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Regional Variation in Nutritional Composition of *Colocasia esculenta* (L.) Leaves and Corms in Himachal Pradesh

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KEYWORDS

Taro, nutritional composition, regional variation, leaves, corms.

ABSTRACT:

Introduction: *Colocasia esculenta* (L.), a tuber crop commonly known as taro in English and arvi or kachalu in Hindi.

Objectives: The present study investigate the regional variation in the proximate and mineral analysis of *Colocasia esculenta* (L.) leaves and corms collected from diverse agro-climatic zones i.e. Kangra, Hamirpur, Bilaspur of Himachal Pradesh.

Methods: Proximate composition and energy was analysed using standard protocols. Mineral analysis done using Atomic Absorption Spectroscopy (AAS).

Results: Significant differences were observed in proximate parameters and mineral analysis across eight samples. Sample WL (86.15%) and WC (73.45%) from the wild habitat of Kangra exhibit the highest moisture content. In contrast, KL and BC samples showed reduced moisture, suggesting superior dry matter accumulation and enhanced storability. Ash content ranged from 12.03% to 13.83% in leaves and 6.36% to 7.48% in corms, reflective of variable mineral content. Crude fat and fibre significantly higher in leaves than corms, with leaves (HL&WL) showing values of 4.31% and 35.25% respectively. Corms of traditional cultivar collected from Kangra region exhibit the highest food energy value (368.90 kJ/100g). Correlation analysis revealed significant inverse association between moisture and both carbohydrate (r= -0.950**) and energy content (r= -0.946**). Additionally, ash, crude fat and fibre displayed strong negative correlations with both carbohydrate and energy content. Mineral profiling indicated considerable variation across samples, with potassium (0.11-1.81%) being the most abundant macronutrient, followed by magnesium and phosphorus. Among micronutrient, iron (64.4-480.15mg/kg) was predominant, followed by zinc, manganese and copper.

Conclusions: These findings emphasize the nutritional richness and regional diversity of *C. esculenta*, suggesting its potential in enhancing food and nutritional security.

1. Introduction

Nutritional value is the most important factor when evaluating a crop as a potential food source. With consumers increasingly focused on nutritional quality of their diet, there is a strong demand for detailed information on the nutrient composition of root crops. Although most root crops are high in starch and serve as excellent sources of energy, they generally provide limited amount of protein. These crops offer a broad range of minerals and trace elements such as iron, calcium, potassium, and magnesium [1]. One such root crop is *Colocasia esculenta* (L.) Schott., known as taro in English and Arvi or Kachalu in Hindi, include around 1,000 recognized cultivars. These cultivars are generally grouped into two main types: *Colocasia esculenta* var. *esculenta* (type eddo), characterized by a small central corm surrounded by numerous cormels and *Colocasia esculenta* var. *antiquorum* (type dasheen), having prominent central corm surrounded by fewer, smaller and tightly clustered cormels [2]. In India, it is cultivated in 0.052 million hectares area with 0.0654 million tons production and 12.57 tons per hectare productivity. It is mostly grown in states like Uttar Pradesh, Bihar, Punjab, West Bengal, Assam, Orissa, Andhra Pradesh, Tamil Nadu, Uttrakhand and Himachal Pradesh [3]. In HP, it is cultivated under low and mid hill conditions by more than 80% farmers even on small scale due to its local preference for consumption as vegetable and pickle. Most commonly consumed part of the plant is corm but the leaves and petiole are also used as vegetable. Taro can be prepared by boiling, baking, roasting or frying [4]. Nutritionally, taro contains broader amount of nutrients than other root and tuber crops. The corms are excellent source of carbohydrate in the form of starch. The starch is 98.8% digestible, a property linked to its small granule size, which makes it suitable for individual with digestive issues. They are good source of potassium (K), calcium (Ca) and iron (Fe) [5]. The leaves of *Colocasia* are also excellent source of fibre, and vitamins. Additionally, it contains about 7% protein on a dry basis which is more than that present in yam, cassava or sweet potato [6]. Taro corms contain low level of protein and fat but rich in starch approximately 73-80% of its dry matter. The nutritional makeup of taro varied based on cultivar type, growing environmental conditions, soil quality, moisture level, harvesting maturity, and post- harvest handling and storage [7]. Therefore, the present study was conducted to investigate nutritional potential of leaves and corms of *Colocasia esculenta* (L.).

2. Objectives

The present study was conducted to investigate the proximate composition, food energy and mineral content in leaves and corms of *Colocasia esculenta* (L.) collected from different regions of Himachal Pradesh.

3. Methods

Sample collection: Traditional cultivar from farm field and wild Sample from wild habitat of leaf and corm were collected from Kangra (32°08’61”N 76°26’43”E), Hamirpur (31°64’02”N 76°54’88”E) and Bilaspur (31°36’88”N 76°62’78”E) district of Himachal Pradesh for two years i.e. 2022-2023, 2023-2024. The sample were coded as KL, KC represent traditional cultivar of leaf and corm samples respectively collected farm field of Kangra district; WL, WC represent wild leaf and corm samples respectively collected from wild habitat of Kangra district; HL, HC represent traditional cultivar of leaf and corm samples respectively collected from farm field of Hamirpur district; BL, BC represent traditional cultivar of leaf and corm samples respectively collected from farm field of Bilaspur district. Collected samples were authenticated at Botanical Survey of India (BSI), High Altitude Western Regional Centre Nauni, Solan, Himachal Pradesh with accession number 00730, 00731, 00732, 00733.

Sample preparation

The harvested leaves and corms were cleaned. Corms were peeled and thin slices were done. Leaves were shade dried while slices of corms were kept in oven for 16 hours at 60°C to remove moisture. Then, dried samples were grinded to make powder and store at room temperature for further analysis.

Proximate Composition and Food Energy:

The proximate composition of leaves and corms were analysed using standard protocols of the Association of Official Analytical Chemists (AOAC 2000, AOAC 2002, AOAC 1990) methods with slight modification [8-10]. The moisture content of leaves and corms was determined using hot air oven method. Ash content was measured by muffle-furnace at 550°C, crude fibre by muslin cloth method. Soxhlet extraction method with petroleum ether for 6 hours was used for crude fat. Kjeldhal method was used for the determination of crude protein content. Starch content was estimated by colorimetric method [11]. Total carbohydrate content was calculated (James., 1995) [12]: 100- (%crude protein + %crude fat + %crude fibre + %crude ash.

Food energy was calculated by the formula of (Muhammad., 2011) [13]. Total energy (kJ/100g) = (9× %crude fat + 4× %crude protein + 4× % total carbohydrate content).

Mineral Analysis

The mineral present in the sample were estimated using Atomic Absorption Spectroscopy (AAS). The diacid mixture method was used to prepare the samples for analysis. [14].

Data Analysis

Data for 2 years were subjected to pooled analysis. Subsequently, pooled mean values of both experimental years were statistically analysed using Duncan’s multiple range tests at the 0.05 significance level and Pearson’s correlation coefficients at 0.05 and 0.01 significance levels with IBMSPSS software.

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4. Results

Proximate composition, food energy and mineral content was analysed by the standard protocols. Data of both the experimental years were pooled and presented in Table 1. Mean value obtained were: moisture, 73.61-86.15% in case of leaves and 66.70-73.45% in corms; ash, 12.03-13.83 and 6.36-7.48% in leaves and corms respectively; crude fibre, 2.92-4.31% and 0.64-0.93% in leaves and corms respectively; crude fibre, 15.35-35.25% in leaves and 2.45-4.23% in corms; crude protein, 14.21-19.08% in leaves and 11.28-14.28% in corms; starch, 22.78-39.69% and 19.70-42.30% in leaves and corm respectively; carbohydrate, 29.40-54.06% in leaves and 74.70-76.93 % in corms; energy, 231.92-299.48 kJ/100g and 359.62-368.90 kJ/100g in leaves and corms respectively.

Food energy and relationship with proximate composition: Highly positive correlation was found between moisture and crude fat (Table 2). A negative correlation was observed between moisture and carbohydrate (r= -0.950**) at 0.01 level, indicting an inverse relationship among moisture and carbohydrate. Additionally, a highly significant negative relationship was observed between energy and moisture (r=-0.946**) at the 0.01 level which shows that, with increasing moisture content the energy content decreases. The significant negative relationship was recorded among ash and carbohydrate (r= -0.881**), ash and energy (r= -0.891**), crude fat and carbohydrate (r= -0.995**) and crude fibre and energy (r= - 0.994**) at the level 0.001 level indicating inverse relationship among them.

Mineral analysis: In the present study, 3 macro-elements (P, K, Mg), 7 microelement (Fe, Mn, Zn, Cu) were analysed in eight samples of taro (Table 3). The concentration of P, K, Mg, Fe, Mn, Zn and Cu in taro leaves and corm ranged from 0.009-0.1% , 0.11- 1.81%, 0.009-0.27%, 64.4 – 480.15 mg/kg, 6.45-114.35 mg/kg, 29.9-115.75 g/kg and 13.95-60.35 mg/kg respectively.

Table 1: Proximate composition and food energy of *Colocasia esculenta* (L.). Different letter within the same column represent significant difference ($p<0.05$)

	Moisture (%)	Ash (%)	Crude Fat (%)	Crude Fibre (%)	Crude Protein (%)	Starch (%)	Total Carbohydrate (%)	Food Energy (kJ/100g)
KL	73.61±0.57^{c}	13.43±0.17^{d}	2.92±0.14^{b}	15.35±0.12^{d}	14.21±0.03^{c}	39.69±1.04^{f}	54.06±0.42^{d}	299.48±0.76^{d}
WL	86.15±0.05^{f}	12.03±0.20^{c}	4.21±0.12^{d}	35.25±0.22^{g}	19.08±0.07^{f}	33.18±0.26^{e}	29.40±0.61^{a}	231.92±1.17^{a}
HL	82.61±0.47^{e}	13.83±0.08^{d}	4.31±0.05^{d}	29.20±0.05^{f}	18.59±0.19^{e}	22.78±0.33^{b}	34.04±0.28^{b}	249.40±0.51^{b}
BL	78.45±0.18^{d}	13.55±0.30^{d}	3.29±0.19^{c}	20.52±0.10^{e}	15.14±0.13^{d}	24.09±0.25^{bc}	47.47±0.64^{c}	280.48±1.06^{c}
KC	67.60±0.40^{a}	6.36±0.19^{a}	0.83±0.01^{a}	2.45±0.12^{a}	14.25±0.10^{c}	28.08±0.27^{d}	76.09±0.20^{f}	368.90±1.11^{f}
WC	73.45±0.41^{c}	6.82±0.07^{a}	0.64±0.08^{a}	3.62±0.02^{b}	14.19±0.06^{c}	24.27±0.16^{c}	74.70±0.11^{e}	361.43±0.31^{e}
HC	69.65±0.13^{b}	7.48±0.10^{b}	0.74±0.01^{a}	3.55±0.05^{b}	11.28±0.07^{a}	42.30±0.42^{g}	76.93±0.15^{f}	359.62±0.49^{e}
BC	66.70±0.59^{a}	6.75±0.05^{a}	0.93±0.02^{a}	4.23±0.10^{c}	12.10±0.13^{b}	19.70±0.17^{a}	75.96±0.21^{f}	360.75±0.54^{e}

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Table 2: Pearson's correlation coefficient among proximate composition and food energy values in *C. esculenta* (L.) **p<0.01level; *p<0.05level.

Parameters	Moisture	Ash	Crude fat	Crude fibre	Crude protein	Starch	Carbohydrate
Ash	0.770*						
Crude fat	0.903**	0.929**					
Crude fibre	0.955**	0.838**	0.974**				
Crude protein	0.913**	0.658	0.858**	0.902**			
Starch	-0.029	0.095	-0.015	-0.016	-0.200		
Carbohydrate	-0.950**	-0.881**	-0.990**	-0.995**	-0.904**	0.020	
Energy	-0.946**	-0.891**	-0.989**	-0.994**	-0.875**	0.004	0.998**

Table 3: Mineral content of *Colocasia esculenta* (L.) (n=3)

	Macroelement (%)			Microelement (mg/kg)			
	P	K	Mg	Fe	Mn	Zn	Cu
KL	0.1	1.59	0.21	168.75	32.3	57.35	17.6
WL	0.09	1.13	0.27	310.6	6.45	35	15.15
HL	0.1	1.81	0.23	199.4	114.35	40.4	60.35
BL	0.13	1.36	0.17	127.5	29.1	33.85	16.65
KC	0.11	0.74	0.13	171.6	15.05	57.05	14.1
WC	0.11	1.15	0.18	64.4	53.5	115.75	20.55
HC	0.1	0.11	0.17	480.15	39.4	37	13.95
BC	0.11	0.85	0.09	64.8	15.85	29.9	17.65

5. Discussion

Distinguished variation was recorded in proximate composition and food energy across leaves and corms of taro samples (Table 1). The highest moisture content was recorded in leave samples WL (86.15%) collected from wild habitat of district Kangra for both the experimental year and pooled data followed by HL, BL and KL. In case of corms, the highest content of moisture was recorded in WC i.e. 73.45%. High moisture content in food can cause its spoilage through microbial infection. KL and BC shows lowest moisture content indicating they both contain high dry matter, a desirable qualitative character. The observed variation might be related with the environment factors, soil pH and agronomic practices etc [15]. These results were similar with the study conducted by [16-17]. However, these values were higher than the moisture content of raw taro reported by [18].

Significant variation in ash content was observed between leave and corm samples. Amount of ash content ranged from 12.03% (WL) to 13.83 % (HL) in leaves and 6.36% (KC) to 7.48% (HC) in corms. The

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ash content helps to measure the amount and type of minerals present in the sample [19]. James et al. 2013[17] and Alcantara et al. 2013[18] reported various studies show 1.56-5.70% ash content in raw taro which was slightly comparable with the current study. Leave samples of traditional cultivar collected from Hamirpur district shows the highest crude fat content (4.31%) among the studied sample. While, corm samples from Bilaspur district shows the highest crude fat content 0.93%. In general leaves have high fat content as compared to corms. The crude fat content of taro were higher than the values in cassava (0.71-1.49%), yam (1.15%) and sweet potato (1.02-1.72%) [20-22]. Highest crude fibre content 35.25% (WL) was observed in leaf sample and 4.23% (BC) in case of corm samples. These results are similar with research done by Buragohain et al. (2013) [23]. The recommended daily intake of crude fibre ranges from 19-25 gram per day for young children while adolescents are advised to consume between 26-38 gram per day. For adults, recommended intake is 25g per day for women and 38gram per day for men [24]. Data represented in table 1 revealed that there was a significant variation in crude protein among the samples studied from different sites. The highest crude protein content in leaves was observed in WL and HL i.e. 19.08% and 18.59% respectively while in corms KC and WC shows highest level of crude protein i.e. 14.25% and 14.19% respectively. On other hand, the

Lowest crude protein content was observed in the samples KL and BC. The range of crude protein content were higher than the study reported by Akalu et al. 2019 [25]. The recommended dietary protein intake of 0.8 gram per kg body weight per day would be expected to meet requirement of healthy adult population [26]. The starch content ranged from 22.78-39.69 % in leave samples and 19.70-42.30 % in corms among samples under study. Highest starch content was recorded in HC (42.30 %). These results were similar to the study conducted by [16]. Carbohydrate is an essential source of energy in the diet of human comprising of 40-80% of total energy intake. The value of carbohydrate for leaves (54.06%) in KL and corm (76.93%) in HC in present study were higher than raw taro, sweet potato (20.28-35.12%) [21] and lower than raw taro (85.65-86.11%) [18]. Total energy content of both corm and leave samples were observed in decreasing order as follow: KC>WC>BC>HC>KL>BL>HL>WL. Highest food energy was observed in corms collected from Kangra district (KC) i.e. 368.90 kJ/100g among all the studied samples. The energy content of corm in present study was higher than potato, yam and sweet potato [27] but lower in case of studied leave samples.

In the present study, both positive as well as negative correlation was observed. Similar study was reported in which significant negative correlation was observed between moisture and protein and positive correlation was observed between moisture and starch [28]. Among macronutrient the highest amount potassium of was observed followed by magnesium and phosphorus whereas, Fe was the highest micronutrient followed by Zn, Mn and Cu in all the studied samples. Iron is important mineral for Hb formation, normal functioning of the neural system and in the oxidation of protein and fat [29]. The variation in mineral may be influenced by many factors such as taro cultivar, production area, soil, climate and agricultural practices. Taro mineral content varies widely according to the research done by Gara et al. 2015 [30].

6. Conclusion

Characterization of taro on the basis of nutritional parameters is crucial for improving this valuable crop. The current research is based on the assessment of nutritional attributes of taro leaves and corms collected from different district of Himachal Pradesh. Taro leaves shows significantly higher moisture content. This is typical of green leafy vegetable due to their higher water retention capacity. Taro corm being storage organs, retain less moisture and thus have higher concentration of dry matter leading to greater energy density. This study suggest that leaves are more nutritious in terms of protein, minerals and fibre while corms serves better as energy sources due to their higher carbohydrate density. As taro provides essential nutrients so its cultivation and consumption should be encourage which could help to overcome malnutrition and reduce the risk of diet related diseases. Expanding its uses across the country could also create new income opportunities for farmers and give greater value to this underutilized crop.

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Conflict of interest

The authors declare no conflict of interest.

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