Research Article

Determination of Antinutritional Changes in Elephant Foot Yam (*Amorphophallus Paeoniifolius* Dennst- Nicolson) Cultivars during Storage

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Abstract

Elephant foot yam plays a key role in household food security in South East Asian food system, but its benefits have been negated due to presence of antinutritional compounds. The eleven cultivars *viz.*, BCA-1, BCA-2, BCA-4, BCA-5, BCA-6, NDA-4, NDA-5, NDA-9, IGAM-1, AC-28 and Gajendra were grown and after harvesting stored at ambient temperature upto three months to analyze the antinutritional changes at monthly intervals. The purpose of this study was to determine the oxalate content in elephant foot yam cultivars during storage condition. While, it was noticed a significantly decrease in all cultivars during storage. The ranges of antinutrient contents were found to be: water soluble oxalate (WSO) 25.61-11.83 mg/100g, total soluble oxalate (TSO) 33.83-18.26 mg/100g, calcium oxalate 15.28-5.97 mg/100g and total oxalate (TO) 37.57-20.70 mg/100g at different stages during storage. The entire investigated samples were found to be low oxalate content in all cultivars, which was safer from the viewpoint of accumulation of urinary oxalate leading to kidney stone. This information will provide researchers with the ability to develop desirable cultivars having high yield and better antinutritional profile.

Keywords: *Amorphophallus paeoniifolius*, Cultivar, Antinutritional, Storage

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Introduction

Amorphophallus paeoniifolius Dennst- Nicolson belongs to *Araceae* family and its common names are Elephant yam, Elephant bread, Elephant foot yam, Suran, Sweet yam, Jimikand. Other common names are Karak-kavanai (Tamil); Konjac, Konniaku, Konnyaku (Japan); Mo-yu (China); Ol (Assam) etc., which varies from region to region. In India, it is commonly known as "Suran" or "Elephant foot yam" and largely cultivated throughout the plains for using its corm (bulb) as food. It is a very popular vegetable due to its high productivity, nonirritant taste, and maximum monetary return within a short period of time [1]. They have played major role in the history of human diet, since they could be collected from the wild and consumed by many of the worlds poorest and most foods insecure households [2]. It contains moisture 74.8%; ash 0.73 %; fat 0.38%; protein 5.1%; carbohydrates 18.4%; crude fibre 0.6% and alkaloid [3, 4]. It is rich in nutrients like minerals (Ca, K, P, Zn), vitamins (A, B1, B2) and contains starch and carbohydrates as a major energy source. Potassium is the most abundant (327.83 mg/100g) macro mineral followed by phosphorus (166.91 mg/100g), calcium (161.08 mg/100 g) and iron (3.43 mg/100 g) [5]. The mean soluble oxalate content (13.53 mg/100 g) of yam is safe from the viewpoint of accumulation of urinary oxalate leading to kidney stones. This tuber is consumed by many people as a food and widely used in many Ayurvedic preparations [6]. The tubers of elephant foot yam are anodyne, anti-inflammatory, anti-haemorrhoidal, haemostatic, expectorant, carminative, digestive, appetizer, stomachic, anthelmintic, liver tonic, aphrodisiac, emmenagogue, rejuvenating and tonic [7]. They are traditionally used in arthralgia, elephantiasis, tumors, inflammations, haemorrhoids, haemorrhages, vomiting, cough, bronchitis, asthma, anorexia, dyspepsia, flatulence, colic, constipation, helminthiasis, hepatopathy, splenopathy, amenorrhea, dysmenorrhoea, seminal weakness, fatigue, anaemia and general debility [8]. The tuber is reported to have antiprotease activity, central nervous system depressant activity, analgesic activity cytotoxic activity [9-12].

It is difficult to ascertain whether the tubers can be relied upon as good sources of minerals because of the presence of anti-nutrition substances (oxalate), which render the minerals, in them unavailable to the consumers [13]. These corms are consumed by many people as a food and widely used in many ayurvedic preparations [12] because it contains different bioactive components like alkaloids, flavonoids, phenols, vitamins, minerals etc. [14-18]. Oxalate is a common constituent of plants and several species, including some crop plants, accumulate high levels of this di-carboxylic acid anion [19]. Oxalates in tubers may either be a cause or a contributor as to the acridity, which causes irritation, and swelling of mouth and throat [20]. Oxalate anion has the chemical formulae of $C_2O_4^{2-}$ or $(COO)_2^{2-}$. Scratching of the mouth and throat is also experienced in yam [21, 13]. Calcium oxalate (CaC_2O_4) is a major component of kidney stone. High intake of oxalate may reduce the calcium availability in the body and this may be an increased risk factor for women who require greater amount of calcium in their diets. Dietary oxalate has been known to complex with calcium, magnesium and iron leading to the formation of insoluble oxalate salt and resulting in oxalate stone. Oxalates also interfere with the utilization of minerals making them unavailable or reduced in the body [13]. The objective of this study is to determine the oxalate content in the some selected elephant foot yam cultivars commonly consumed in India in daily diet which helps to the researchers to develop desirable types cultivars having high yield and better nutritional profile.

Materials and Methods

Collection of samples

Elephant foot yam cultivars having smooth and glabrous pseudo-stems, collected from the State Agricultural Universities and Research Institutes under the Indian Council of Agricultural Research, India (**Table 1**) and cultivated at Horticultural Research Station, Mondouri, Bidhan Chandra Krishi Viswavidyalaya, West Bengal. Sample collection was started at the time of harvesting and stored at Horticultural Research Station, Mondouri, BCKV, West Bengal, India and analyzed at monthly intervals. The station was located at 23.5 ^{O}N latitude and 89 ^{O}E longitudes with an altitude of 9.75 m above mean sea level from 2010 to 2012. The soil was a slightly acidic (pH 6.5) with sandy loam. The climate of the region is tropical humid with rainfall of 0.00 to 264.00 mm, temperature maximum 37.59 ^{O}C and minimum 9.62 ^{O}C along with RH (%) 96.87 to 36.74 (Annual average) by *AICRP on Agricultural Meteorology*, BCKV, Kalyani, Nadia West Bengal.

Table 1 Source and plant type of elephant foot yam cultivars

Cultivar	Source of cultivar in India	Pseudo-stem type
BCA-1	BCKV, Kalyani, West Bengal	Smooth
BCA-2	BCKV, Kalyani, West Bengal	Smooth
BCA-4	BCKV, Kalyani, West Bengal	Smooth
BCA-5	BCKV, Kalyani, West Bengal	Smooth
BCA-6	BCKV, Kalyani, West Bengal	Smooth
NDA-4	NDUAT, Faizabad, Uttar Pradesh	Smooth
NDA-5	NDUAT, Faizabad, Uttar Pradesh	Smooth
NDA-9	NDUAT, Faizabad, Uttar Pradesh	Smooth
AC-28	ANGRAU, Rajendranagar, Hyderabad	Smooth
IGAM-1	IGKV, Raipur, Chhattisgarh	Smooth
Gajendra	ANGRAU, Rajendranagar, Hyderabad	Smooth

BCA - Bidhan Chandra Amorphophallus; NDA – Narendra Dev Amorphophallus; AC - Amorphophallus Companulatus; IGM - Indira Gandhi Amorphophallus BCKV- Bidhan Chandra Krishi Viswavidyalaya; NDUAT- Narendra Dev University of Agriculture and Technology; ANGRAU- Acharya NG Ranga Rao Agricultural University; IGKV- Indira Gandhi Krishi Viswavidyalaya

Physico-chemical analysis

The physic-chemical characteristics of elephant foot yam were recorded from randomly selected corms from each stored cultivars throughout the year at monthly intervals during storage by mentioned methods *viz.*, oxalate by titrimetric methods of AOAC [22] and Holloway [20].

Statistical procedure

All the lab data were used to Complete Randomized Design (CRD) as suggested by Raghuramula [23]. The critical difference (CD) value at 5% level of probability was used for comparing the treatments and to find out the significant difference in between them. Each treatment was replicated for three times. The data analyzed with the help of statistical software from AGRES version 3.01 (Data Entry Module for Ag Res Statistical Software <c> 1994 Pascal Intl software solution).

Results and Discussion

Water-soluble oxalate

WSO content of corm also varied significantly among the different cultivars which shows in **Table 2** and it was noticed that an in increasing trend during storage. It was depicted that cultivar BCA-4 content least amount of water-soluble oxalate at 0 DAS (Days After Storage) and 90 DAS (17.32 and 11.83 mg/100g, respectively). While, was content highest amount of water soluble oxalate in cv. NDA-9 at 0 DAS and 90 DAS (25.61 and 18.08 mg/100g) respectively. Such variation in water-soluble oxalate content might be related to their genetic origin, geographical sources, and the level of soil fertility, where they are grown and the storage periods. However, these results were consistent with the results of a study by Chattopadhyay [5] and Misra and Sriram [24].

Table 2 Changes in Water-soluble oxalate content (mg/100g) in elephant foot yam corm during storage

Cv.\DAP	**0**			**30**			**60**			**90**		
	2011-12	**2012-13**	**Pooled**	**2011-12**	**2012-13**	**Pooled**	**2011-12**	**2012-13**	**Pooled**	**2011-12**	**2012-13**	**Pooled**
BCA-1	24.10	25.64	24.87	22.67	23.56	23.12	19.74	18.52	19.13	16.28	16.85	16.56
BCA-2	21.04	23.97	22.51	20.84	20.20	20.52	16.62	15.46	16.04	14.08	13.74	13.91
BCA-4	18.85	15.80	17.32	17.44	14.67	16.06	16.05	13.83	14.94	12.21	11.46	11.83
BCA-5	23.15	24.28	23.72	22.69	21.40	22.04	19.46	18.53	19.00	17.69	16.80	17.24
BCA-6	22.72	25.85	24.28	21.32	20.49	20.91	19.56	17.63	18.60	16.67	15.08	15.87
NDA-4	24.10	26.90	25.50	22.89	23.32	23.11	18.62	19.07	18.84	14.41	16.03	15.22
NDA-5	21.49	21.23	21.36	19.90	18.43	19.16	17.13	15.91	16.52	15.54	14.15	14.85
NDA-9	25.03	26.21	25.62	24.82	23.38	24.10	21.03	19.67	20.35	18.87	17.28	18.08
IGAM-1	26.15	21.67	23.91	23.35	19.36	21.35	19.18	17.06	18.12	15.39	16.64	16.01
AC-28	25.80	22.15	23.97	24.22	19.63	21.93	18.46	17.53	18.00	16.85	15.87	16.36
Gajendra	19.28	21.28	20.28	17.45	18.32	17.89	16.13	14.79	15.46	13.59	12.21	12.90
Mean	22.88	23.18	23.03	21.60	20.25	20.93	18.36	17.09	17.73	15.60	15.10	15.35
	CD 0.05	**S Ed**		**CD 0.05**	**S Ed**		**CD 0.05**	**S Ed**		**CD 0.05**	**S Ed**	
C	3.062	1.519	**	2.521	1.251	**	2.574	1.277	*	192.194	95.363	NS
Y	1.306	0.648	NS	1.075	0.533	*	1.097	0.544	*	81.951	40.663	NS
CY	4.331	2.149	NS	3.565	1.769	NS	3.640	1.806	NS	271.803	134.864	NS

C-Cv.- Cultivar; Y- Year; CD- Critical Difference at 5 %; S Ed- Standard Error of Deviation; DAS- Days After Storage; R- Replication (3); NS- Non Significant; **- Highly Significant; *- Significant

Table 3 Changes in Total-soluble oxalate content (mg/100g) in elephant foot yam corm during storage`

Cv.\DAP	**0**			**30**			**60**			**90**		
	2011-12	**2012-13**	**Pooled**	**2011-12**	**2012-13**	**Pooled**	**2011-12**	**2012-13**	**Pooled**	**2011-12**	**2012-13**	**Pooled**
BCA-1	29.80	31.38	30.59	27.94	28.56	28.25	24.77	23.34	24.06	20.82	21.59	21.21
BCA-2	27.41	33.33	30.37	26.45	28.67	27.56	21.79	23.82	22.81	19.14	21.59	20.37
BCA-4	26.92	24.64	25.78	24.89	22.89	23.89	22.64	20.75	21.70	18.44	18.26	18.35
BCA-5	28.85	29.08	28.96	27.89	25.34	26.62	24.44	22.24	23.34	22.38	20.32	21.35
BCA-6	28.05	31.64	29.85	26.29	25.45	25.87	24.51	22.56	23.54	21.43	19.79	20.61
NDA-4	29.74	32.90	31.32	27.57	28.46	28.01	22.77	23.67	23.22	18.49	20.42	19.46
NDA-5	31.33	32.40	31.86	28.89	28.62	28.76	25.51	26.03	25.77	23.59	23.15	23.37
NDA-9	33.28	34.38	33.83	32.83	30.89	31.86	28.19	27.11	27.65	25.29	23.70	24.49
IGAM-1	31.80	28.77	30.28	28.23	26.03	27.13	23.31	22.76	23.03	19.31	22.24	20.77
AC-28	31.92	28.51	30.22	29.35	25.53	27.44	23.55	23.25	23.40	21.64	21.35	21.50
Gajendra	26.05	27.90	26.97	23.35	24.22	23.78	21.94	20.02	20.98	19.19	17.33	18.26
Mean	29.56	30.45	30.00	27.61	26.79	27.20	23.95	23.23	23.59	20.88	20.89	20.89
	CD 0.05	**S Ed**		**CD 0.05**	**S Ed**		**CD 0.05**	**S Ed**		**CD 0.05**	**S Ed**	
C	2.386	1.184	**	2.453	1.217	**	2.405	1.193	**	2.198	1.091	**
Y	1.017	0.505	NS	1.046	0.519	NS	1.025	0.509	NS	0.937	0.465	NS
CY	3.374	1.674	*	3.469	1.722	NS	3.401	1.687	NS	3.108	1.542	NS

C-Cv.- Cultivar; Y- Year; CD- Critical Difference at 5 %; S Ed- Standard Error of Deviation; DAS- Days After Storage; R- Replication (3); NS- Non Significant; **- Highly Significant; *- Significant

Total soluble oxalate

Total soluble oxalate (TSO) content of corm was significantly influenced by cultivars during storage (**Table 3**). Lowest content of total soluble oxalate depicted in cultivar BCA-4 (25.78 mg/100g) at 0 DAS and in cv. Gajendra

(18.26 mg/100g) at 90 DAS. While, in cultivar NDA-9 content highest amount at both stage (0 and 90 DAS) 33.83 mg/100g and 24.49 mg/100g, respectively. The mean value varied significantly and constant decrease in total soluble oxalate content of corms was found during storage period. However, TSO compositions of elephant foot yam corms studied were similar to reported values of several cultivated elephant foot yam cultivar by Chattopadhyay [5].

Calcium oxalate

Calcium oxalate content of elephant foot yam corm ranged from 5.97-15.28 mg/100g during different stages. The highest calcium oxalate content was found in cultivar NDA-5at 0 DAS (15.28 mg/100g) and 90 DAS (12.40 mg/100g), respectively. While, the lowest calcium oxalate value was observed in cv. BCA-5 at 0 and 90 DAS (7.63 and 5.97 mg/100g), respectively (**Table 4**). Taking into consideration all the storage stage it was observed that there was significant variation in mean calcium oxalate content and a decreasing trend in calcium oxalate was observed in all cultivar during storage of corms. The average value of over cultivars was <50 mg, which is found in most of the cultivars, and does not pose a problem to human digestion. This result agrees well with the study results reported by Fasset [25].

Table 4 Changes in Calcium oxalate content (mg/100g) in elephant foot yam corm during storage

Cv.\DAP	**0**			**30**			**60**			**90**		
	2011-12	**2012-13**	**Pooled**	**2011-12**	**2012-13**	**Pooled**	**2011-12**	**2012-13**	**Pooled**	**2011-12**	**2012-13**	**Pooled**
BCA-1	8.28	8.36	8.32	7.66	7.27	7.47	7.31	7.01	7.16	6.60	6.90	6.75
BCA-2	9.27	13.61	11.44	8.17	12.32	10.24	7.52	12.16	9.84	7.37	11.41	9.39
BCA-4	11.75	12.87	12.31	10.84	11.96	11.40	9.59	10.07	9.83	9.06	9.89	9.48
BCA-5	8.28	6.97	7.63	7.57	5.74	6.65	7.24	5.39	6.31	6.81	5.12	5.97
BCA-6	7.76	8.43	8.09	7.23	7.22	7.22	7.20	7.17	7.18	6.93	6.85	6.89
NDA-4	8.21	8.73	8.47	6.80	7.47	7.14	6.04	6.70	6.37	5.94	6.40	6.17
NDA-5	14.32	16.24	15.28	13.08	14.83	13.95	12.20	14.72	13.46	11.71	13.09	12.40
NDA-9	12.01	11.90	11.95	11.65	10.92	11.29	10.43	10.82	10.62	9.34	9.33	9.33
IGAM-1	8.21	10.33	9.27	7.11	9.70	8.40	6.01	8.29	7.15	5.71	8.14	6.92
AC-28	8.91	9.25	9.08	7.46	8.58	8.02	7.40	8.32	7.86	6.97	7.97	7.47
Gajendra	9.85	9.62	9.73	8.57	8.59	8.58	8.46	7.61	8.03	8.15	7.46	7.80
Mean	9.71	10.57	10.14	8.74	9.51	9.12	8.12	8.93	8.53	7.69	8.42	8.05
	CD 0.05	**S Ed**		**CD 0.05**	**S Ed**		**CD 0.05**	**S Ed**		**CD 0.05**	**S Ed**	
C	1.095	0.543	**	1.191	0.591	**	1.239	0.614	**	1.276	0.633	**
Y	0.467	0.232	**	0.508	0.252	**	0.528	0.262	**	0.544	0.270	**
CY	1.549	0.768	*	1.685	0.836	*	1.752	0.869	*	1.804	0.895	*

C-Cv.- Cultivar; Y- Year; CD- Critical Difference at 5 %; S Ed- Standard Error of Deviation; DAS- Days After Storage; R- Replication (3); NS- Non Significant; **- Highly Significant; *- Significant

Table 5 Changes in Total oxalate content (mg/100g) in elephant foot yam corm during storage

Cv.\DAP	**0**			**30**			**60**			**90**		
	2011-12	**2012-13**	**Pooled**	**2011-12**	**2012-13**	**Pooled**	**2011-12**	**2012-13**	**Pooled**	**2011-12**	**2012-13**	**Pooled**
BCA-1	32.38	34.00	33.19	30.33	30.84	30.58	27.05	25.53	26.29	22.88	23.75	23.32
BCA-2	30.31	37.59	33.95	29.00	32.52	30.76	24.14	27.62	25.88	21.44	25.16	23.30
BCA-4	30.59	28.66	29.63	28.28	26.63	27.45	25.64	23.90	24.77	21.27	21.35	21.31
BCA-5	31.43	31.26	31.34	30.26	27.13	28.70	26.70	23.92	25.31	24.51	21.92	23.21
BCA-6	30.48	34.27	32.38	28.55	27.71	28.13	26.76	24.80	25.78	23.59	21.93	22.76
NDA-4	32.31	35.62	33.97	29.69	30.79	30.24	24.66	25.76	25.21	20.35	22.42	21.39
NDA-5	35.81	37.47	36.64	32.98	33.25	33.12	29.32	30.63	29.98	27.25	27.25	27.25
NDA-9	37.04	38.10	37.57	36.47	34.31	35.39	31.45	30.49	30.97	28.21	26.61	27.41
IGAM-1	34.36	32.00	33.18	30.45	29.06	29.76	25.18	25.35	25.27	21.09	24.78	22.94
AC-28	34.71	31.40	33.06	31.68	28.21	29.95	25.86	25.85	25.85	23.81	23.85	23.83
Gajendra	29.13	30.90	30.02	26.02	26.91	26.47	24.58	22.40	23.49	21.74	19.66	20.70
Mean	32.59	33.75	33.17	30.34	29.76	30.05	26.49	26.02	26.26	23.29	23.52	23.40
	CD 0.05	**S Ed**		**CD 0.05**	**S Ed**		**CD 0.05**	**S Ed**		**CD 0.05**	**S Ed**	
C	1.584	0.786	**	2.398	1.190	**	2.456	1.218	**	2.706	1.343	**
Y	0.675	0.335	**	1.023	0.507	NS	1.047	0.519	NS	1.154	0.572	NS
CY	2.241	1.111	**	3.392	1.683	NS	3.473	1.723	NS	3.828	1.899	NS

C-Cv.- Cultivar; Y- Year; CD- Critical Difference at 5 %; S Ed- Standard Error of Deviation; DAS- Days After Storage; R- Replication (3); NS- Non Significant; **- Highly Significant; *- Significant

Total oxalate

Total oxalate (TO) content of corm was significantly influenced by cultivars during storage (**Table 5**). The cultivars NDA-9 content highest amount of total oxalate at 0 and 90 DAS (37.57 and 27.41 mg/100g, respectively). While, the cultivars BCA-4 and Gajendra content lowest (29.63 and 20.70 mg/100g) at 0 and 90 DAS, respectively. The mean value at all storage stages was also varied significantly among the cultivars and a decrease in total oxalate content of corms was found during storage. The range of variation observed in this study on this aspect among different collections are some what in accordance with findings [26-28] and these variation in total oxalate content might be related to their genetic origin, geographical sources, the level of soil fertility, where they are grown and the harvesting periods.

Conclusion

This paper demonstrates the level of oxalate content at various stages during storage of elephant foot yam corms and it depicted that these low oxalate content cultivars should not be ignored because these are under permissible limit. We hope that this study will help to propagate knowledge on these underutilized vegetable for their commercial cultivation and it provide breeders and researchers with the ability to develop desirable types having high yield and better antinutritional profile cultivar of elephant foot yam.

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