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Evaluation of Nutritional Quality of Under-utilized Wild Yams of Western Ghats of India

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Abstract

Wild Yams belonging to the family Dioscoreaceae makes significant contribution in the diets of the tribals in India. Wild yams are considered as a "life saving" crop among many tribal community. They also have immense medicinal properties due to the presence of secondary metabolites especially diosgenin. In this study, biochemical variation among the major wild yams were studied to identify nutrient dense genotypes in germplasm. The biochemical evaluation of starch, sugar, crude protein, crude fat and crude fibre was carried out keeping in mind the nutritive value of the yam tubers. The result indicated that wild yams have abundant nutrient richness than the cultivated greater yam varieties. Among the *Dioscorea* species, *D. oppositifolia,* one of the most common wild yams in India, had the highest starch content (28.90%). *D. floribunda* had the highest content of sugar (1.75%), fibre (0.40%) and fat (8.05%). *D. bulbifera* had the highest protein content (4.23%) in fresh tuber. From the genetic correlations estimated, the fibre content showed negative correlation to starch content (-0.1956).

Key words: *Dioscorea*, wild yams, starch, protein, sugar, fibre, fat, heritability, correlation

Introduction

The English term 'Yam' is believed to be originated from the tribal African word '*niam*' meaning 'to sample' or 'to taste' (Coursey, 1967). Yams belong to the family Dioscoreacea. These are monocotyledonous, perennial, herbaceous vines constituting an important part of the forest flora forming edible aerial and underground tubers. Approximately 850 *Dioscoreae* species are known to occur all around the world. Yam is a food source for more than 100 million people and is an important income source for small farmers in many developing countries (Lebot, 2009). Yam is primarily eaten for its carbohydrates (Tetchi et al. 2007), as well as protein, potassium, sodium, magnesium, copper and zinc (Baah et al., 2009). are also rich in phytochemicals like flavanoids, cholesterol, alkaloids, terpenoids, cardiac glycosides, saponins, and steroids (Sheikh et al., 2013) and also rich in vitamins like ascorbic acid, niacin, riboflavin and thiamine. The bitterness and toxicity in some wild yams is due to the presence of saponin and alkaloids.

Yams have cultural, economic and nutritional importance in the tropical and subtropical regions of the world (Bhandari and Kawabata, 2005). These crops have great potential to serve as sources of nutrients for tribals and will serve as an excellent dietary supplement for the future generations. In fact, they are one of the principal sources of food and nutrient energy for many people in the tropics and have nutritional superiority as compared with other tropical root crops (Baquar and Oke, 1976). In addition to the regular use, tribals depend on the yams especially during the period of drought and food scarcity. Wild yams are considered as a 'life saving' crop among many poor indigenous community in India. In Western Ghats, the tribes consume various species of *Dioscorea* like *D. pentaphylla, D. oppositifolia, D. wallichii, D. pubera, D. wightii, D. bulbifera, D. hispida* etc. Among wild yams,

tubers of *D. pentaphylla* and *D. oppositifolia* are the most popular, safe and used as food. The species like *D. hamiltonii* and *D. hispida* tastes bitter and considered to be toxic and therefore requires thorough processing before consumption (Narayanan et al., 2011).

The bitterness and toxicity in wild yams are caused due to the presence of high level of a steroidal saponin, which is a secondary metabolite produced by yams namely diosgenin. The consumption of these tubers without processing causes vomiting and diarrhoea. When large amount are ingested it will cause itching sensation among children (Webster et al., 1984). In India, yams are grown practically in all the States but the major yam producing States are Kerala, West Bengal, Bihar, Odisha, Assam, Gujarat and Maharashtra. The genetic variability available in India have been collected and maintained at the National Repository for tuber crops germplasm, ICAR-CTCRI. Since wild yams form one of the major food sources for the tribal population of Kerala, it is imperative to study the biochemical variation among wild yams seen in Western Ghats for assessing their nutritional quality. This research work attempts investigation of major biochemical traits contributing to nutritional quality of different wild yams consumed by the tribal population in India. The exploitation of the genetic variation so determined serves to facilitate the development of better varieties of wild edible yams with good nutritional quality for ensuring nutritional security of the marginalised tribal population in Western Ghats.

Materials and Methods

Planting material

The planting materials used for the study comprises of 21 accessions of *Dioscorea* collected from the germplasm maintained in the field gene bank at ICAR-CTCRI, Thiruvananthapuram during 2016-2018. The variation among the wild yam species, based on biochemical traits were carried out in the wild yam genotypes listed in Table 1. Tuber cuttings were planted in pots arranged at a spacing of 1m×1m. The vines were supported on a stake of about 2m height. Harvest was done by manually digging out the tubers and the tubers were cleaned free of soil and kept in ventilated yam storage house till the next planting season.

The tuber samples were used for analyzing the biochemical properties and nutritional qualities. The harvested tubers were collected and cleaned for analyzing the dry matter, starch, sugar, fat, fibre and protein contents.

Table 1. Accessions of wild yam species used for the study

Sl. No	Species Name	Accession code
1	*D. alata 340*	Da 2
2	*D. belophylla*	Dbe1
3	*D. bulbifera*	Dbu 1
4	*D. bulbifera*	Dbu 2
5	*D. esculenta*	De 1
6	*D. floribunda*	Df 1
7	*D. floribunda*	Df 2
8	*D. hispida*	Dh 1
9	*D. hispida*	Dh 2
10	*D. oppositifolia*	Dol 1
11	*D. oppositifolia*	Dol 2
12	*D. rotundata*	Dr 1
13	*D. tomentosa*	Dt 1
14	*D. tomentosa*	Dt 2
15	*D. vexans*	Dv 1
16	*D. wallichii*	Dw 1
17	*D. wallichii*	Dw 2
18	*D. wallichii*	Dw 3
19	*D. wallichii*	Dw 4
20	*D. wallichii*	Dw 5
21	*Dioscorea.spp*	Du 1

The yam tubers were washed, peeled and sliced into cubes of 50 g size and dried in hot air oven at a temperature of 60°C. The samples were weighed until constant weight obtained. The dried samples were floured and stored in plastic bottles for further biochemical analysis. The dry matter was expressed on a percentage basis and calculated using the following formula; Dry matter percentage = (dry wt/fresh wt) x 100. Starch and sugar content analysis was done based on a rapid Titrimetric method (Moorthy and Padmaja, 2002; Nelson, 1944).

For estimating crude protein, nitrogen content was estimated by Micro Kjeldahl method (Humphries, 1956). The crude protein content (AOAC, 1960) was obtained by multiplying the total Nitrogen content with a factor of 6.25. Crude fat content was estimated based on Folch

et al. (1957) method wherein extraction of fat was done using organic solvents (two extractions with alcohol: ether (3:1) and a single extraction with chloroform: ethanol (1:1).

Crude fibre content was estimated based on AOAC (1975) method wherein crude fibre was extracted by digestion with acid (Sulphuric acid – 1.25%) and alkali (Sodium hydroxide – 1.25%).

The genetic variability assessed using different genetic parameters such as phenotypic and genotypic coefficient of variation, heritability along with genetic advance is essential to accomplish a successful crop improvement programme. Hence genetic parameters viz. genotypic and phenotypic components of variance, coefficients of variability, broad sense heritability and genetic advance were estimated with the biochemical data by adapting the formulae suggested by Allard (1960) and Singh and Chaudhary (1997).

Results and Discussion

Within the wild *Dioscorea* species a wide range of variation in biochemical traits was observed. The variation for biochemical traits for wild yams are given in Table 2 and also depicted in Fig. 1 & 2. Biochemical analysis of the samples were done for drymatter, starch,

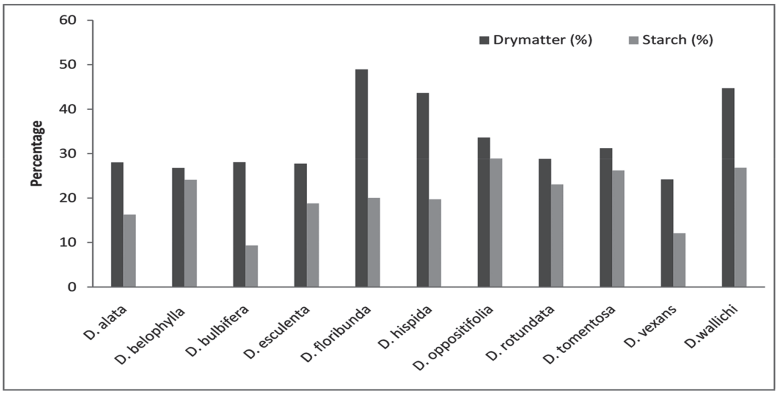

Fig. 1. Variation in dry matter and starch content among *Dioscorea* species

Table 2. Nutritional composition of fresh tubers from different *Dioscorea* species

Accession Code	Dry matter (%)	Starch (%)	Total Sugar (%)	Crude protein (%)	Crude fibre (%)	Crude fat (%)
Da 1	28.02	16.29	0.58	1.94	0.03	0.52
Dbe1	26.79	24.11	0.42	1.41	0.00	0.47
Dbu 1	27.40	21.92	0.50	1.67	0.02	0.50
Dbu2	28.07	9.36	0.40	4.23	0.18	0.72
De 1	27.74	18.79	0.45	2.95	0.10	0.61
Df 1	48.93	20.02	1.75	3.17	0.40	8.05
Df 2	38.33	19.41	1.10	3.06	0.25	4.33
Dh 1	43.63	19.71	1.42	3.11	0.32	6.19
Dh2	40.98	19.56	1.26	3.09	0.28	5.26
Dol 1	24.02	13.51	0.40	3.02	0.09	0.77
Dol2	33.61	28.90	1.40	1.85	0.04	1.41
Dr 1	28.82	23.06	0.90	2.44	0.06	1.09
Dt 1	31.21	26.23	1.15	2.15	0.05	1.25
Dt2	26.19	6.74	0.65	1.26	0.06	0.88
Dv 1	24.21	12.11	1.05	1.67	0.31	1.59
Dw 1	25.20	9.42	0.85	1.47	0.19	1.23
Dw2	41.89	25.13	1.31	2.93	0.19	1.53
Dw3	33.54	17.28	1.08	2.20	0.19	1.38
Dw4	39.05	15.97	0.78	3.92	0.16	0.90
Dw5	44.71	26.83	1.24	2.86	0.11	1.23
Du1	35.61	20.03	0.59	2.74	0.11	0.87

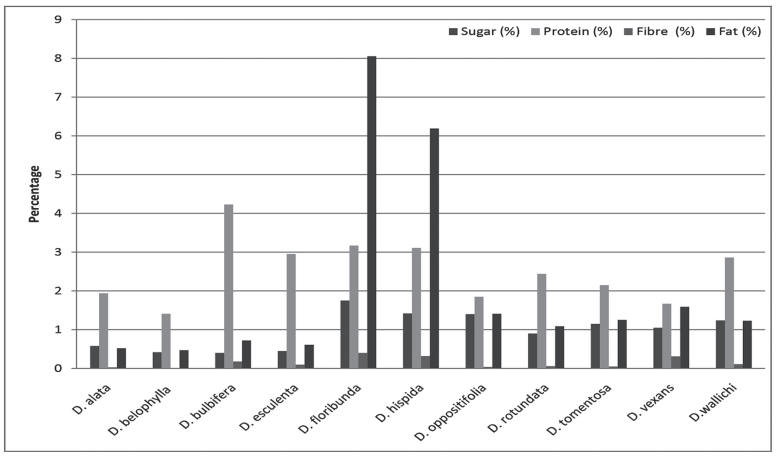

Fig. 2. Variation in sugar, protein, fibre and fat content among *Dioscorea* species

sugar, crude protein, crude fibre and fat. 321 accessions of wild yams collected from different parts of Western Ghats were conserved as field Gene bank in the National Repository on Tuber Crops germplasm at ICAR-Central Tuber Crops Research Institute, Thiruvananthapuram, India. The wild yams used for this study were collected from the field gene bank representing the popular species in India. From the analysis it was observed that drymatter content is highest for *D. floribunda* with 48.93% followed by *D. wallichi* (44.71%) and *D. hispida* (43.63%) and lowest value was observed in *D. oppositifolia* (24.02%) and *D. vexans* (24.21%). Starch content was observed to be highest in *D. oppositifolia* (28.90%) followed by *D. wallichi* (26.83) and the lowest was recorded in *D. tomentosa* (6.74%) in fresh tubers. Sugar content was observed to be highest in *D. floribunda* (1.75%) followed by *D. hispida* and lowest in *D. bulbifera* (0.40%).

Crude protein content was highest in *D. bulbifera* (4.23%) followed by *D. wallichi* (3.92%) and lowest in *D. tomentosa* (1.26%). The accessions of *D. floribunda*, *D. hispida* and *D. wallichi* had higher crude protein content than *D. alata.* Fibre content was highest in *D. floribunda* (0.40%) and lowest value was recorded in *D. belophylla* (0.01%). Fat content was observed to be highest in *D. floribunda* (8.05%) followed by *D. hispida* (6.19%) and the lowest value was recorded in *D. belophylla* (0.47%). Sugar content was observed to be highest in *D. floribunda* (1.75%) followed by *D. hispida* and lowest value in *D. bulbifera* (0.40%).

Wanasundera and Ravindran (1994) reported an average crude protein content of 7.4% on dry weight basis in *D. alata* cultivars while Da 340, the greater yam genotype evaluated in the present study had a higher crude protein content of 11.50%. The crude fibre content obtained for *D. esculenta, D. rotundata, D. alata,* and *D. bulbifera* were found to be lesser than the species studied in the Eastern region of Ghana (Polycarp et al., 2012). The range in crude fibre content was lesser and for the crude fat content it was higher than the wild yams species studied from in the Eastern region of Ghana (Polycarp et al., 2012). This may be due to the difference in the loccation of sample collection, since wild yam species collected from Ghana (Africa) may have suitable climatic condition and since Africa is considered as one of centre of origin of yams.

The crude protein content in *D. bulbifera* was found to be higher (6.32%) than the aerial tuber studied from tribal Kanikkars of Kanyakumari district (Shanthakumari et al., 2008). The percentage of fat content in *D. floribunda* was highest among the accessions studied which ranged from 31% - 16.45% which was a unique and informative value obtained. The present investigation also indicated higher fat content in *D. floribunda* and *D. hispida* as compared to other wild yams studied.

D. bulbifera (9.36%-21.92%) and *D. tomentosa* (6.74% - 26.23%) species had the widest range in starch content. *D. oppositifolia* also had wide variation (0.40% - 1.40%) for sugar content. Within *D. floribunda*, a wide range (4.33% - 8.05%) in crude fat content was observed. The results revealed that *D. floribunda* (1.7%) had higher sugar content than the cultivated *D. alata* (0.58%). Similarly, *D. wallichi* (3.92%) and *D. bulbifera* (4.23%) have higher protein content than *D. alata* (1.94%). *D. oppositifolia* (28.90%), *D. wallichi* (26.83%), and *D. belophylla* (24.11%) had higher starch content than *D. alata* (16.29%). Among the wild yam species, *D. floribunda* was observed to be rich in dietary nutrients than other species of wild yams from Western Ghats. *D. bulbifera* had high protein content coupled with low sugar and hence can be used as a safe food for patients suffering from diabetics.

The yam genotypes were also statistically analyzed for genetic parameters for the nutritional traits. Genotypic and phenotypic

coefficient of variation measures the extent of variation present in the population. Estimate of PCV is an indication of total variability, while GCV provides a basis for assessment and comparison of the genetic variability for the traits studied. The estimation of heritability and genetic advance as percent of mean is also needed to assess the heritable portion of total variation and to predict the extent of genetic gain expected under selection. Evaluation of genetic parameters in yams for biochemical traits is given in Table 5. All the traits studied had very high heritability (>0.9). The highest heritability was observed for fat content (0.9994). Genetic advance was observed to be highest in drymatter content with 15.11% followed by starch (14.04%). Most of the biochemical traits exhibited high heritability in broad sense but with low genetic advance indicating non additive nature of character expression. Sugar content was also found to be highly correlated with protein (0.6430) and fat (0.7552) contents. Negative genotypic correlation (Table 3 & 4) was observed for starch with fibre (-0.1956) which means that as starch increases the fibre content in tubers decreases. Crude protein, sugar, and fat contents had positive correlation with starch. Highest genotypic correlation (0.9332) existed between fat and protein content.

Table 3. Phenotypic correlation among biochemical traits in wild yams

Biochemical parameters	Drymatter	Starch	Sugar	Protein	Fibre	Fat
Drymatter	1					
Starch	0.5905	1				
Sugar	0.7550	0.4447	1			
Protein	0.7748	0.2540	0.6480	1		
Fibre	0.4495	-0.1906	0.5894	0.5959	1	
Fat	0.7621	0.7503	0.7122	0.9324	0.7673	1

Table 4. Genotypic correlation among biochemical traits in wild yams

Biochemical parameters	Drymatter	Starch	Sugar	Protein	Fibre	Fat
Drymatter	1					
Starch	0.5926	1				
Sugar	0.7672	0.4488	1			
Protein	0.7780	0.2540	0.6430	1		
Fibre	0.4573	-0.1956	0.5945	0.5989	1	
Fat	0.7698	0.1569	0.7552	0.9332	0.7689	1

Table 5. Evaluation of genetic parameters in wild yams for biochemical traits

Biochemical parameters(%)	GCV	PCV	HERITABILITY	GA 5%	GA AS % OF MEAN
Drymatter	23.49	23.75	0.9790	15.11	47.89
Starch	39.12	39.52	0.9802	14.04	79.79
Sugar	53.21	53.63	0.9844	0.9083	108.75
Protein	62.31	62.35	0.9985	3.01	128.26
Fibre	102.97	103.33	0.9929	0.2561	211.38
Fat	139.62	139.66	0.9994	4.303	287.53

Conclusion

The study explored the genetic variability in biochemical traits of yams collected from different regions of Western Ghats in India. Twenty one accessions of wild yams collected from Western Ghats and from different forest ecosystems maintained in the field genebank of ICAR – CTCRI were selected for the study.

It was revealed that the wild yams are rich in starch, sugar, fibre, fat and protein contents. Among the *Dioscorea* species studied, *D. floribunda, D. bulbifera, D. hispida, D. oppositifolia* and *D. wallichi* have higher protein content than the cultivated yams. Also *D. belophylla* has higher starch content along with lower fibre content than *D. alata,* which is a cultivated species. *D. bulbifera* has high protein content coupled with low sugar and can be used as a safe food for patients suffering from diabetics. All the biochemical traits studied had very high heritability (>0.9). Negative genotypic correlation was observed for starch with fibre (-0.1956) while all others recorded high positive genotypic correlation with each other. Since the wild yams play an important role in the diet of tribal communities, the information on nutritive quality traits will enhance further utilization of wild yams in Kerala. The exploitation of the genetic diversity so determined serves to facilitate the development of better varieties through conventional and marker assisted breeding programme for future nutritional enhancement in cultivars.

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