrate percentage in al three plant materials, it was found that their was very minor difference in values of *C. papaya* (30.96%) and *A. marmelos* (29.8%). Crude carbohydrate in *P. emblica* was found to be very less (7.67%).

If we over all analyse and compare the elements and nutritive value of plant parts tested we come to the conclusion that the bark of *Aegle marmelos* have good amount of carbohydrate, fat and sufficient amount of protein with suitable mineral element and showing high Nutritive value. On dry matter basis these fruit plants shows high Nutritive value with maximum percentage of important minerals, which can be used for health care and also in preparation of nutritive compounds. The significance of fruits of these plants is well known and studied but by determining the elements and nutritive value of bark can give other direction to exploit them and use them for welfare of mankind.

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