Indian Journal of Natural Products and Resources
Vol. 10(3), September 2019, pp. 200-209

Physico-chemical parameters and nutritive value of *Pavetta crassicaulis* Bremek and *Olea dioica* Roxb. collected from Western Ghats region of Karnataka

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Received 06 June 2016; Revised 17 February 2019

Pavetta crassicaulis and *Olea dioica* are two unexplored medicinal plants used by some of the tribal communities in India, in curing different ailments such as, fever, headache and cancer. The flower of *P. crassicaulis* and the fruit of *O. dioica* were eaten by the tribes of Mizo's, Mizoram and locals of Kerala respectively. The present study was aimed to investigate the physico-chemical, elemental composition and nutritive value of selected medicinal plant parts such as. From this experiment, it is revealed that mainly leaf, stem and root have the highest macro and micronutrients. But, even though the flower of *P. crassicaulis* and fruit of *O. dioica* have moderate macro and micronutrients showed excellent nutritive value due to higher crude protein, fat and carbohydrate. From the results, it is concluded that the flower of *P. crassicaulis* and fruit of *O. dioica* is loaded with higher crude protein, fat and carbohydrate along with appreciable macro and micronutrients. The study also gave positive feedback on the traditional use of tribes in Mizoram and tribes in Kerala, India.

Keywords: Heavy metals, Macronutrients, Micronutrients, Nutritive value, *Olea dioica* Roxb, *Pavetta crassicaulis* Bremek, Physico-chemical parameter.

IPC code; Int. cl. (2015.01)- A61K 36/00

Introduction

Plants are the main resources of food as well as medicine in maintaining human health. Medicinal plants were naturally yielding treasured phytochemicals in stress is often used in the treatment of various human ailments. During the evolution of the human race have been using selected medicinal plants to cure diseases. But most of the medicinal plants not only cure diseases but, also have some nutritional value. In ancient times, ancestors teach their offspring to eat seasonal fruits to improve the immunity and healthy life, literally means that wild edible fruits have a specific formula of nutrients, with medicinal compounds to improve resistance in human body[1].

Nutritive value can be evaluated by measuring carbohydrates, proteins, fat, fibre along with macro and micro nutrients[2], these molecules are indirectly or directly involved in different human body process like antimicrobial resistance, reducing reactive oxygen species, works as signalling molecules in activating hormonal or enzyme pathway and keeps the body fit and healthy[3].

Leafy vegetables and sprouted cereals are the richest sources of protein as well as, minerals, macronutrients, micronutrients, vitamins and energy. Different types of elements have the property of neutralizing protein toxicity and prevent osteoporosis results in leaching of blood from the bone[4].

Fibre contains major fractions like cellulose, hemicellulose, pectin, lignin and other cell filaments, having a key role in decreasing the risk of cardiovascular disease, digestive disorders, constipation, diabetes, obesity and also clean the digestive track effectively[5].

Determination of mineral elements in edible parts of the known and unknown plants is necessary, because, the concentration of minerals present in the edible part is either in lower levels or in a toxic level, will determine the amount of edible part must consume per day. Quality of many fresh or preserved food depends on the concentration of minerals at a sufficient level, play an important role in human metabolism[6].

In local folkloric medical methods of *Mizos*, Mizoram, India, *Pavetta crassicaulis* Bremek plant

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parts like bark pulverized or in decoction is used for visceral obstructions arthritis. Leaves and roots are used in poultices for boils and itches, whereas decoction of leaves are used externally for hemorrhoidal pains. The root of this plant is bitter and is given in visceral problems and dropsy. The bark is formulated and used in the treatment of epilepsy. Boiled leaves are used to cure hemorrhoids, urinary complaints, and anticephalagic. Fruits are used as anthelmintic. *P. crassicaulis* flowers are eaten fried[7].

The roots of the *Olea dioica* Roxb. have many medicinal properties and are used for the treatment of cancer and snake bite in Siddha medicine. In Maharashtra, the tribes use *O. dioica* fruits for treatment of skin disease. Bark and fruit paste are used in the treatment of rheumatism; decoction of the bark is used to wash old wounds and given to counter fever[8]. Ripe fruits are eaten and traditionally used by the tribes in Kerala forest[9-10].

The present study was undertaken to evaluate the nutritive properties and elemental composition of two selected medicinal plants.

Materials and Methods

Study area

The field study was conducted in Western Ghats regions of Karnataka by covering specific regions like Agumbe, Chakra, Sagara, and Sringeri located in Shivamogga and Chikkamagaluru districts of Karnataka, India, situated in the central Western Ghats region. Climate condition varies with the altitude also plays a vital role in the formation of different type of vegetation. Being tropical region Western Ghats experience humid and warm condition throughout the year with an average temperature of 24-26ºC. The forest type varies with the place to place in the Western Ghats like Evergreen forest present in Agumbe, semi-evergreen, dry deciduous forest types were found in Chakra and Sringeri followed by dry deciduous forest found in Sagara. The study area receives the maximum rain during the South West Monsoon with average rainfall 250-310 cm, the peak period of rainfall is in between June to August[11].

The study places were situated between Chikkamagaluru (13°18' N and 75°49' E) and Shivamogga (13°56' N and 75°38' E) having rich biodiversity and total of 5000 square miles with average rainfall of 190 cm, average temperature is 24-28 ºC and average relative humidity is about 60-90%. Vegetation is varying with the altitude; highest peak will have shola grassland and lowest with moist deciduous with small patches of evergreen forest[12].

Collection and identification of plant materials

The plant Sample of *Pavetta crassicaulis* and *Olea dioica* were collected during the summer and winter season of the year 2014, in the following latitude and longitude places viz., Agumbe - 13.71' N, 75.12' E, Chakra - 13.81' N, 74.96' E, Sringeri - 13.43' N, 75.26' E, Sagar - 14.14' N, 74.96' E. Samples were carefully cleaned and kept in airtight plastic bags. Plant samples were authenticated and herbarium was kept in the Department of Applied Botany Kuvempu University Shankaraghatta, Shivamogga district of Karnataka, India, with voucher specimen number (KU/AB/RN/AN-1&2-2014-15).

Preparation of plant sample

Plant materials like leaf, bark, root, flower and fruits of the *P. crassicaulis* and *O. dioica* were collected from the study area and they were washed with water and dried in shade. The dried materials were ground to a powder. The powder was used for the determination of mineral composition and nutritive values. For micro and macronutrient analysis plant samples were digested with nitric acid-hydrochloric acid (1:3) and make it up to 50 mL by volumetric flask. The analysis was done at GKVK Bengaluru, India.

Elemental analysis

The macroelements *viz*., sodium and potassium were analyzed by Flame photometer- Jenway-PFP-7 FPM Compressor unit- 122. The phosphorus was analyzed by Jenway 6300 spectrophotometer. The microelements *viz*., calcium, magnesium, zinc, copper, manganese, lead, and cadmium were analyzed by using atomic absorption spectra GBC 932 AA/AAS.

Atomic absorption spectra analysis the plant samples were predigested with nitric acid (HNO_3) and HCl in the ratio of 1:3 for 1-4 hour depending upon the plant sample. Then, the sample is kept over a hot water bath (95 ºC) for 4-5 hours until the sample completely dissolved[13].

Physico-chemical parameters

Physico- chemical parameters such as, foreign matter, pH, water-soluble extractive, alcohol soluble extractive, total ash content, water-soluble ash and acid insoluble ash were determined by using standard procedures and protocols[14].

Elemental composition and Nutritive value

The microelements sodium and potassium were analyzed by Flame Photometer- Jenway-PFP-7 FPM Compressor Unit- 122. The phosphorus was analyzed by Jenway 6300 Spectrophotometer. The microelements calcium, magnesium, zinc, copper, manganese, iron, lead and cadmium were analyzed by atomic absorption spectra GBC 932 AA/AAS. Nutritive value was finally determined by using standard procedure[15].

Determination of macroelements

Macro elements such as crude Carbohydrates, crude fat, crude protein along with crude fiber and moisture content was determined using standard protocols[16].

Acute Toxicity Test

The plant parts were shade dried for 30 days and cold extracted with ethanol. The concentrated ethanolic extract was stored in a sterile container. Twenty-five mice of both sexes were randomly grouped into five groups (A-E) of five mice each. Groups A, B, C, D, and E mice were dosed with 100, 500, 1000, 2000, and 3000 mg/kg respectively orally by gastric gavage. The animals were given free access to feed and water. They were observed over a period of 24 hours for signs of toxicity and mortality[17].

Data analysis

The experiment is triplicated and the result was presented as Mean±SEM, the data was analyzed in the statistical software Prism.

Results and Discussion

Acute toxicity test

Acute toxicity test of the extract produced no death or signs of toxicity after 24 hours. The *Pavetta crassicaulis* and *O. dioica* ethanolic extracts of different plant parts were at the dose at the range from 2500-3000 mg/kg which shows that the extract was well tolerated. The animal experiment was permitted by the Institutional Animal Ethical Committee, India (SCSCP/IAEC-10, Dated 15-04-2017).

The *P. crassicaulis* and *O. dioica* ethanolic extracts of different plant parts were at the dose at the range from 2500-3000 mg/kg which shows that the extract was well tolerated. The documented edible parts are flower of *P. crassicaulis* and fruit of *O. dioica* is experimentally proved to have nil toxicity which is also traditionally used by the tribes in dishes and pickling, but, other parts even though used in decoction, paste and consumed orally to cure different ailments, not been experimented for its toxicity which is also evaluated from our experiment.

Physico-chemical parameters

To check the purity of the sample or plant materials, physicochemical parameters like total ash content, acid insoluble ash, water-soluble ash, pH, foreign matter, alcohol soluble extractive and dry matter were measured (Table 1 and Fig. 1).

The total percentage of ash found in stem and root. *P. crassicaulis* even though a shrubby plant of about 1-1.5 meters tall, but, the outer stem is woody and *O. dioica*, is a 15- 20 meters tall tree and the maximum mass of the tree is occupied by stem and root, they must contain the highest percentage of ash. Acid soluble and water-soluble ash determines the different types of nutrients dissolved in it and also its solubility, the stem has more acid soluble ash percentage and leaf has more water-soluble percentage.

pH is directly proportional to the hydrogen ion concentration, in our experiment, the different parts of *P. crassicaulis* and *O. dioica* were exhibit different pH. The pH of the stem, root and leaf is nearer to

Table 1 — Physico-chemical parameters of plant samples

Parameters	*P. crassicaulis* plant samples					*O. dioica* plant samples				
	Flower	Fruit	Leaf	Root	Stem	Flower	Fruit	Leaf	Root	Stem
Total ash content	4.21±0.23	5.32±0.94	7.65±1.21	8.43±0.26	9.3±1.35	7.23±1.67	6.65±1.32	8.52±1.12	7.82±1.05	10.54±1.31
Acid insoluble ash	1.02±0.15	4.21±1.43	5.22±1.76	2.34±1.19	5.5±2.31	2.32±1.04	5.82±0.61	6.19±1.87	3.28±0.93	5.57±1.47
Water soluble ash	2.34±1.24	9.11±1.54	7.32±1.03	4.33±1.04	15.11±0.87	2.87±0.1	8.94±1.21	8.47±0.98	5.67±0.67	16.87±1.11
pH of 5% w/v solution of aqueous extract	6.54±1.54	7.32±0.76	9.44±0.99	10.43±0.94	13.34±0.49	7.38±0.05	4.34±1.02	9.54±0.92	7.33±0.65	14.67±0.52
Foreign matter	1.01±0.98	1.24±0.35	2.32±0.87	7.54±0.85	2.34±1.22	1.09±0.23	1.11±1.10	1.98±1.63	8.98±1.42	8.29±1.11
Alcohol soluble extractive	65.32±0.93	65.43±0.57	70.22±0.46	67.43±1.26	70±1.54	78.46±1.55	76.29±0.34	78.76±1.24	78.65±1.11	89±1.07
Dry matter percentage	9.43±0.46	11.34±1.54	14.33±1.26	23.33±0.35	24.21±0.98	10.21±0.11	12.21±2.11	15.21±0.26	21.34±0.59	25.54±2.55

alkaline and other plant parts like fruit and flower was nearer to neutral. The root, stem and leaf were found to be alkaline in nature, while flower and fruit pH was nearer to neutral, maybe due to the translocation of water from root to flower[18].

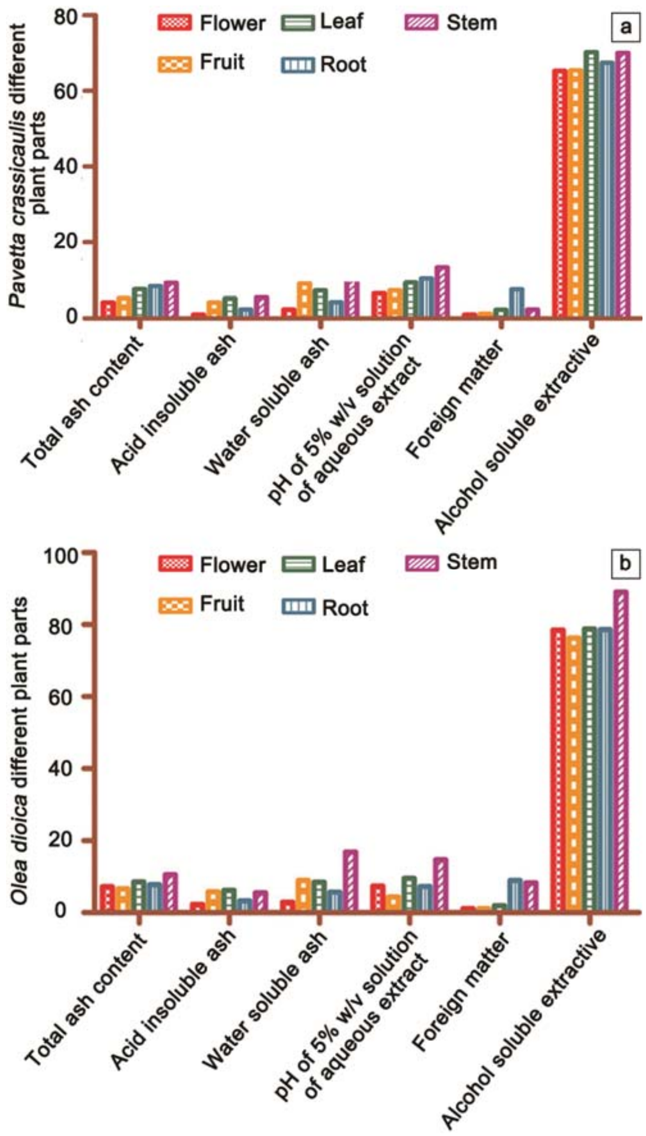

Fig. 1 — Physico-chemical parameters of plants parts; a) *P. crassicaulis* and b) *Olea dioica.*

The foreign matter is the main drawback in the quality and purity of a sample, In *P. crassicaulis* and *O. dioica* plant parts, the root is found to have a maximum portion of foreign matter. Root always encounters with the soil, so, the root must have maximum foreign matter. All samples were found to contain an appreciable percentage of alcohol-soluble extractive in that, leaf and stem had the highest alcohol-soluble extractive. The leaf contains mainly chlorophylls, xanthophyll, carotenoids etc. readily dissolves in alcohol and stem mainly contains lignin, pectin, suberin, terpenoids which were easily dissolved in alcohol than water. The stem and root have a larger portion of dry matter, maybe due to its woody nature so, stem and root have maximum dry matter compared to other tested plant parts. Stem mainly contains lignin, pectin, suberin, terpenoids which are not present in other parts, so, these chemical easily dissolves in alcohol than water.

Macronutrients

Macronutrients such as, calcium, potassium, magnecium, nitrogen, sodium and phosphorus were analysed in the given plant parts. (Table 2; Fig. 2)

Macronutrient analysis of *P. crassicaulis* plant parts revealed that the stem has more calcium (Ca), Roots take up the calcium and transfers through xylem along with the water. Calcium has a vital role in both plants and animal metabolism, acts as ion gated channels in cell signalling function. In *O. dioica* plant parts in that, calcium (Ca) was found to be high in stem and root, because, calcium activates calcium-dependent protein kinase (CPK28) in stem and help in stem elongation and vascular development[19].

In *P. crassicaulis* plant parts, Potassium (K) was found to be highest in leaf. The plant was even though collected from the Western Ghats, high rainfall and biotic rich place, has some biotic stresses like pathogens and pests, for its survival it has to show defence mechanism so that disease-prone parts like leaf, stem, and root has most potassium accumulation. Potassium is a vital macronutrient which helps in the

Table 2 — Macronutrients in plant parts

Samples	Macronutrients in *P. crassicaulis* ppm (Mean±SD)						Macronutrients in *O.dioica* ppm (Mean±SD)					
	Ca	K	Mg	N	Na	P	Ca	K	Mg	N	Na	P
Flower	0.24±0.13	0.42±0.02	0.18±0.05	0.43±0.54	0.84±0.12	0.26±0.04	0.22±0.11	0.23±0.11	0.12±0.01	0.55±0.1	0.73±0.02	0.1±0.02
Fruit	0.32±0.1	1.74±0.1	0.54±0.02	1.33±0.45	0.76±0.16	0.53±0.08	0.24±0.09	1.18±0.18	0.4±0.1	1.04±0.06	0.63±0.02	0.43±0.04
Leaf	0.46±0.1	2.72±0.27	0.45±0.04	2.24±0.83	0.86±0.12	0.72±0.14	0.38±0.04	1.36±0.54	0.38±0.05	2.04±0.06	0.7±0.05	0.63±0.02
Root	0.86±0.09	2.55±0.43	0.25±0.06	2.21±0.98	0.6±0.16	0.79±0.12	0.65±0.1	2.14±0.17	0.3±0.01	2.03±0.06	0.66±0.02	0.73±0.03
Stem	1.43±0.39	2.6±0.55	0.35±0.07	1.94±0.92	0.75±0.6	0.44±0.09	1.06±0.14	2.25±0.24	0.36±0.02	2.05±0.16	0.64±0.09	0.42±0.01

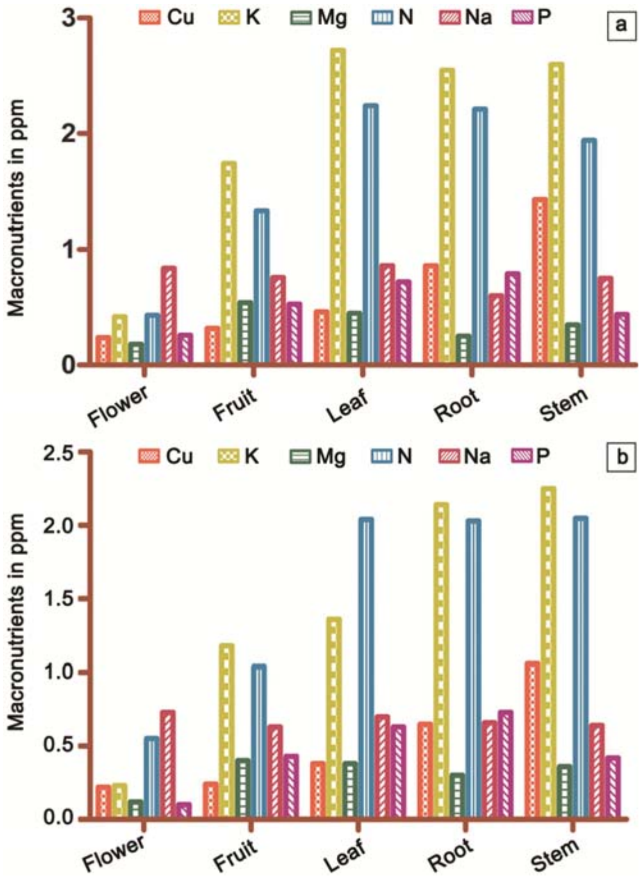

Fig. 2 — Macronutrients of the plant parts ; a) *P. crassicaulis* and b) *Olea dioica.*

maintenance of body fluid, in the contraction of muscles, neural stability, important enzyme activation, maintenance of proper blood pressure and proper formation of skeletal bones. In *O. dioica* plant parts, Potassium (K) was also high in stem and root, potassium was major nutrient essential for the proper growth of the plant and potassium mainly accumulates in the stem, root due to abiotic stress[20].

In the human body, magnesium play an important role in maintaining steady heartbeat, in proper functioning of enzymes and activation, in normal functioning of muscle, in improving bone stability, in normal functioning of nerve, in maintenance of normal sugar level in blood, in maintaining normal body fluid, cell division, transport substances across cell membranes, in protein and ATP synthesis. In *P. crassicaulis* plant parts, percentage of magnesium (Mg) was high in fruit. Magnesium is an essential nutrient which mainly situated in leaf and fruit. In leaf, magnesium is required for photosynthesis and in fruit, magnesium mainly triggers an enzyme that synthesis sugars. In *O. dioica* plant parts, Magnesium (Mg) was found to be high in fruit and leaf, because, it is the most sensitive part in plant and magnesium as an essential mineral element for plants to defend microbes[21].

Nitrogen is a major constituent of DNA, RNA, amino acids. Nitrogen is required in the proper maintains normal growth of cell and proper functioning of muscles. Nitrogen has a vital role in protein synthesis, enzyme synthesis. In the cell cycle, nitrogen has an important role. In *P. crassicaulis* plant parts, Nitrogen (N) was highly distributed in leaf. Nitrogen is an essential nutrient mainly required for protein synthesis and enzymes etc. In *O. dioica* plant parts, Nitrogen (N) was high in stem and root, nitrogen plays defence role as well as the constructive role, stem and root, much prone to pathogens than other parts, it only the strong reason that maximum nitrogen is located at stem and root[22].

In the human body sodium has a vital role in maintaining the blood pressure, balance the body fluid, normal functioning of nerve and muscles. In *P. crassicaulis* plant parts, Sodium (Na) was maximum noticed in leaf. Generally, a higher portion of sodium is noticed in leaf and flower parts to maintain the tissue fluidity and sodium is a key nutrient in the proper functioning of photosynthesis. In *O. dioica* plant parts, Sodium (Na) is an essential nutrient, which was high in flower and leaf, sodium is very much essential in plants metabolism, photosynthesis and osmosis, which mainly occurs in leaf and little percentage in flower[23].

Phosphorus (P) an essential element participates in photosynthesis, respiration and other metabolic processes. In animals phosphorous play an important role in energy metabolism and bone mineralization, phosphorus take part in the structural component of DNA and RNA. In *P. crassicaulis* plant parts, was found high in the root. Phosphorus is distributed in all plant parts mainly present in foliage older to younger leaves, flowers and seeds, meanwhile, easily percolated from one organ to another. In *O. dioica* plant parts, Phosphorus (P) was found higher percentage in root and leaf, the role of phosphorus in the plant is to promote normal growth and maturity of roots, photorespiration, proper photosynthesis of leaf and proper growth of stem[24].

The known edible part in *Pavetta crassicaulis* is flower. From our study it is proved that *Pavetta crassicaulis* flower even though contain moderate macroelements concentration compared to leaf and fruit (Table 2 and Fig. 1), sufficient enough to full fill the daily macronutrient dose of an adult human being. In *Olea dioica* plant, the documented edible part is fruit. From our study, it is proved that fruit contains sufficient macronutrients, in that, Magnesium (Mg) was found to be maximum when compared to other plant parts. Magnesium is essential macronutrient having various roles in the plant. In leaf, magnesium required for photosynthesis and in fruits it is mainly present to activate sugar-producing enzyme. In the human body magnesium has various vital role, in regulation normal blood glucose level, in bone stability, in normal nerve and muscle function, in maintaining steady heartbeat, promote the normal function of enzymes, in maintaining normal body fluid, in protein synthesis, in cell reproduction, in transport substances across cell barriers, in the synthesis of ATP and also cofactor for many enzymes. From our study, it is evident that one gram of fruit sample contains 0.4 ppm of magnesium, daily we need around 100 ppm of magnesium for normal body function, in this regards, *Olea dioica* fruit can be used as a magnesium booster in our body.

Micronutrients

Micronutrients such as, copper, manganese, iron and zinc were analysed in the given plant parts. (Table 3; Fig. 3)

Copper is an essential micronutrient, has vital role in the human body, as a main messenger in neuron communication and also in the proper brain health, triggers antioxidant defence, copper is very much essential in maintenance of skin and connective tissue health, proper functioning of heart and blood vessels and circulation of blood, formation of white blood cells in triggering immune response and normal function of cell organelles like mitochondria and chloroplasts. In the micronutrient analysis of *P. crassicaulis* plant parts, Copper was found to be highest in fruit. The fruit part has the highest copper percentage mainly because to prevent oxidative stress against unfavourable conditions. Copper (Cu) was majorly found in fruits and leaf parts. In-plant copper has a vital role in photosynthesis, plant growth, pathogenic defence. In animals, copper has an important role in the activation of proteins and metalloenzymes, proper development of nerves, brain, heart and bone. Copper has anti-cancer properties[25].

In *P. crassicaulis* plant parts Iron was found to be highest in leaf and fruit. The leaves have the highest iron content mainly involved in photosynthesis, mitochondrial respiration, nitrogen assimilation and hormone biosynthesis (ethylene, gibberellic acid, jasmonic acid). Up to 80% of the cellular iron is found in the chloroplasts that is consistent with its major function in photosynthesis. Fruits have high iron deposition, is mainly for the scavenging of reactive oxygen species, osmoprotectant, and pathogen defence. Most of the fruits have anti-oxidant properties, mainly due to the presence of iron, fruits having this property will help in the treatment of anaemia. In *O. dioica* plant parts iron (Fe) was majorly found in fruit and leaf. In a plant, iron has many key roles, especially, in mitochondrial respiration, hormone biosynthesis and in pathogenic defence. The maximum portion of iron was present chloroplast helps in photosynthesis. In the human body, iron is a vital component of red blood cells (RBC), constituent for many proteins, enzymes and hormones, the function of haemoglobin and myoglobin, a cofactor for enzyme and in electron transport[26].

In *Pavetta crassicaulis* plant parts, Manganese was found to be high in roots. The roots and stem parts have the highest manganese maybe for the defence and radical scavenging purpose. In human body manganese work as metalloenzymes in the activation of enzyme-substrate reaction, also present in bone, cartilages, connective tissue synthesis, urea cycle, carbohydrate metabolism, amino acid metabolism and

Table 3 — Micronutrients and Heavy metal in plant parts

Samples	Micronutrients *P. crassicaulis* (Mean ± SD) in ppm				Heavy metals in *P. crassicaulis*		Micronutrients *O. dioica* (Mean ± SD) in ppm				Heavy metals in *O.dioica*	
	Cu	Fe	Mn	Zn	Cd	Pb	Cu	Fe	Mn	Zn	Cd	Pb
Flower	34.88±1.5	424.07±2.51	54.59±0.9	43.38±0.96	0.75±0.6	-	29.58±5.16	392.09±1.51	40.37±5.44	35.43±3.99	0.51±0.4	-
Fruit	65.1±1.53	695.78±3.78	44.08±1.31	57.27±0.43	3.45±0.82	-	68.36±4.23	702.45±3.72	45.51±3.78	58.24±1.12	3.16±0.44	-
Leaf	53.29±1.82	773.67±1.52	39.15±3.65	66.72±0.6	4.7±1.12	-	44.03±6.27	665.69±2.21	34.04±2.66	52.26±0.99	4.7±0.52	-
Root	44.47±1.81	454.12±2.8	65.58±1.21	47.28±2.46	4.7±0.6	-	36.54±8.86	384.96±2.32	60.32±5.6	37.58±2.97	3.6±0.62	0.1±0.01
Stem	46.89±5.2	614.63±3.51	58.73±1.17	48.13±0.49	5.45±0.18	-	38.85±5.92	550.62±1.11	52.4±6.91	42.88±2.18	4.46±0.81	0.08±0

‘-’ Absent

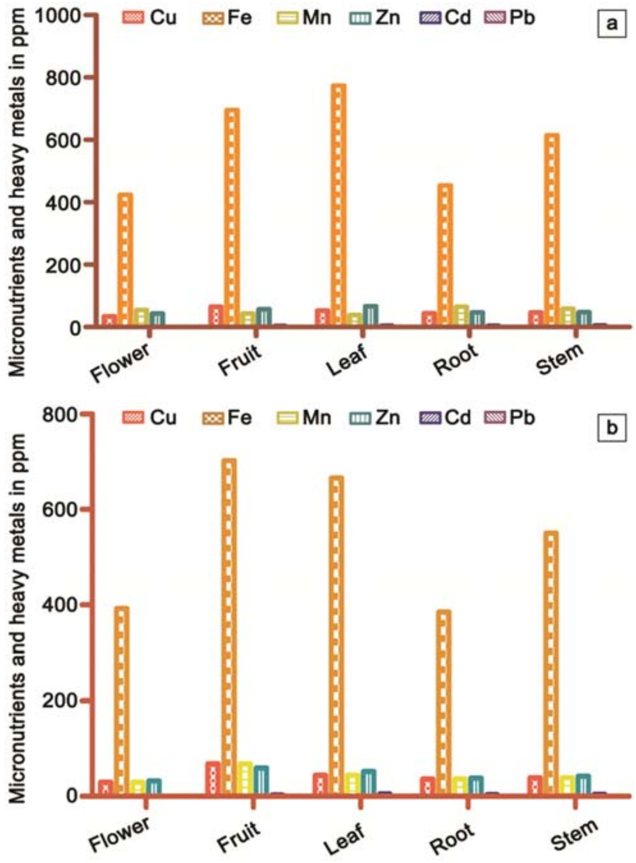

Fig. 3 — Micronutrients and heavy metals of plants parts; a) *P. crassicaulis* and b) *Olea dioica*

also has antioxidant, anti-cancer properties. In *O. dioica* plant parts, manganese (Mn) was majorly noticed in root and stem. In plants, manganese has a vital role like a cofactor for photosynthesis and chloroplast biosynthesis, membrane permeability in the cell membrane, nitrogen metabolism and synthesis of some important enzymes in plant metabolism. Manganese has antioxidant properties in suppressing reactive oxygen species and also helps in the synthesis of bone, cartilages, connective tissue, cofactor for many enzymes in the carbohydrate, fat, amino acid metabolism, proper functioning of thyroid and sex hormone, maintenance of blood sugar level, proper functioning urea cycle, and key element in blood clotting mechanism[27].

In *Pavetta crassicaulis*, Zinc was found to be high in leaf whereas, the flower has the least percentage of zinc. In a plant, zinc plays also an important role in seed development, DNA-transcription, RNA-processing, and translation. Fruits of *Olea dioica* contains an appreciable amount of zinc, which will help in skin protection, increase in appetites etc. In *O. dioica* plant parts, zinc (Zn) was found to be highest in fruit and leaf. In the plants, zinc has many important roles as a cofactor for many enzymes and proteins, zinc also helps in growth hormone synthesis. In the human body, zinc plays a vital role in activation T lymphocytes, activation of many essential enzymes in metabolism and in the proper maintenance of neurophysiological function[28].

The known edible part in *P. crassicaulis* is flower, from our study it is proved that *P. crassicaulis* flower contains appreciable microelements concentration compared to leaf and fruit (Table 3 and Fig. 2), sufficient enough to full fill the daily micronutrient dose of an adult human being. In *Olea dioica* plant, the documented edible part is fruit. By the data obtained from our study, it is proved that fruit contains sufficient micronutrients, in that, copper, iron, Manganese and zinc was found to be in higher quantity than the commercially available fruits. (Table 3; Fig. 3)

Heavy metals

Two heavy metals were analyzed in the *P. crassicaulis* and *O. dioica* plant parts, the results showed that in *P. crassicaulis* plant parts lead (Pb) content was completely absent in all the plant parts, whereas, cadmium was noticed in the stem. In *Olea dioica* plant parts, the results showed that lead (Pb) was found maximum percentage in the root and stem, whereas, in the other plant parts it was absent. In plants, lead is essential to defence pathogens and also helpful in antioxidant defence[29].

In *Olea dioica* plant parts, cadmium was found to be highest in leaf and stem. Cadmium is also toxic to plant inhibiting the growth. In animals, the toxicity of cadmium leads to abnormal neural function and induce cancer. Cadmium deposition in leaf and stem is due to the anthropogenic activities like industrial waste improper processes, manufacturing and burning of plastics, mining etc. The cadmium is an essential element in plants which is having the capability to fix nitrogen in the root tubercles. In humans, cadmium plays an important in role in the proper functioning of thyroid gland along with iodine, in higher quantity becomes cytotoxic to human beings[30].

In *Olea dioica* plant, the known edible part is fruit, from the study it is proved that fruit possess little cadmium (Cd) and the absence of lead (Pb) content, so, the fruit is safer to eat and it also gives the positive feedback on the traditional use of tribes in Kerala (Table 3; Fig. 3).

Nutritive value

To evaluate the nutritive value of *P. crassicaulis* and *O. dioica* plant parts, parameters such as moisture, carbohydrates, crude protein, crude fibre and crude fat is crucial (Table 4 and Fig. 4).

Moisture content in the plant directly proportional to the water uptake, as well as, the translocation of water in different plant parts. In *P. crassicaulis* plant parts, moisture content was found to be highest in flower and fruit. If the fruit is fleshy it has more moisture with full of carbon source and essential nutrients, to nourish the seeds. The flower must have higher moisture content to attract many insects, to retain its fluid equilibrium in the cells. Plant moisture directly proportional to the soil moisture percentage, *P. crassicaulis* plants are mainly grown in dry deciduous and moist deciduous forest and these forests contain rich full of litter on the soil, which holds the water for longer period of time. In *O. dioica* plant parts, moisture content was found to be high in fruit and flower. Fruit contains a carbon source, moisture, essential nutrients etc. for nourishing seed. Excess of moisture in fruit and leaf prone to infection due to fungi which indirectly helps in the symbiotic association with the host plant [31].

Carbohydrate is one of the chief energy resources abundantly found in plants. In *P. crassicaulis* plant parts, carbohydrate content was mainly noticed in flower and fruit. In *O. dioica* plant parts, carbohydrate content was mainly noticed in flower and fruit. In flower carbohydrates are in the form of nectar, it is an inbuilt system to attract insect in pollination and fruit must have carbon source to nourish the growing seed[32].

In *P. crassicaulis* plant parts, crude protein content was found high in flower and fruit. Proteins in one of the energy resources and main component of chloroplast, mitochondria, ribosomes etc. were a different form of proteins mainly located in aerial parts like leaf, fruit and flower which is metabolically active compared to other parts. In *O. dioica* plant parts, crude protein content was found high in flower followed by leaf and fruit. Proteins are the building block of living things and also alternative energy resources. Leaf, fruit and flower parts mainly contain the maximum number of chloroplasts, mitochondria and ribosomes when compared to rest, which is metabolically active compared to other parts[33].

Plant fibre is a made up of pectin and lignin. Fibre cell not only supports the aerial parts but also effectively defend the biological threats. In *P. crassicaulis* plant parts, crude fibre was found high

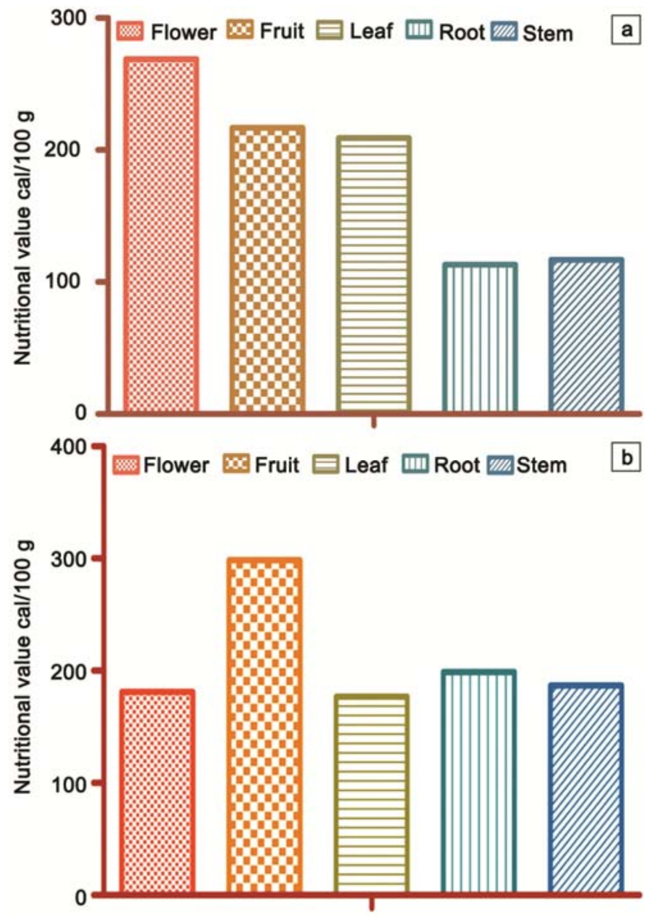

Fig. 4 — Nutritive value of the plant parts; a) *P. crassicaulis* and b) *Olea dioica*

Table 4 — Nutritive value of plant parts

	Nutritive value of *P. crassicaulis* plant parts						Nutritive value of *P. crassicaulis* plant parts					
Samples	Moisture (%)	Carbohydrate (%)	Crude protein (%)	Crude fiber (%)	Crude fat (%)	Nutritive value Cal/100 gm	Moisture (%)	Carbohydrat e (%)	Crude protein (%)	Crude fiber (%)	Crude fat (%)	Nutritive value Cal/100 gm
Flower	76.45±0.23	49.43±1.43	12.33±1.54	1.34±0.76	2.43±1.21	268.91±1.76	65.32±0.52	32.22±2.09	10.11±2.11	1.1±0.37	1.32±2.16	181.2±3.11
Fruit	82.65±1.03	41.44±0.99	9.76±0.87	2.24±0.46	1.34±0.35	216.86±0.57	82.11±1.11	56.21±0.92	13.22±0.26	1.12±1.11	2.32±1.78	298.6±1.10
Leaf	65.43±0.94	39.19±0.15	8.54±1.24	9.76±1.54	2.01±0.98	209.01±0.93	61.23±0.52	31.22±2.21	7.63±0.82	8.23±2.45	2.39±0.52	176.91±0.93
Root	54.43±0.94	23.32±0.26	2.44±0.85	11.34±1.26	1.13±1.35	113.21±1.54	55.32±2.32	44.21±1.02	3.21±0.65	12.32±2.25	1.02±0.64	198.86±1.95
Stem	56.45±0.87	21.54±0.49	5.36±1.22	12.67±1.19	1.02±1.04	116.78±1.32	49.88±0.52	40.11±1.11	4.11±2.04	11.76±0.33	1.1±2.12	186.78±2.18

in stem and root. In *O. dioica* plant parts, crude fibre content was found high in stem and root. Fibre is a made up of cellulose, pectin and lignin. In timber plants, fibre was heavily lignified and located in the cell walls. On maturation, fibre cells will die and be filled with mainly lignin and pectin compounds and function as support tissue in stems and roots. Fibre cell effectively defends the pathogen, physical damage and protect the plant from physical and biological stress[34].

In both, *P. crassicaulis* and *O. dioica* plant parts, crude fat was mainly noticed in flower and leaf. Fat is the highest energy-rich carbon resource gives more energy than carbohydrates. In leaf and flower, fat is in the form of a cuticle layer. Especially in flower, fats or lipid is present to synthesize sex-related hormones. Lipids also have a role in pollination and flower senescence[35].

Nutritive value of *Pavetta crassicaulis* plant parts was calculated and the flower was found to have high nutritive value compared to other parts examined. The flower of *Pavetta crassicaulis* is used as a vegetable material by tribes called Mizo people from Mizoram, India. The tribes used to fry the flower and used in their daily food.

Nutritive value of *Olea dioica* plant parts was calculated and fruit was found to have the highest nutritive value, compared to other parts examined (Table 4 and Fig. 4). The *Olea dioica* fruit is unknown for its edible value, but, Yasodharan and his co-researchers, reported edible value of Olea used by the tribes of Parambikulam Wildlife Sanctuary, Kerala, India. From the present study, it has lime lighted the edible value of the plant flower of *P. crassicaulis* and fruit of *O. dioica*, besides, also gave the positive feedback on the traditional use of tribes in Mizoram and tribes in Kerala, India.

Conclusion

The nutritive value and elemental studies were conducted on leaf, bark, flower, fruit and root plant parts of the tested plants using standard procedures. On the basis of the result obtained in the present investigation, we concluded that the *Pavetta crassicaulis* flower part even though micro, macro, and heavy metal elements were found in moderate concentration, the nutritive value was found to be highest among all parts, because of high carbohydrates, crude protein and crude fat, which in turn confirms the unknown traditional knowledge in the consumption of flowers by tribes of Mizoram, India. In *Olea dioica* plant parts, the fruit was found to have moderate micro, macro, and heavy metals presence but has the highest nutritive value, which is also edible by the local people in Kerala. It is quite evident that the fruit of *Olea dioica*, showed the highest nutritive value which is traditionally used by Indian tribes of Kerala, unknowingly. Heavy toxic metal like lead was completely absent in the flower of *Pavetta crassicaulis* and the fruit of *Olea dioica* which confirms the nil toxic effect of both plant parts. Research in the exploration of the unknown wild edible plant is essential to get nutrient, micro, macroelements rich plant products than the cultivated commercial horticulture crops.

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