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Association and Variation among Some Important Nutritional Traits of Kair (*Capparis decidua*)

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Abstract: The natural variability in contents of various metabolites and minerals in buds and fruits of kair (*Capparis decidua*) has been studied. The results showed that fruits and buds of kair are rich in carbohydrates, protein and calcium. The mean and variance of carbohydrates and moisture were not significantly different in fruits and buds. However, the variability was much higher for minerals like zinc and sodium in fruits and zinc and iron in buds. Various traits of fruits as well as buds were correlated either negatively or positively in wild populations of kair. This information can be used for selection of desired genotypes for domestication and preservation of diversity.

Key words: *Capparis*, kair, biochemical analysis, mineral, variability, fruits, buds.

There exists rich biodiversity in perennial plants for vegetable purposes, yet most of our food requirements are met from highly managed croplands. Intensive cultivation of these croplands is degrading the soils, which may adversely affect the food supply. However, the rich diversity in perennial plants can be used for domestication of wild species to produce food. Indian Thar desert has a number of species, like *Prosopis cineraria, Acacia senegal*, *Carissa carandas* and *Capparis decidua* that can withstand harsh environments, that are rich in nutrients and can be exploited for producing food for human beings and fodder for animals.

C. decidua - a rangeland perennial bushy shrub belongs to *Capparaceae* family. *Capparaceae* comprises roughly 650 species of small trees and shrubs in 30 genera, which are found primarily in tropical and warm temperate regions. Twenty six of these species are reported to occur in India. It coppices well and produces root suckers freely. It is a drought-resistant bush and is also tolerant to frost, and can be used for afforestation and reforestation of semi-arid and arid areas to arrest soil erosion. Young roots are used to cure boils and swelling, and bark is useful in asthma; the very bitter roots are used in the pharmacopoeia (Ozcan, 2005). Its pink fleshy berries are mostly eaten by birds. However, the flower buds, called capers, and fruits of its various species (*C. spinosa*, *C. corymbifera* and *C. mitchellii*) including *C. decidua*. (syn. *C. aphylla*) are also used as food in the form of curry, pickle and condiment mostly by the people living around the desert.

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In recent past some studies have been carried out to understand the biochemical constituents of *C. decidua* and found that this plant is a rich source of nutrients (Duhan *et al*., 1992; Chadda, 2008). However, these studies used collective samples and do not provide information on the variability in its important traits. Hence the available information is insufficient to take any decision on its domestication and systematic selection of desired genotypes. In this study we provide biochemical parameters and variability therein, which can be utilized to conserve plant diversity and select desired genotypes for domestication.

Materials and Methods

Fruits and buds from 10 randomly tagged *C. decidua* plants in the common land of village Kodamdesar, and nine naturally growing plants on the campus of Agricultural Research Station in Bikaner district of western Rajasthan were collected separately in paper bags. The region receives scanty rainfall (<250 mm) and experiences extreme temperature (48°C in June) and deep water table (250-600 ft) with sandy soil low in fertility. Fully mature buds and immature chickpea size fruits were collected and weighed immediately in the field using battery operated electronic balance.

A plant-wise biochemical analysis of fruits and buds was undertaken to determine moisture, nutrients and minerals. Moisture content was estimated after drying the samples in an oven at 60°C for 24 hours and was expressed in percentage (ICMR, 1983). Ash, dietary fiber (hemicellulose, cellulose and lignin), crude fiber, crude fat, total carbohydrate, vitamin C, phosphorus and calcium contents were estimated using AOAC method (1995). Crude protein content was estimated by multiplying the Kjeldahl nitrogen by a factor of 6.25.

To determine mineral composition (magnesium, iron, zinc, manganese, copper and cobalt) oven-dried fruits and buds (1 g) were left undisturbed in 10 ml of concentrated HNO_3, 4 ml of 60% perchloric acid and 1 ml of concentrated H_2SO_4 overnight, and the contents were heated on a hot plate until the brown fumes ceased. The contents were cooled and filtered through Whatman No. 42 filter paper. The filtrate was brought up to 100 ml with distilled water and fed into a GBC-932 Atomic Absorption Spectrophotometer to determine mineral composition (Bishnoi and Brar, 1988).

Soluble sugar and starch were estimated by anthrone method as suggested by Dubios *et al*. (1951). Proline was estimated by method given by Bates *et al*. (1973). Phosphorus was determined by colorimetric method using the vanadomolybdate (yellow) method (AOAC, 1995). Sodium and potassium were estimated using flame photometer after digestion with diacid and triacid, respectively.

The results were statistically evaluated for mean, standard deviation (SD), coefficient of variation (CV) and correlation coefficient among the characteristics. Pearson correlation was used to assess the association between different traits.

Results and Discussion

Biochemical analysis

The mean moisture content in fresh fruits was 78.37±2.08% and in buds it was 65.46±2.83%. As for most vegetable crops, the mean moisture content was more in fruits and buds of *C. decidua*, and is comparable with that reported by Umar-Dahot (1993).

The nutrients in the fruit and bud of *C. decidua* are at par with or even better than many vegetable crops. Among total solids, carbohydrates were major constituents in fruits as well as in buds and are in agreement with those reported by Bala and Goyal (1999). Crude protein was 29.62±3.37% in fruits and 22.64±3.28% in buds. Neutral detergent fiber (NDF) contributed most to the total carbohydrate in fruits

Table 1. Biochemical and mineral contents in fruits and buds of kair (C. decidua)

Statistic	Maximum		Minimum		Mean		SD		CV	
Sample	Fruits	Buds	Fruits	Buds	Fruits	Buds	Fruits	Buds	Fruits	Buds
Biochemicals										
Moisture (%)	82.10	70.67	74.20	57.73	78.37	65.46	2.08	2.83	2.65	4.33
Crude protein (%)	36.52	27.66	23.90	16.38	29.62	22.64	3.37	3.28	11.37	14.48
Proline (mg/100 g)	17.60	16.50	7.50	6.50	12.14	11.09	2.99	3.06	24.66	27.57
Total carbohydrate (%)	61.25	69.03	49.06	57.62	55.94	63.41	3.19	3.47	5.70	5.48
Soluble carbohydrate (%)	23.20	22.43	10.10	11.10	17.34	15.65	3.07	3.17	17.68	20.28
Starch (%)	21.95	30.29	9.43	11.89	16.17	21.63	3.66	5.35	22.61	24.74
Crude fiber (%)	16.05	9.20	7.70	7.40	10.72	8.04	2.18	0.53	20.30	6.59
NDF (%)	40.60	31.60	24.10	22.30	30.57	26.79	4.62	3.07	15.11	11.45
Hemicellulose (%)	14.30	11.90	8.30	8.30	11.49	10.04	1.85	1.22	16.12	12.19
Cellulose (%)	12.70	9.70	6.80	6.70	8.89	7.56	1.64	0.62	18.43	8.19
Lignin (%)	9.40	9.20	6.10	4.90	7.64	7.01	1.09	0.90	14.30	12.83
Crude fat (%)	9.98	12.91	5.82	3.30	8.42	7.91	1.14	1.97	13.58	24.92
Minerals										
Phosphorus (mg/100 g)	357.00	370.00	109.00	142.00	222.95	233.21	56.53	56.45	25.35	24.21
Magnesium (mg/100 g)	57.60	57.48	43.46	44.65	48.90	50.63	4.76	4.30	9.73	8.50
Iron (mg/100 g)	6.58	7.46	1.30	1.84	4.33	4.84	1.33	1.58	30.77	32.71
Zinc (mg/100 g)	0.74	0.76	0.03	0.05	0.29	0.33	0.19	0.19	64.61	57.51
Copper (mg/100 g)	2.40	2.78	1.68	1.86	2.04	2.32	0.22	0.30	10.66	12.90
Sodium (mg/100 g)	2.78	2.94	0.75	0.87	1.34	1.78	0.47	0.56	35.44	31.61
Potassium (%)	4.34	4.59	2.32	2.37	3.09	3.21	0.52	0.52	16.76	16.07
Calcium (%)	3.52	3.93	3.04	3.09	3.22	3.50	0.12	0.27	3.79	7.60
Total ash (%)	14.30	6.80	8.30	5.40	11.49	6.04	1.85	0.35	6.68	5.82

and buds and had a mean value of 30.57±4.62% and 26.79±3.07%, respectively. Also the mean value of NDF and crude protein in fruits is consistent with that reported by Goyal and Grewal (2003). Starch content was higher than crude fiber in fruits (Table 1). Hemicellulose, cellulose and lignin contributed to NDF in decreasing order in both fruits and buds.

As per observed coefficient of variation, proline was the most variable trait (CV=24.66%), followed by starch (CV=22.61%) and crude fiber (CV=20.30%) in fruits. With marginally higher values, similar affinity was found in buds. Moisture content was the least variable trait in fruits (CV=2.65%) and buds (CV=4.33%). Total carbohydrate in fruits, and crude fiber and total carbohydrate in buds were less variable compared to other non-mineral traits.

Ash content of the fruits and buds ranged from 8.30% to 13.40% and 5.30% to 6.80%, respectively (Table 1). Amongst all minerals, calcium and potassium were higher in buds than in fruits. The minerals, especially Mg, Fe, Zn and Cu, in kair fruits ranged from deficient to sufficient contents. Chouhan *et al*. (2002) and Chaturvedi and Nagar (2001) have also reported similar composition. Average phosphorus content in fruit was 222.95±56.53 mg/100 g while in bud it was 233.21±56.45 mg/100 g. Manganese and cobalt were not detected. Interestingly, while ash content of fruits and buds showed less variability, most of the minerals showed higher variability. The most variable traits were Zn (CV=64.61%), Na (CV=35.44%), Fe (CV=30.77%), P (CV=25.35%), proline (CV=24.66%), starch (CV=22.61%), crude fiber (CV=20.30%) and cellulose (CV=18.43%) thus providing an opportunity for selection. While variability in the levels of Ca (CV=3.79%), total carbohydrate (CV=5.70%), ash (CV=6.68%) and Mg (CV=9.73%) were less.

Correlation among traits

Most parameters studied in fruits showed significantly positive correlations among themselves (Table 2); for example crude fiber and lignin (0.51), phosphorus and calcium (0.55), crude fiber and hemicellulose (0.56). Likewise in buds too, lignin and iron (0.51), moisture and phosphorus (0.54) were highly correlated (Table 3). Nonetheless, in fruits significantly negative correlations were found for lignin and calcium (-0.47), phosphorous and crude fiber (-0.49), proline and phosphorus (-0.50), crude fiber and zinc (-0.59), and crude protein and total carbohydrate (-0.95). Similarly for buds too, significant negative correlations were found for proline and phosphorus (-0.46), NDF and crude fat (-0.49), cellulose and crude fat (-0.52), proline and calcium (-0.55), carbohydrate and sodium (-0.57), crude fiber and crude fat (-0.61), and crude protein and total carbohydrate (-0.82).

Protein content was positively correlated with ash and negatively correlated with fat and carbohydrate indicating that selection for high protein will decrease the carbohydrate content and increase the ash content, which will make the nutritionally improved superior clone. The competition for photosynthates by these three energy-rich components is expected to be responsible for the negative correlation. Klepper (1975) also found such a negative association in wheat, and attributed this to the competition for energy between nitrate reduction (to produce protein) and CO_2 fixation (to produce photosynthate and yield) at the level of ferrodoxin. Rai and Rai (1987) reported similar results in *C. decidua* fruits. While positive correlation between protein and ash could be due to role of various enzymes and proteins in ion absorption and accumulation in cells. A positive correlation between NDF and its three components (cellulose, hemicellulose and lignin) suggests that the change in NDF content is distributed in its all three components. However, a significant correlation (0.47) between lignin and cellulose may hamper our efforts to select a genotype with lignin-free fruits, or *vice versa*.

Lignin and compatible solutes such as proline and glycinebetaine play an important role under abiotic stress in many higher plants (Ali *et al*., 2006). In this study, we found a significant positive correlation (0.56) in proline and lignin. Thus plant under stress accumulates the compatible solutes with increases in lignin concentration. The potassium as a salt, controlling the movement of water within the plant and the plants' respiration rate (stomatal opening and closing) may explain the positive correlation (0.48) of potassium with moisture in buds.

Calcium is relatively immobile in the phloem of plants, and source-to-sink transfer rates are invariably low. However, the Ca content had significantly negative association (-0.55) with proline probably because of their common role in maintaining osmolarity of the cell and to compensate NaCl-induced Ca loss (Shah *et al*., 2003). Thus, positive correlation between Ca and Na provides opportunities for simultaneous improvement. This result could probably reflect the fact that Ca

Table 2. Pearson's correlation coefficients among various biochemical and mineral contents of kair (C. decidua) fruits

Biochemical parameters	Moisture	Crude protein	Proline	Total carbohydrate	Carbohydrate	Starch	Crude fiber	NDF	Hemicellulose	Cellulose	Lignin	Crude fat	Ash	P	Mg	Fe	Zn	Cu	Na	K	Ca
Moisture	1.00																				
Crude protein	0.35	1.00																			
Proline	-0.06	0.11	1.00																		
Total carbohydrate	-0.33	-0.95	-0.27	1.00																	
Carbohydrate	0.31	-0.13	0.10	0.03	1.00																
Starch	0.17	0.22	0.01	-0.16	0.00	1.00															
Crude fiber	-0.26	0.28	0.33	-0.28	-0.27	0.03	1.00														
NDF	-0.17	0.24	0.32	-0.16	-0.01	-0.07	0.81	1.00													
Hemicellulose	-0.33	0.28	0.28	-0.18	-0.03	0.00	**0.56**	0.80	1.00												
Cellulose	-0.06	0.07	0.29	0.01	0.12	-0.11	0.66	0.90	0.58	1.00											
Lignin	-0.07	0.03	**0.56**	-0.03	0.18	-0.26	0.51	0.74	**0.47**	0.76	1.00										
Crude fat	-0.21	-0.40	0.43	0.11	0.19	-0.28	0.04	-0.20	-0.32	-0.20	0.03	1.00									
Ash	0.27	0.29	0.01	-0.29	0.31	0.27	-0.26	-0.17	-0.03	-0.14	-0.08	-0.41	1.00								
P	0.19	-0.22	**-0.50**	0.30	-0.01	0.17	**-0.49**	-0.43	-0.34	-0.39	-0.45	-0.12	-0.21	1.00							
Mg	-0.34	-0.04	0.18	0.07	-0.18	0.01	0.11	0.01	0.02	0.12	0.24	-0.14	0.19	-0.30	1.00						
Fe	0.15	-0.22	-0.15	0.23	0.18	-0.19	-0.20	-0.04	-0.15	0.01	0.25	0.02	0.01	0.05	-0.31	1.00					
Zn	0.23	-0.28	-0.18	0.33	0.40	-0.28	-0.59	-0.29	-0.15	-0.12	-0.12	-0.15	0.16	0.20	-0.26	**0.48**	1.00				
Cu	0.03	0.16	-0.09	-0.05	0.01	-0.02	-0.03	0.17	0.06	0.24	0.03	-0.42	0.23	0.01	0.16	-0.23	0.08	1.00			
Na	-0.06	-0.17	-0.01	0.18	-0.14	-0.03	-0.17	-0.26	-0.04	-0.23	-0.24	0.09	-0.28	0.32	0.24	-0.24	0.02	0.10	1.00		
K	-0.18	-0.04	-0.31	0.08	-0.38	0.20	-0.02	-0.19	-0.12	-0.30	-0.19	-0.12	0.04	0.16	0.16	0.39	-0.06	-0.25	-0.05	1.00	
Ca	-0.11	-0.16	-0.44	0.22	-0.22	-0.34	-0.25	-0.33	-0.13	-0.38	**-0.47**	-0.05	-0.26	**0.55**	-0.11	-0.02	0.22	0.22	0.62	0.08	1.00

Font underlined are level of significance at 0.01 and bold are level of significance at 0.05.

Table 3. Pearson's correlation coefficients among various biochemical and mineral contents of kair (C. decidua) buds

Biochemical parameters	Moisture	Crude protein	Proline	Total carbohydrate	Carbohydrate	Starch	Crude fiber	NDF	Hemicellulose	Cellulose	Lignin	Crude fat	Ash	P	Mg	Fe	Zn	Cu	Na	K	Ca
Moisture	1.00																				
Crude protein	-0.28	1.00																			
Proline	-0.45	-0.15	1.00																		
Total carbohydrate	0.22	-0.82	0.13	1.00																	
Carbohydrate	0.12	-0.30	0.28	0.17	1.00																
Starch	-0.26	-0.24	0.42	0.39	-0.01	1.00															
Crude fiber	0.06	0.23	-0.08	0.17	-0.15	0.25	1.00														
NDF	0.08	0.28	-0.26	0.04	-0.20	0.25	0.83	1.00													
Hemicellulose	0.14	0.30	-0.30	0.00	-0.32	0.20	0.73	0.92	1.00												
Cellulose	0.01	0.27	-0.09	0.05	-0.18	0.25	0.69	0.63	0.66	1.00											
Lignin	0.16	-0.25	-0.21	0.35	-0.10	0.03	-0.07	0.03	-0.07	0.06	1.00										
Crude fat	0.13	-0.27	-0.03	-0.32	0.17	-0.24	-0.61	**-0.49**	-0.45	**-0.52**	-0.15	1.00									
Ash	-0.27	0.30	0.26	-0.42	0.17	-0.23	-0.30	-0.30	-0.30	-0.01	-0.30	0.06	1.00								
P	**0.54**	0.08	**-0.46**	-0.06	0.04	-0.28	0.17	0.39	0.41	0.14	0.20	-0.01	-0.07	1.00							
Mg	-0.19	-0.04	0.34	-0.18	0.29	**0.48**	-0.43	-0.25	-0.20	-0.31	-0.30	0.39	-0.07	-0.32	1.00						
Fe	0.05	-0.30	-0.33	0.31	-0.21	-0.13	-0.09	0.02	0.09	0.25	**0.51**	-0.04	-0.08	0.18	-0.43	1.00					
Zn	-0.31	0.06	-0.01	0.05	-0.23	-0.24	-0.03	0.12	0.21	-0.07	-0.13	-0.21	0.16	0.01	-0.25	0.29	1.00				
Cu	-0.02	0.10	-0.05	-0.22	0.27	0.14	0.04	-0.02	-0.04	0.18	-0.31	0.23	0.00	-0.07	0.29	-0.06	-0.39	1.00			
Na	-0.16	0.27	-0.08	-0.19	-0.57	-0.21	0.06	0.17	0.29	-0.09	-0.10	-0.05	-0.36	0.24	-0.11	0.07	**0.51**	-0.22	1.00		
K	**0.48**	-0.27	-0.28	0.21	0.41	-0.02	-0.15	-0.12	-0.09	-0.07	-0.11	0.09	-0.08	0.17	0.20	0.15	0.01	0.44	-0.24	1.00	
Ca	0.18	-0.22	**-0.55**	0.30	-0.13	-0.17	0.12	0.08	0.06	-0.02	0.33	-0.12	-0.32	-0.03	-0.38	0.10	-0.06	-0.30	-0.19	-0.11	1.00

Font underlined are level of significance at 0.01 and bold are level of significance at 0.05.

provides normal transport and retention of other elements in plants (Jiang *et al*., 2007). One of the probable biochemical defense reactions to salinity stress is the production and accumulation of Reactive Oxygen Species (ROS). Zinc is required for scavenging of ROS including super oxide radical and H_2O_2. This explains the positive correlation (0.51) between Na and Zn. Uptake of Na element by plants leads to accumulation of Zn in cells to protect the biomolecules from ROS (Jamalomidi *et al*., 2006). Mg, the central atom of chlorophyll, is essential for carbohydrate metabolism as it also serves as a carrier of phosphate compounds during plant growth and explains the positive correlation (0.48) between Mg and starch, reflecting their important role in photosynthesis. Zn concentration was positively correlated with Fe indicating co-segregation of genes affecting both Zn and Fe (Cakmak *et al*., 2008). Thus selection for one element (for example, iron) will in fact result in an increase in other element(s) like Zn.

In conclusion, there is an extent of variation among the individuals of *C. decidua.* Also various biochemical traits, depending upon environment-related conditions, show associations. Therefore, exploration can be made to collect the superior plant material on the basis of the studied biochemical traits.

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