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Nutritional analysis and development of value added savoury snack from underutilized *Colocasia esculenta* (Taro) leaves

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Abstract
Underutilized edible plants play a significant role in food and economic security. The study was undertaken to investigate the nutritional composition of the dehydrated leaf powder of *Colocasia esculenta* (*Colocasia*). The *Colocasia* plants are basically grown for their edible tubers but the leaves are still considered as underutilized. The leaves of the *Colocasia* plant were collected, sorted, washed, blanched and dried for the preparation of *Colocasia* leaf (CL) powder. *Colocasia* leaf (CL) powder was analysed for proximate content, minerals, antioxidants, vitamins and antinutritional factors. The dehydrated CL powder is a concentrated source of various nutrients such as crude protein (33.27%), crude fibre (15.66%), calcium (316.51 mg), iron (47.08 mg) and beta-carotene (1239 µg). The phytochemical content comprised of flavonoids (169.26 mg RE), total phenol content (52.76 mg GAE) and total antioxidant activity (68.02%). The value added savoury snack *Sev* was prepared by substituting gram flour with 3%, 5%, 7%, 9% and 11% CL powder. The products were evaluated organoleptically on a score card. *Sev* with 7% CL powder incorporated *Sev* was accepted organoleptically. The value-added product made by incorporating CL powder can be consumed for preventing various public health diseases such as vitamin A deficiency, iron deficiency anaemia and protein deficiencies among the population.

Keywords: Underutilized leaves, *Colocasia*, nutritional composition, antioxidants, *Sev*

1. Introduction
India is a mega biodiversity due to its diversified topography and climate. Biodiversity is considered as the bedrock for all ecosystem services, which serves as a life support system for humans. Being a dwelling to the diversified flora, the availability of underutilized plants is also high. In the ancient time the knowledge of these folklore plant foods was popular but due to modernization, changing food habits, loss of traditional food system, the trend of dependence on a fewer convenient food products is increasing. This has resulted in the disintegration of the traditional dietary diversity and sustainability food system. The various uncommon, underutilized plant vegetables are being neglected due to their time-taking processing and unavailability in the local market. Due to the depletion of existing food sources, the world's growing population is facing food insecurity due to the depletion of already known food sources. In the world, food insecurity has resulted in problems like hunger, undernutrition and micronutrient deficiencies. The global food crisis and nutritional inadequacies worldwide has reignited the interest in alternative food sources which are not only rich in nutrients but also maintains the food security and sustainability.
Colocasia esculenta is a perennial herbaceous plant which belongs to *Araceae* family, commonly known as *Colocasia*, Cocoyam, Arbi etc. The plant is native to Southeast Asia but also found in various parts of Africa and America. *Colocasia* is grown for its edible tubers in the localized pockets in various states of India like Uttarakhand, Kerala, Tamil Nadu, Karnataka, Goa, Assam etc. (Sirinivas *et al.*, 2011) [18]. Neglecting the presence of various nutrients in the *Colocasia* leaves, the popularity of *Colocasia* tubers is comparatively higher that's why they are considered as underutilized. The other advantage of the plant includes its less susceptibility to various pests and disease attacks (Mohammad Thamseer *et al.*, 2021) [11]. The leaves of the plant are used as folklore medicines (Odedeji *et al.*, 2014 and [14]. The *Colocasia* leaves are economic source of various nutrients. A large variety of traditional recipes can be prepared using these exotic plants are ascribed to the cause of livelihood sustainability of the local people The *Colocasia* leaves are not sold in Indian markets even though they are consumed as a delicacy in various parts.

The main factors limiting their consumption are the perishable nature as well as seasonal-availability. The time taken during the cleaning of the leaves is also more due to their large size. The other limiting factor for the consumption of *Colocasia* leaves is the presence of various anti-nutritional factors such as oxalate, phytate etc. The basis technique for the removal of ANFs is heat treatment or fermentation.

Sev is a ready-to-eat popular savoury snack which looks similar to small pieces of thin noodles. Its crunchiness and crispiness makes it is an established snack in various parts of India. It is basically prepared with gram flour as a base material with some commonly used spices. Gram flour is rich in various macronutrients and micronutrients. The prepared sev can be stored in an air tight container for longer duration. Being a finger snack, *Sev* is easy to prepare product which leads to its high popularity in various parts of India so, it was chosen for value addition. There is unavailability of *Sev* with incorporation of leaf powder in the market. *Sev* made with dehydrated leaf powder will not only add dietary diversity to the traditional food system but also will help in improving the nutritional status of the population. According to Joshi and Raghuvanshi (2020) [7] the household dietary diversity score in the Kumaon region of Uttarakhand was found to be 7.6. Hoddinott and Yohannes (2002) [8] explained that the dietary diversity is an alternate indicator of food security.

The present study was conducted to develop *Colocasia* leaf (CL) powder and to evaluate its nutritional composition. Further to use the concentrated source of various nutrients, CL powder was used for making nutrient dense savoury snack. This food based approach will be sufficient for meeting the nutrient requirement of various nutrients such as vitamin A, protein, fibre, iron, calcium etc among the population.

Materials and Methods

The present investigation was carried out in the Department of Foods and Nutrition. The tender leaves of *Colocasia* were procured from the local kitchen garden of district U.S. Nagar and taken to the laboratory. The leaves were separated from the stalks and sorted to remove tarnished leaves. The sorted leaves were washed under running water to remove dirt. In order to remove toxicity and improve digestibility of the *Colocasia* leaves, these were subjected to wet blanching. The leaves were blanched for 4 minutes at 80 °C and immediately transferred to a big vessel containing cold water. The water was drained off using a strainer and the leaves were placed on the drying trays for drying in a cabinet drier at 60 °C for 24 hours. The dried leaves were ground and sieved through 60 size mesh sieve and stored in air tight containers at room temperature.

Nutritional Analysis: The crude fat, crude fibre and total ash were estimated using the standard method of (AOAC, 2000) [1] and crude protein was estimated using AOAC (2010) [3] method. The total carbohydrate content was determined by difference method. Iron was estimated colorimetrically (Wong, 1928) [23] whereas, calcium and potassium were estimated by flame photometer. The minerals like manganese, phosphorus, magnesium, copper and zinc were estimated using atomic absorption spectrophotometer (Raghuramulu *et al.*, 2003) [15]. *In-Vitro* iron bioavailability was estimated using the method given by Rao and Prabhavati (1978) [16]. The dietary fibre was estimated by enzymatic gravimetric method (Asp and Johansson, 1981) [5]. Beta-carotene was estimated using spectrophotometrically (Srivastava and Kumar, 2002) [19]. The ascorbic acid was estimated using titration method using 2,6-dichlorophenol-indophenol dye (AOAC, 2000) [1]. The total polyphenolic content was determined using Folin-Ciocalteu method and expressed as Gallic acid equivalent (GAE) (Singleton *et al.*,1999) [17]; flavonoid content was estimated using aluminium chloride colorimetric assay (Zhishen *et al.*, 1999) [24] and total antioxidant activity was estimated using DPPH (2,2-Diphenyl-1-picrylhydrazyl) reduction (Williams *et al.*, 1995) [22]. The oxalate content was estimated using standard titration method using potassium permanganate (AOAC, 2005) [2] whereas, the phytate content was analysed using complied method (Wheeler and Ferrel, 1971) [21]. All the analytical grade chemicals were used for nutritional analysis.

Product Development: An Indian savoury snack *Sev* was selected for product development. The main ingredient for the preparation of *Sev* was gram flour. The control was prepared using gram flour and the blends were prepared by substituting gram flour with CL powder in different proportions i.e. 3%, 5%, 7%, 9% and 11%. The gram flour and CL powder were mixed together for the preparation of different blends. The flour mixture along with carom seeds, red chilly powder and common salt was taken in a bowl. The flour mix was kneaded to make dough by adding water. Oil was added to make the dough softer. The soft dough was taken and extruded through a mechanical sev machine. The extruded soft *Sev* was left for 3-4 minutes in air and then deep fried in the mustard oil maintained at 170-180° C approximately. The fried sev were taken out once they were cooked properly.

Sensory Analysis of Products: The organoleptic evaluation of the savoury snack *Sev* was done using the Sensory Score Card (Amerine *et al.*, 1967) [4]. The formulated products were organoleptically evaluated by a semi-trained panel of 30 members.

Statistical Analysis: The data obtained was statistically analysed and presented as mean of the triplicate values and the variation among the observations was analysed using standard deviation. The organoleptic evaluation of the savoury snack *Sev* was analysed using One way Analysis of Variance (ANOVA). WASP statistical software (Web Agri Stat Package, Version 2.0) of ICAR (Jayade *et al.*, 2015) [9] was used for statistical analysis.

Results and Discussion

The current study was conducted to analyse the nutritional content of dehydrated CL powder. It was found that after blanching, the recovery of the dehydrated CL powder was 7.7 percent with a moisture content of 6.03 percent. The proximate and mineral composition was analysed on dry matter basis and the results are presented in table 1. The table 2 represents the ascorbic acid, beta-carotene, oxalate, phytate content and antioxidant composition of the CL powder.

The proximate composition analysis of the CL powder reported that (on dry matter basis) the total ash content, crude protein, crude fat, crude fibre was 13.75, 33.27, 3.73, 15.66 percent, respectively whereas the carbohydrate and physiological energy present in the CL powder was 33.59 percent and 176.89Kcal/100 g. The insoluble and soluble dietary fibre was reported to be 1.56 g and 1.03 g per 100 g respectively. The calcium, iron, zinc, potassium, magnesium, phosphorus, manganese and copper content in the CL powder

was reported as 316.15, 47.08, 0.42, 6.7, 2.31, 0.48,0.22 and 0.07 mg per 100 g respectively. The *In vitro* iron bioavailability of the CL powder was found to be 2.57 percent. The ascorbic acid in CL powder was 14.45 mg per 100 g. Bhosale and Arya (2010) have reported that the loss of ascorbic acid content in cabinet dried green leafy vegetables was found to be least decreased during cabinet drying in comparison to sun drying and shade drying. They also reported that cabinet drying process has least influence on the total iron content whereas the bioavailability of the iron decreases due to drying process. In the present study (On dry matter basis) the iron content in CL powder was found to be 47.08 mg per 100 g whereas its bioavailability was found to be appreciably higher i.e. 5.45% making it to 2.57 mg per 100 g, in spite of oxalate and phytate content of 0.60 and 1.89 g per 100 g.

The heat treatment during drying significantly reduces the activity of enzyme named ascorbic acid oxidase (AAO) which results in retention of ascorbic acid (Leong and Oye., 2012, Munyaka *et al*., 2010) [10, 12]. The beta-carotene is fat-soluble vitamin significantly decreases the drying process (Gupta *et al.*, 2011) [6]. They also revealed that dehydration of green leafy vegetable have least effects on the proximate as well as the mineral composition of the vegetable. The most common antinutrients found commonly in green leafy vegetables are oxalates and phytates. The oxalates basically binds with calcium and prevents its absorption whereas, phytates prevents the absorption of iron. The food with high oxalic acid can cause problems like kidney stones and also damages the kidneys.

According to Vidinamo *et al.*, (2020) [20] the phytochemical composition of the vegetables are effected by various factors such as harvesting time, type of cultivar, environmental factors and processing. Drying of vegetables causes the release of the phytochemicals such as flavonoids and phenols that are bound to the cell wall of the plant which tend to increase the antioxidant activity of the product and provide protection against the oxidative degradation of the product.

The dried CL powder was incorporated to produce a value added savoury snack known as *Sev*. The main ingredient of the snack was gram flour, the CL powder, carom seeds and spices. The control was prepared using 100 percent gram flour and the blends were prepared by substituting gram flour with the CL powder in different proportions i.e. 3%, 5%, 7%, 9% and 11%. For the preparation of the *Sev* all other ingredients were procured from the local market. The organoleptic evaluation of the *Sev* is given in table III. All the *Sev* were adjudged in the category of "Good" in terms of organoleptic analysis in the terms of overall acceptability by the sensory panellists. The overall acceptability of the *Sev* with 7% CL powder incorporation was highest. It was found that the *Sev* prepared with 9% and 11% CL powder have slight aftertaste so, *Sev* with 7% CL powder was selected so, it was selected for nutritional evaluation.

The proximate analysis of the *Sev* made with 7% CL powder revealed that crude protein, crude fibre, total ash content was higher as compared to Control. The total dietary fibre content of the *Sev* made with CL powder was found to be higher than the control. The nutritional evaluation of the product has been described in the table IV. The incorporation of the CL powder in the *Sev* has significantly increased the minerals like calcium, manganese and phosphorus. The evaluation of vitamins revealed that the ascorbic acid was found to be higher in the *Sev* with 7% incorporation of CL powder. The antioxidant content of the *Sev* made with CL powder was comparatively higher than that of the control.

Nutritional contribution of Savoury Snack *Sev* in daily diet

Fifty gram will make one serving of *Sev* incorporated with CL powder. The nutritional composition per 100 g of two commercial *Sev* were compared with the developed value added *Sev*. The nutritional composition of two commercial was taken as imprinted on the label. The comparison revealed that the protein, fibre and carbohydrate content of the developed *Sev* was higher than the commercial *Sev*. Labelling on the commercial *Sev* doesn't contain any information for individual minerals and antioxidants. The nutritional comparison of *Sev* has been given in table V.

Fifty gram serving of value added *Sev* with CL powder was able to fulfil 20.4 percent RDA for protein, 9.6 percent RDA for fibre, 10.24 percent RDA for iron, 18.16 percent RDA for beta-carotene and 12.63 percent of RDA for calories in an Indian sedentary adult woman. Similarly, for an Indian sedentary adult man a 50 g serving of these *Sev* can fulfil 17.25 percent RDA for protein, 6.69 percent RDA for fibre, 15.63 percent RDA for iron, 15.62 percent RDA for beta-carotene and 9.94 percent of RDA for calories.

Table 1: Proximate and mineral composition of the dehydrated CL powder (Dry matter basis)

Parameter	CL powder
Total Ash	13.75±0.106
Crude Protein	33.27±0.046
Crude Fat	3.73±0.17
Crude Fibre	15.66±0.025
Carbohydrate	33.59±0.026
Physiological Energy	176.89±0.68
Insoluble Dietary Fibre	1.56±0.03
Soluble Dietary Fibre	1.03±0.03
Calcium	316.51±0.47
Iron	47.08±0.22
In vitro Iron Bioavailability	2.57±0.02
Zinc	0.42±0.01
Potassium	6.7±0.19
Magnesium	2.31±0.01
Phosphorus	0.48±0.01
Manganese	0.22±0.02
Copper	0.07±0.01

All the values represented as Mean ± S.D. of the triplicate values

Table 2: Vitamin composition, antioxidant and antinutrients content of CL powder

Vitamin	CL powder
Ascorbic acid	14.45±0.01
Beta-carotene	1239±0.10
Total Polyphenols	52.76±1.89
Flavonoids	191.29±1.29
Total Antioxidant Activity	73.57±0.48
Phytate	1.89±1.03
Oxalate	0.60±0.06

All the values represented as Mean ± S.D. of the triplicate values

Table 3: Organoleptic analysis of *Sev* using Score card method by 30 panelists

Sensory attributes	Control *Sev* (100% Gram flour)	3% CL powder with 97% Gram flour	5% CL powder with 95% Gram flour	7% CL powder with 93% Gram flour	9% CL powder with 91% Gram flour	11% CL powder with 89% Gram flour	C.D. at p≤0.01
Taste	8.36±0.46^{a}	8.01±0.53^{b}	7.86±0.71^{b}	7.75±0.54^{b}	7.01±0.61^{b}	6.89±0.50^{c}	0.385*
Texture	8.4±0.43^{a}	8.23±0.54^{a}	7.93±0.49^{b}	7.68±0.59^{bc}	7.50±0.52^{c}	7.06±0.49^{d}	0.351*
Flavour	8.23±0.35^{a}	7.81±0.56^{b}	7.58±0.56^{b}	7.56±0.47^{b}	7.18±0.53^{c}	6.9±039^{d}	0.332*
Colour	8.36±0.49^{a}	7.48±0.49^{b}	7.1±0.52^{c}	7.13±0.46^{c}	6.93±0.51^{c}	6.56±0.39^{d}	0.339*
Overall acceptability	8.55±0.41^{a}	7.73±0.52^{b}	7.56±0.63^{bc}	7.76±0.46^{c}	7.51±0.49^{c}	7.23±0.55^{d}	0.352*

Values represent Mean± S.D. and *-significant difference at $p \leq 0.01$

Table 4: Result of nutrient value of the CL powder incorporated *Sev* compared with the Control

Product	Moisture	Crude Protein	Crude Fat	Total Ash	Crude fibre	Carbohydrate	Physiological energy	Total dietary fibre
Control	1.83±0.03	18.30±0.35	14.15±0.01	2.62±0.15	5.82±0.24	57.28±0.60	429.67±0.02	1.42±0.01
Sev with 7% CL powder	2.05±0.22	19.15±0.31	13.66±0.05	2.85±0.01	6.44±0.31	55.85±0.1	422.49±0.23	1.58±0.08

All the values represented as Mean ± S.D. of the triplicate values

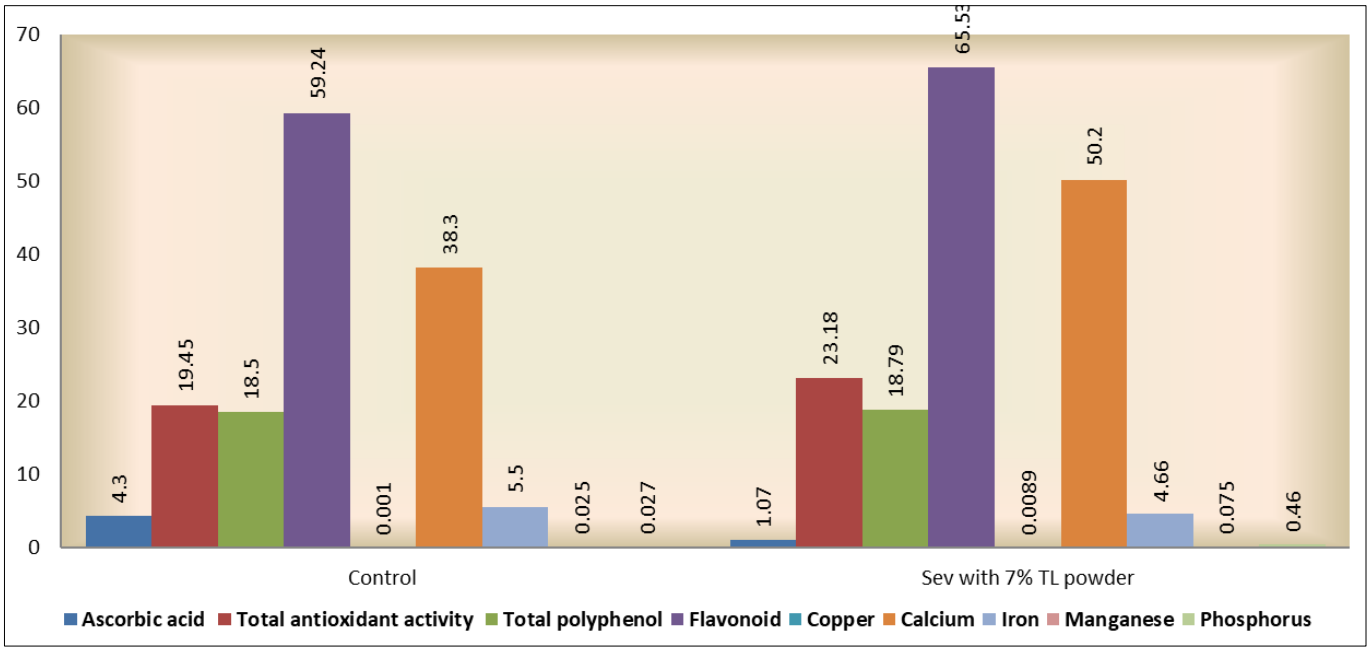

Fig 1: Vitamin, antioxidant and mineral composition of the incorporated product compared with the Control

Conclusion

From the present findings it is concluded that dehydration of the *Colocasia* leaves is a most reliable and convenient method for preparation of CL powder with minimal effect on its nutritional composition. The underutilized CL powder is a concentrated source of nutrients like protein, fibre, beta-carotene, minerals and antioxidants. The dehydration of the *Colocasia* leaves not only extends the shelf life of the leaves but also makes them easier to store and use during off-season. The richness of various nutrients in CL powder made it a functional ingredient which can be added to various traditional recipes to improve their nutritional values. The consumption of value added products will not only add dietary diversity but also help in meeting the requirements for vitamin A, protein, fibre, calcium and iron among the population. The antioxidants present in the *Colocasia* will be helpful in preventing various chronic health problems.

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