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Evaluation of Primary Metabolites during Different Developmental Stages in *Alhagi maurorum* and *Caralluma edulis* from Arid Zone

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***Abstract*:** The present study deals with evaluation of primary metabolites in two important medicinal plants, *viz. Alhagi maurorum* (Camelthorn) and *Caralluma edulis* (Pimpa) from the Indian Thar desert. Primary metabolites such as leaf pigments, osmotic potential, proline, total sugars, crude protein and phosphorus were estimated during different developmental stages, *i.e.* vegetative, flowering and fruiting. The leaf pigments, total sugars, phosphorus and crude protein were maximum during vegetative stage, whereas proline and osmotic potential during flowering and fruiting stages, respectively in *A. maurorum.* In *C. edulis,* maximum amount of leaf pigments and proline were observed during fruiting stage; whereas osmotic potential, total sugars and phosphorus during flowering stage; and crude protein in vegetative stage.

Keywords: *Alhagi maurorum, Caralluma edulis,* Primary metabolites, Arid zone

In recent times, focus on plant research has increased all over the world and evidence has been collected to show the immense potential of medicinal plants used in traditional systems (Aali et al 2010). Plant medicines are ideal tools to restore health and treat disease precisely because they consist of a multiplicity of chemical components. The medicinal value of these plants lies in the bioactive phytochemical constituents that produce definite physiological effects on human body. These natural compounds formed the base of modern drugs as in use today (Rout et al 2009). Medicinal plants are of great importance not only for their biologically active secondary metabolites but also for their primary metabolites such as carbohydrates, proteins and lipids. These primary metabolites are essential for the growth and development of a plant and are carriers of chemical energy to the successive trophic levels of the food chain (Borkataky et al 2014).

Alhagi maurorum Medikus (Family: Fabaceae), commonly known as Camelthorn and whose distribution is restricted to rocky and gravelly soils of north-west Rajasthan, is a small erect shrub, armed with sharp and long spines and grows with massive rhizomatous systems, which extends up to 5-6 feet into the ground. It grows horizontally and has a potential to allow new shoots to grow upwards (Plate 1, Photo 1). The plants are used to treat numerous diseases such as gastro-entroenteritis (Varshney and Singh 2008), headache, toothache and cancer (Zou et al 2012), liver disorders, kidney stone and urinary tract infections (Badshah and Hussain 2011). *Caralluma edulis* Edgew. (Family: Apocynaceae), popularly known as Pimpa is an erect, succulent, branched, perennial herb with viscous watery sap (Plate 1, Photo 2). Traditionally, this plant is used to treat parasitic infections, Alzheimer disease, rheumatism, hypertension, gastric problems, diabetes, leprosy and is enriched in pregnane & megastigmane glycosides, flavone and esters (Adnan et al 2014). Thus, the present study was conducted to investigate estimation of primary metabolites such as leaf pigments, proline, osmotic potential, total sugars, crude protein and phosphorus during different developmental stages, *i.e.* vegetative, flowering and fruiting for evaluating suitable stage to harvest these plants for obtaining the maximum amount of these products.

MATERIAL AND METHODS

For chemical analyses of plants, leaf samples of *A. maurorum* were collected from Kanana, village of the Barmer district (25^0 49' 17.5944'' N and 72^0 25' 59.5416'' E), which is located 105 km away in south-west direction from the University Campus, Jodhpur during three developmental stages, *viz.* vegetative (August to February), flowering (March to May) and fruiting (April to July). The shoot samples of *C. edulis* were collected during vegetative (July and August), flowering (September to January) and fruiting (January to May) from Jaisoorana village of the distric Jaisalmer (27.0556^0 N and 71.1330^0 E), which is located 308.3 km away in western direction from the University Campus, Jodhpur.

The samples of both medicinal plants were collected during 2020 and 2021. The identification of plants were confirmed from the Botanical Survey of India, Jodhpur and specimens have been deposited in BSI herbarium. Plant

materials were washed with running tap water to remove the adherent foreign particles, air-dried and used for chemical analyses. Leaf pigments, osmotic potential and proline were estimated in fresh leaf samples, while other parameters from oven-dried leaves in *A. maurorum,* but in *C. edulis* all parameters were estimated from the shoots. Fresh leaves and shoots were extracted with 80% acetone for estimation of leaf pigments as per Arnon (1949). Free proline and osmotic potential were estimated as per Bates et al (1973) and Janardhan et al (1975), respectively. The total sugars were estimated as per standard methods given by Plummer (1971), while nitrogen by micro-kjeldahl apparatus as suggested by Peach and Tracey (1955) and phosphorus as per Allen et al (1976). The data collected during both the years (2020 and 2021) were subjected to analyses of variance (ANOVA) as suggested by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

The total chlorophylls and carotenoids ranged from 1.27 to 1.82 and 0.001373 to 0.002523 mg g^{-1} f. wt., respectively, being the maximum during vegetative stage in *A. maurorum* (Table 1, Fig. 1). Daiya and Kasera (2016) reported highest values of total chlorophylls during vegetative stage in *Corbichonia decumbens*, which support present findings. The proline values ranged from 24.31 to 26.87 µg g^{-1} f. wt. during three stages, being the maximum in flowering stage and the minimum in fruiting stage (Table 1, Fig. 2). Daiya and Kasera (2016) reported maximum proline content at flowering stage in *C. decumbens.* Values for osmotic potential varied from 1.97 to 2.63 -MPa, being highest at fruiting while the lowest in flowering stage (Table 1, Fig. 2). Proline accumulation in *Trianthema triquetra* is accompanied by a decrease in osmotic potential (Mohammed et al 2000). In the present investigations, proline was maximum with minimum values of osmotic potential and *vice versa*, which is in accordance with present observations.

Plate 1. *Alhagi maurorum* with massive rhizome system (1), and *Caralluma edulis* in vegetative stage (2) growing in natural habitats

Total sugars ranged from 5.5 to 20.84 mg g^{-1} d. wt. during three phases, being the maximum in vegetative stage (Table 1, Fig. 3). Sagar and Kasera (2016) reported the maximum amount of total sugars during vegetative stage in *D. erythraeum.* The maximum crude protein were observed during vegetative stage (11.23% d. wt.) while non-significant variations were observed during flowering and fruiting stages. The phosphorus content was the highest (0.245% d. wt.) during vegetative followed by flowering and minimum at fruiting stage (Table 1, Fig. 4). Sagar and Kasera (2016) documented the highest content of crude protein along with phosphorus during vegetative stage in *Dipcadi erythraeum*. The present finding also support the above observations. The maximum content of total chlorophylls and carotenoids were reported during fruiting stage in *C. edulis*. The total chlorophylls and carotenoid values ranged from 0.348 to 0.404 and 0.00036 to 0.000508 mg g^{-1} f. wt., respectively

Table 1. Primary metabolic parameters in *A. maurorum* during different developmental stages

Parameters	Stages			CD
	Vegetative	Flowering	Fruiting	
Chlorophyll *a* (mg g^{-1} f. wt.)	1.26	0.890	0.914	0.2866^{ns}
Chlorophyll *b* (mg g^{-1} f. wt.)	0.557	0.382	0.500	0.1413^{ns}
Total chlorophylls (mg g^{-1} f. wt.)	1.82	1.27	1.41	0.4136^{ns}
Carotenoids (mg g^{-1} f. wt.)	0.002523	0.001466	0.001373	0.00044^{ns}
Proline (µg g^{-1} f. wt.)	24.81	26.87	24.31	3.8252^{*}
Osmotic potential (-MPa)	2.34	2.63	1.97	0.6941^{ns}
Soluble sugar (mg g^{-1} d. wt.)	8.59	2.14	5.75	3.9463^{ns}
Insoluble sugar (mg g^{-1} d. wt.)	12.25	3.36	3.41	5.9409^{*}
Total sugars (mg g^{-1} d. wt.)	20.84	5.5	9.16	6.9155^{*}
Crude protein (% d. wt.)	11.23	8.58	8.58	3.5452^{ns}
Phosphorus (% d. wt.)	0.245	0.219	0.196	0.0327^{*}

ns = Non-significant; and * = Significant at (<0.05) level

(Table 2, Fig. 5). Daiya and Kasera (2016) noted higher amount of carotenoids during fruiting stage in *C. decumbens*, which is in accordance with present studies.

In the present studies, the proline level increases with the decreases in osmotic potential in *C. edulis*, which can be correlated with its tolerance to environmental stress. The

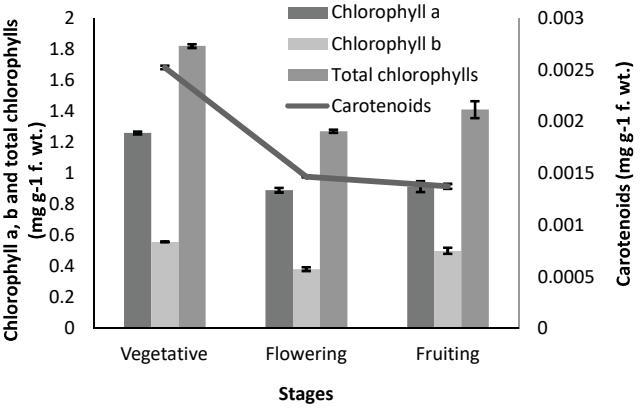

Fig. 1. Leaf pigment (mg g^{-1} f. wt.) contents in *A. maurorum* leaves during different growth stages (Mean values and standard error are presented)

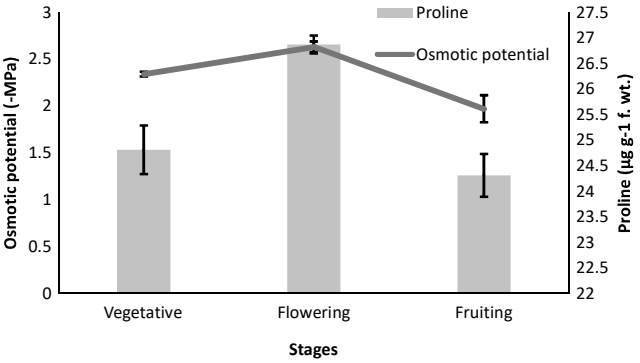

Fig. 2. Proline (µg g^{-1} f. wt.) and osmotic potential (-MPa) values in *A. maurorum* leaves during different growth stages (Mean values and standard error are presented)

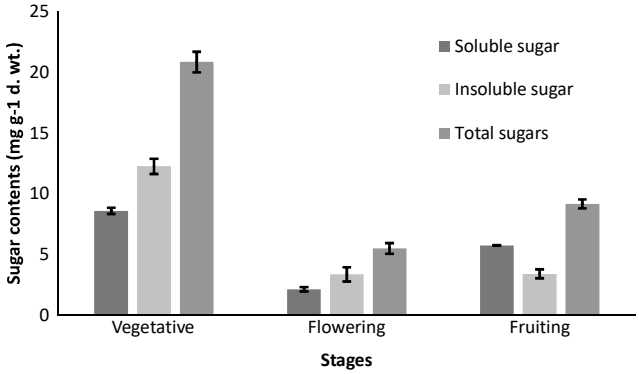

Fig. 3. Sugar (mg g^{-1} d. wt.) contents in *A. maurorum* leaves during different growth stages (Mean values and standard error are presented)

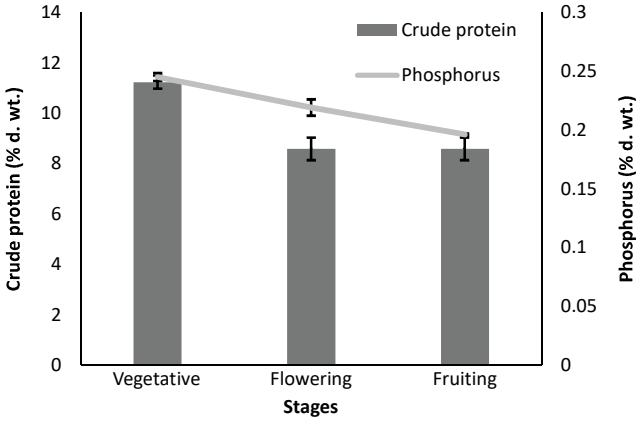

Fig. 4. Crude protein and phosphorus (% d. wt.) contents in *A. maurorum* leaves during different growth stages (Mean values and standard error are presented)

Table 2. Primary metabolic parameters in *C. edulis* during different developmental stages

Parameters	Stages			CD
	Vegetative	Flowering	Fruiting	
Chlorophyll *a* (mg g^{-1} f. wt.)	0.226	0.229	0.259	0.0515^{ns}
Chlorophyll *b* (mg g^{-1} f. wt.)	0.136	0.118	0.144	0.0315^{ns}
Total chlorophylls (mg g^{-1} f. wt.)	0.362	0.348	0.404	0.0775^{ns}
Carotenoids (mg g^{-1} f. wt.)	0.00036	0.00042	0.000508	8.3640^{*}
Proline (µg g^{-1} f. wt.)	0.793	0.698	1.33	1.223^{*}
Osmotic potential (-MPa)	0.985	0.834	1.13	0.3985^{ns}
Soluble sugar (mg g^{-1} d. wt.)	11.70	10.64	8.79	8.911^{ns}
Insoluble sugar (mg g^{-1} d. wt.)	2.26	6.93	7.22	4.358^{ns}
Total sugars (mg g^{-1} d. wt.)	13.97	17.56	16.01	9.299^{ns}
Crude protein (% d. wt.)	9.23	9.0	7.55	2.764^{ns}
Phosphorus (% d. wt.)	0.298	0.373	0.349	0.0997^{ns}

ns = Non-significant; and * = Significant at (<0.05) level

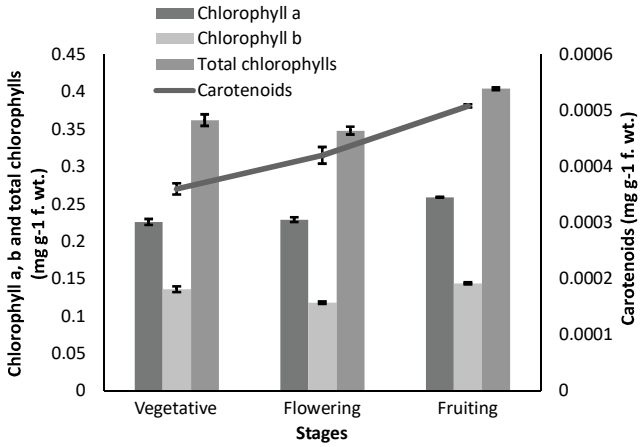

Fig. 5. Leaf pigment (mg g^{-1} f. wt.) contents in *C. edulis* shoots during different growth stages (Mean values and standard error are presented)

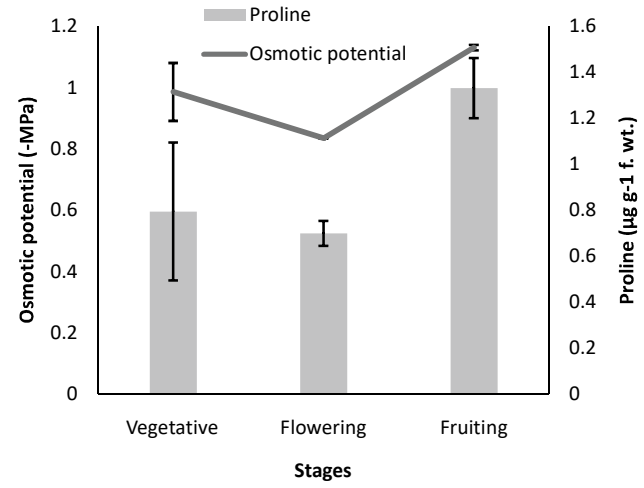

Fig. 6. Proline (µg g^{-1} f. wt.) and osmotic potential (-MPa) values in *C. edulis* shoots during different growth stages (Mean values and standard error are presented)

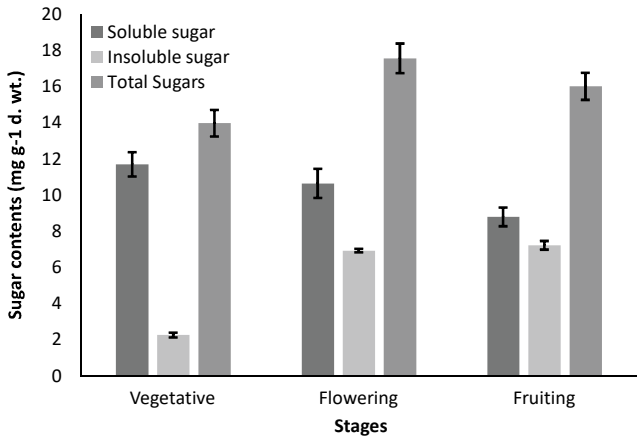

Fig. 7. Sugar (mg g^{-1} d. wt.) contents in *C. edulis* shoots during different growth stages (Mean values and standard error are presented)

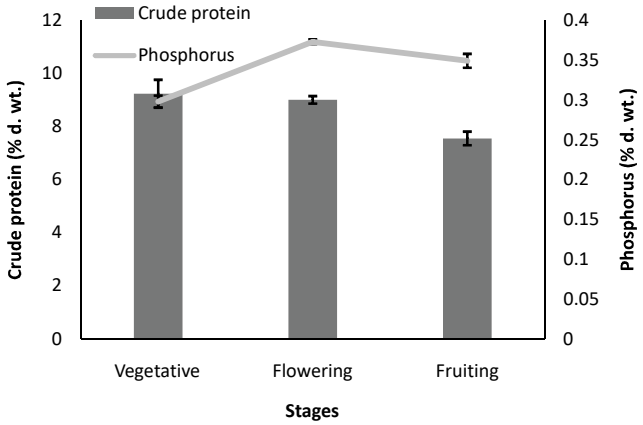

Fig. 8. Crude protein and phosphorus (% d. wt.) contents in *C. edulis* shoots during different growth stages (Mean values and standard error are presented)

higher values of proline were reported during fruiting stage, while osmotic potential in flowering stage (Table 2, Fig. 6). The values of proline and osmotic potential ranged from 0.698 to 1.33 µg g^{-1} f. wt. and 0.834 to 1.13 -MPa, respectively. The maximum proline and osmotic potential in *C. decumbens* were recorded during fruiting and flowering stages by Kasera et al (2018) and Daiya and Kasera (2016), respectively. Saharan et al (2001) also reported the lowest value of osmotic potential when proline content was at peak in *Evolvulus alsinoides,* which support the present findings. Hence, a positive correlation between proline and osmotic potential was observed in the present study. The maximum content of total sugars was reported during flowering stage, while the minimum in vegetative stage in *C. edulis*. The total sugars ranged from 13.97 to 17.56 mg g^{-1} d. wt. (Table 2, Fig. 7). Sagar and Kasera (2021) reported the maximum amount of total sugars during flowering stage in *Drimia indica*, which is supported by the present investigations. In *C. edulis*, crude protein and phosphorus values ranged from 7.55 to 9.23 and 0.298 to 0.373% d. wt., respectively (Table 2, Fig. 8). The maximum values of crude protein and phosphorus were noted during vegetative and flowering stages, respectively. Daiya and Kasera (2016) reported higher content of crude protein during vegetative stage in *C. decumbens.* Swami (2006) observed the maximum amount of phosphorus during flowering stage in *Solanum surattense.* The above observations are in accordance with the present investigations. The data on proline, total sugars and phosphorus were significant, while remaining parameters were non-significant in *A. maurorum,* whereas in *C. edulis*, except carotenoids and proline remaining all parameters were non-significant.

CONCLUSIONS

The leaf pigments, total sugars, phosphorus and crude

protein were accumulated in maximum amount during vegetative stage, while proline during flowering and osmotic potential in fruiting stage in *A. maurorum.* In *C. edulis*, fruiting stage was the most favourable for obtaining the maximum production of leaf pigments and proline, while osmotic potential, total sugars and phosphorus during flowering and crude protein in vegetative stage. Thus, on the basis of present findings we can find out the most suitable developmental stage to obtain the maximum amount of these products for commercial utility.

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