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Novel processing method for improved antioxidant and nutritional value of elephant foot yam (*Amorphophallus paeoniifolius* Dennst-Nicolson)

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Amorphophallus paeoniifolius Dennst-Nicolson, commonly known as the Elephant foot yam, is a highly potential edible aroid of Araceae family. Fresh yams are difficult to store due to their perishable nature and deteriorate in quality during storage. Therefore, making processed products *viz*., dry and fry cubes will be an alternative value added product with nutritional value. In this experiment, elephant foot yam corm cubes were stored to analyze the nutritional and antioxidant values at monthly intervals. The *cv*., BCA-1 dry cubes (soaking in 2% salt followed by blanching) had the highest ascorbic acid and total phenol throughout the storage period. Highest β-carotene was observed in *cv*., IGAM-1 dry cubes (2% alum) and fry cubes (2% alum) at 0 and 13 months after storage, respectively. The *cv.*, BCA-1 had the highest starch in dry cubes (1.5% alum) and fry cubes (2% salt) at 0 and 13 months after storage, respectively. The protein and organoleptic values were the highest throughout the storage in *cv*., BCA-1, both dry and fry cubes, were from soaking in 1.5% alum and blanching.

Keywords: Antioxidants, Ascorbic acid, β-Carotene, Dry cubes, Fry cubes, Total phenol

Roots and tubers are the third important food for humans after cereals and legumes. These crops constitute either stable or subsidiary food for about one-fifth of the world population and are known to supply a cheap source of energy especially for the weaker sections of the population[1]. Elephant foot yam (*Amorphophallus paeoniifolius* Dennst-Nicolson) is popular in India, Philippines, Malaysia, Indonesia, China, Sri Lanka and many other Southeast Asian countries as traditional medicine and animal feed[2,3]. The area and production of elephant foot yam in India is reported as 26, 000 ha and 6.59 lakh metric ton, respectively[4].

Generally, vegetables and fruits are grown only during the predetermined season and there is a need to increase the shelf life of these perishable natural resources. Dehydration is one of the most common natural and reliable techniques where vegetables and fruits in its dehydrated form are preserved for a longer period and are made available during the off-season. Drying is used to improve the economics of dehydration processes of elephant foot yam corms for sustained supply of new processed products of interest to the consumer.

In India, the corms and cormels of elephant foot yam are usually boiled or baked and eaten as a vegetable. In Tripura, locals consume the leaf lamina, petiole (pseudostem), corm and cormels of wild species of elephant foot yam, and particularly banana flesh coated of elephant foot yam balls for controlling stomach disorders and piles[5]. In the Car Nicobar Islands, the tribals consume wild elephant foot yam tubers collected from the forest. They are boiled in hot water with salt and chilli powder and are consumed along with the wild pork dish[6]. Elephant foot yam is processed into cubes and cooked with fresh spices (ginger and garlic) paste followed by slow cooking on a pan till the crispiness is obtained[7]. The sprouts and petioles that resemble asparagus sprouts are used as a vegetable in some parts of Asia[8]. In China, the bulbils of *A. yuloensis* are eaten by indigenous people in the Southern and South Western Yunnan Provinces[9]. The tubers of elephant foot yam are commonly used as a vegetable, and also in the preparation of indigenous ayurvedic medicines to control asthma, bronchitis, abdominal pain, emesis, dysentery, etc. They are the cheapest source of

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carbohydrates, mainly starch and fibre, vitamins and minerals[10,11] and play an important role in food security as the staple or subsidiary food for a large group of population[12].

Elephant foot yam is a healthy low-fat food, and a rich source of essential fatty acids (Omega-3 fatty acids) which are known to increase the good cholesterol [High-density lipoprotein (HDL)] levels in the blood[13]. It has several medicinal properties *viz*., ayurvedic drugs in the treatment of inflammatory conditions, hemorrhoids, rheumatism and gastro-intestinal disorders[14]. This herb is also used in ear ache, pain, intercostal neuralgia, puerperal fever and swelling of throat[15]. The paste of tubers is applied externally to reduce pain arthritis. In China, the *A. konjac* is used in the traditional chinese medicines as an immune-regulation and healthcare food[16,17]. The high acrid wild elephant foot yam corms are used for the treatment of mouth ulceration and tympanitis in cattle in India. The farmers provide 100 g of ground elephant foot yam as a drench in the affected cattle and it creates a stinging effect on the lips and the tongue of the cattle causing an increase in salivary secretions, thereby helping the animals to get temporary relief from tympani[18]. Over the years, osmotic dehydration and drying technique has gained considerable attention for preservation of fruits and vegetables due to its potential to keep sensory and nutritional properties similar to the fresh fruits[19].

In this study, we tried to produce a novel shelf stable high quality dried and fried *Amorphophallus* cubes using a combination of pretreatment and conventional hot air drying. We studied the effect of different concentrations of salt and alum on starch, ascorbic acid, protein, β-carotene, total phenol and also observed the organoleptic quality during storage. Further, we optimized the processing condition to obtain a quality product.

Materials and Methods

The experiments were carried out in the laboratory of All India Coordinated Research Project on Tuber Crops, Research Complex, Kalyani (Bidhan Chandra Krishi Viswavidyalaya) West Bengal to analyze the nutritional and antioxidant content in elephant foot yam cubes. Two cultivars (BCA-1 & IGAM-1) were selected on the nutritional point of view at the maturity stage, and after peeling it was sliced into the suitable size of pieces (2.5×2.5×2.5 cm) for preparing cubes with the help of a knife. Browning and acridity are the major problems in elephant foot yam tubers. For prevention of browning and acridity as well as to develop firmness and check the oxidation process in cubes from the selected tubers, standardized treatments were used *viz*., soaking in alum and common salt at 1.5 and 2.0% concentration for 5 h. and then blanched it at 7 kg/cm^2 for 28 min. After blanching cabinet drying was done at 55 °C for 6 h, then half of the cubes were packed in polyethylene packets, and remaining cubes fried in mustard oil for a minute and after cooling packed in polythene paper to check the variation at monthly intervals.

Physicochemical analysis

Physicochemical attributes of elephant foot yam cubes were analyzed by mentioned methods like starch by anthrone titration method[20], ascorbic acid by 2,6-dichlorophenol indophenols visual titration method, β-carotene analyzed with the help of ELICO Bio-spectrophotometer at 452 nm[21], protein was estimated by Lowry's method[22] and total phenol was estimated by folin-ciocalteu method using ELICO Bio-spectrophotometer at 660 nm[23,24] at monthly intervals.

Organoleptic test

Organoleptic test of the freshly prepared product and the stored product was evaluated at 9 Point Hedonic scale[25]. Elephant foot yam cubes samples were evaluated on a team of panelist of 10 members drawn from amongst post-graduate students and others. The samples were rated for appearance, color, taste, consistency and aroma. Overall acceptability was measured by adding individual member scores, and the sample rated like extremely, like moderately, like slightly, dislike moderately, dislike extremely with organoleptic scores 9, 7, 5, 4 2, respectively.

Statistical procedure

Laboratory data were computed to analyze the analysis of variance using Complete Randomized Design (CRD) as suggested by Raghuramula *et al.*[26]. 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. The data analyzed with the help of statistical software from AGRES version 3.01 (Data Entry Module for AgRes Statistical Software <c> 1994 Pascal Intl software solution).

Results and Discussion

From the statistical analysis of the results obtained, it could be concluded that the independent variable year (Y) affected starch, ascorbic acid, protein, β-carotene, total phenol and organoleptic value of the crop. The interaction between year and treatment affected the quality of the cubes.

Variation of starch and protein content in dry and fry cubes

Physicochemical compositions of dry and fry cubes varied significantly with treatments and it was noticed that the starch and protein both were found in decreasing trend during storage. The *cv*., IGAM-1 content lowest starch in dry cubes salt (1.5%) and fry cubes salt (1.5%) at 0 and 13 months after storage, respectively. While, the *cv*., BCA-1 content highest starch in dry cubes alum (1.5%) and fry cubes salt (2%) at 0 and 13 MAS, respectively (Table 1). The decrease in starch might be due to breaks down of sugar in the form of water from dry fry cubes during storage. The range of starch content found in this experiment (28.57-41.65%) was compared to the observation of in cassava hot fries with the highest starch and sweet fries with lowest starch[25]. The protein content was the lowest in *cv*., BCA-1 fry cubes salt (2%) and *cv*., IGAM-1 fry cubes salt (1.5%) at 0 and 13 MAS, respectively. While, *cv*., BCA-1 dry cubes alum (1.5%) content highest protein at both stages 0 and 13 MAS (Table 2). The decrease in protein content during storage might be due to the denaturation of protein caused by heat in the presence of moisture. A similar finding was reported in cassava flour[27].

Antioxidant compounds

Antioxidant compounds in elephant foot yam varied with treatment and year, and it was found that ascorbic acid, β-carotene and total phenol showed an in decreasing trend during the storage. The ascorbic

Table 1 — Changes in Starch (%) in elephant foot yam dry fry cubes during storage

MAS/cv.	BCA-1												IGAM-1											
	Dry (Salt 2%)			Dry (Alum 1.5%)			Fry (Salt 2.0%)			Fry Alum (1.5%)			Dry (Salt 1.5%)			Dry (Alum 2.0%)			Fry (Salt 1.5%)			Fry Alum (2.0%)		
	1st	2nd	Pooled	1st	2nd	Pooled	1st	2nd	Pooled	1st	2nd	Pooled	1st	2nd	Pooled	1st	2nd	Pooled	1st	2nd	Pooled	1st	2nd	Pooled
0	39.23	37.89	38.56	43.21	40.08	41.65	40.05	38.93	39.49	40.74	39.03	39.89	35.02	33.39	34.21	37.73	33.44	35.59	36.88	32.12	34.50	36.71	31.98	34.35
1	35.33	33.21	34.27	38.89	35.02	36.96	36.89	35.97	36.43	37.29	35.89	36.59	32.96	31.76	32.36	35.23	31.89	33.56	34.36	30.01	32.19	34.21	30.51	32.36
2	32.65	31.12	31.89	35.56	33.65	34.61	34.27	33.78	34.03	35.09	32.94	34.02	31.32	30.21	30.77	33.76	30.41	32.09	32.12	29.11	30.62	33.03	29.38	31.21
3	30.45	29.10	29.78	32.77	32.41	32.59	32.56	32.89	32.73	34.89	31.23	33.06	30.21	29.10	29.66	32.21	29.22	30.72	31.02	28.39	29.71	32.12	28.11	30.12
4	29.57	28.39	28.98	30.89	31.33	31.11	31.11	32.02	31.57	33.37	30.09	31.73	29.68	28.42	29.05	31.02	28.39	29.71	30.22	27.88	29.05	31.41	27.42	29.42
5	29.01	27.90	28.46	29.93	30.49	30.21	30.45	31.25	30.85	32.42	29.49	30.96	29.22	27.88	28.55	29.96	27.79	28.88	29.47	27.39	28.43	30.82	26.89	28.86
6	28.49	27.47	27.98	29.17	29.92	29.55	29.92	30.81	30.37	31.55	28.97	30.26	28.77	27.41	28.09	29.39	27.21	28.30	28.93	26.91	27.92	30.19	26.42	28.31
7	28.02	27.07	27.55	28.49	29.47	28.98	29.51	30.42	29.97	30.88	28.49	29.69	28.39	26.97	27.68	28.82	26.84	27.83	28.49	26.66	27.58	29.69	26.02	27.86
8	27.61	26.65	27.13	27.89	29.02	28.46	29.13	30.14	29.64	30.07	28.03	29.05	28	26.59	27.30	28.19	26.49	27.34	28.04	26.37	27.21	29.21	25.79	27.50
9	27.24	26.32	26.78	27.41	28.55	27.98	28.86	29.87	29.37	29.39	27.69	28.54	27.68	26.29	26.99	27.72	26.05	26.89	27.72	26.08	26.90	28.85	25.59	27.22
10	26.87	26.05	26.46	26.97	28.09	27.53	28.62	29.68	29.15	28.83	27.33	28.08	27.41	26.02	26.72	27.19	25.82	26.51	27.48	25.93	26.71	28.55	25.48	27.02
11	26.59	25.79	26.19	26.59	27.72	27.16	28.37	29.50	28.94	28.47	26.98	27.73	27.19	25.88	26.54	26.83	25.61	26.22	27.21	25.89	26.55	28.31	25.32	26.82
12	26.25	25.58	25.92	26.28	27.38	26.83	28.12	29.35	28.74	28.11	26.77	27.44	26.96	25.79	26.38	26.59	25.47	26.03	27.02	25.75	26.39	28.17	25.22	26.70
13	25.02	25.39	25.21	25.95	27.11	26.53	27.95	29.24	28.60	27.91	26.64	27.28	26.82	25.74	26.28	26.41	25.32	25.87	26.91	25.61	26.26	28.04	25.13	26.59
Mean	29.45	28.42	28.94	30.71	30.73	30.72	31.13	31.70	31.42	32.07	29.97	31.02	29.26	27.96	28.61	30.07	27.85	28.96	29.70	27.44	28.57	30.66	27.09	28.88
	CD 0.05	S Ed		CD 0.05	S Ed		CD 0.05	S Ed		CD 0.05	S Ed		CD 0.05	S Ed		CD 0.05	S Ed		CD 0.05	S Ed		CD 0.05	S Ed	
M	1.885	0.941	**	1.772	0.884	**	1.715	0.856	**	1.695	0.846	**	1.791	0.894	**	1.910	0.954	**	1.839	0.918	**	1.883	0.940	**
Y	0.712	0.355	**	0.669	0.334	NS	0.648	0.323	NS	0.641	0.319	**	0.677	0.338	**	0.722	0.360	**	0.695	0.347	**	0.711	0.355	**
MY	2.667	1.331	NS	2.506	1.251	NS	2.425	1.211	NS	2.397	1.196	NS	2.534	1.265	NS	2.702	1.349	NS	2.601	1.298	NS	2.663	1.329	NS

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

Table 2 — Changes in Protein (%) in elephant foot yam dry fry cubes during storage

MAS/cv.	BCA-1												IGAM-1											
	Dry (Salt 2%)			Dry (Alum 1.5%)			Fry (Salt 2.0%)			Fry Alum (1.5%)			Dry (Salt 1.5%)			Dry (Alum 2.0%)			Fry (Salt 1.5%)			Fry Alum (2.0%)		
	1st	2nd	Pooled	1st	2nd	Pooled	1st	2nd	Pooled	1st	2nd	Pooled	1st	2nd	Pooled	1st	2nd	Pooled	1st	2nd	Pooled	1st	2nd	Pooled
0	6.99	7.12	7.05	8.82	8.78	8.80	5.89	5.74	5.81	6.39	6.50	6.44	6.32	6.50	6.41	8.41	8.50	8.46	6.01	5.91	5.96	6.89	6.96	6.93
1	6.72	6.48	6.60	8.33	8.18	8.26	5.69	5.61	5.65	6.12	6.10	6.11	6.09	6.10	6.10	7.95	7.90	7.92	5.93	5.87	5.90	6.12	6.07	6.09
2	6.17	6.34	6.26	7.45	7.07	7.26	5.50	5.46	5.48	6.01	5.91	5.96	5.88	5.93	5.90	6.88	6.77	6.83	5.88	5.74	5.81	5.95	5.81	5.88
3	6.10	6.29	6.19	7.01	6.77	6.89	5.41	5.38	5.40	5.88	5.80	5.84	5.29	5.38	5.34	6.30	6.13	6.21	5.59	5.42	5.51	5.72	5.61	5.67
4	5.99	6.06	6.02	6.58	6.26	6.42	5.31	5.28	5.29	5.54	5.47	5.51	5.21	5.33	5.27	6.15	6.01	6.08	5.02	4.64	4.83	5.40	5.26	5.33
5	5.88	5.90	5.89	6.19	5.92	6.05	4.91	4.71	4.81	5.29	5.16	5.22	5.05	5.20	5.12	6.01	5.91	5.96	4.69	4.52	4.61	4.93	4.72	4.82
6	5.81	5.61	5.71	5.73	5.41	5.57	4.70	4.61	4.66	4.93	4.71	4.82	4.82	4.96	4.89	5.82	5.79	5.81	4.49	4.39	4.44	4.79	4.53	4.66
7	5.49	5.36	5.43	5.51	5.39	5.45	4.60	4.53	4.56	4.77	4.54	4.66	4.62	4.73	4.68	5.28	5.25	5.26	4.27	4.12	4.20	4.39	4.12	4.26
8	4.87	4.76	4.82	5.36	5.21	5.28	4.11	4.08	4.10	4.23	4.07	4.15	4.24	4.19	4.22	4.69	4.51	4.60	3.98	3.81	3.90	4.01	3.82	3.91
9	4.62	4.46	4.54	4.94	4.79	4.87	3.82	3.71	3.77	4.10	3.94	4.02	4.12	4.07	4.09	4.45	4.39	4.42	3.77	3.61	3.69	3.88	3.75	3.82
10	4.02	3.85	3.94	4.73	4.65	4.69	3.65	3.45	3.55	3.64	3.41	3.52	3.78	3.53	3.65	4.23	4.14	4.18	3.69	3.54	3.62	3.71	3.64	3.68
11	3.40	3.25	3.33	4.60	4.52	4.56	3.10	2.93	3.02	3.42	3.38	3.40	3.39	3.39	3.39	3.89	3.79	3.84	3.08	2.81	2.94	3.59	3.52	3.56
12	2.90	3.08	2.99	4.25	4.19	4.22	2.99	2.75	2.87	3.00	3.28	3.14	3.11	3.14	3.13	3.52	3.48	3.50	2.69	2.59	2.64	3.22	3.19	3.21
13	2.69	2.99	2.84	4.14	4.10	4.12	2.27	2.18	2.23	2.79	2.80	2.80	2.79	2.87	2.83	3.18	3.19	3.19	2.51	2.41	2.46	2.69	2.71	2.70
Mean	5.12	5.11	5.12	5.97	5.80	5.89	4.43	4.32	4.37	4.72	4.65	4.69	4.62	4.67	4.64	5.48	5.41	5.45	4.40	4.24	4.32	4.66	4.55	4.61
	CD 0.05	S Ed		CD 0.05	S Ed		CD 0.05	S Ed		CD 0.05	S Ed		CD 0.05	S Ed		CD 0.05	S Ed		CD 0.05	S Ed		CD 0.05	S Ed	
M	2.299	1.148	*	1.637	0.817	**	1.281	0.639	**	1.863	0.929	*	1.341	0.669	**	2.054	1.025	**	1.177	0.588	**	1.282	0.639	**
Y	0.869	0.434	NS	0.618	0.309	NS	0.484	0.241	NS	0.704	0.351	NS	0.507	0.253	NS	0.776	0.387	NS	0.445	0.222	NS	0.484	0.242	NS
MY	3.252	1.623	NS	2.315	1.155	NS	1.813	0.905	NS	2.634	1.315	NS	1.897	0.947	NS	2.905	1.450	NS	1.665	0.831	NS	1.813	0.905	NS

[Cv.- Cultivar; MAS- Months After Storage; Y- Year; CD- Critical Difference at 5 %; S Ed- Standard Error of Deviation; R- Replication (3); NS- Non Significant; **- Highly Significant; *- Significant] acid content of elephant foot yam ranged from 0.59-4.38 mg/100 g during different storage stages. The *cv*., BCA-1 fry cubes salt (2%) lowest ascorbic acid and *cv*., BCA-1 dry cubes salt (2%) highest ascorbic acid at both stages 0 and 13 MAS (Table 3). The reduction in ascorbic acid at the later stages might be related to enzymatic loss of ascorbic acid through oxidation as indicated[28]. The *cv*., BCA-1 fry cubes salt (2%) content lowest β-carotene at both stage 0 and 13 MAS. While, the *cv*., IGAM-1 content highest β-carotene in dry cubes alum (2%) and fry cubes alum (2%) at both stages 0 and 13 MAS, respectively (Table 4). The range of β-carotene content found in this experiment (41.35-77.86 μg/100 g) was in line with the results observed in elephant foot yam products[1]. The reports on total phenol composition in elephant foot yam products are limited. However, total phenol content was lowest in *cv*., IGAM-1 fry cubes alum (2%) at both stage 0 and 13 MAS, while the, highest total phenol content was observed in *cv*., BCA-1 dry cubes salt (2%) at both stage 0 and 13 MAS (Table 5).

Organoleptic quality

The organoleptic quality of dry and fry cubes were evaluated at room temperature (20-30°C) up to 13 months of storage. It was found that the product remains acceptable at room temperature in all treatments up to 13 months of storage. The organoleptic content of elephant foot yam ranged from 6.44-8.36 hedonic values during different storage stages. The *cv*., IGAM-1 dry cubes alum (2%) content had lowest organoleptic qualities at both stages both stage 0 and 13 MAS, while, *cv*., BCA-1 fry cubes alum (1.5%) content reported highest organoleptic characters at both

Table 3 — Changes in Ascorbic acid (mg/100g) in elephant foot yam dry fry cubes during storage

MAS/cv .	BCA-1												IGAM-1											
	Dry (Salt 2%)			Dry (Alum 1.5%)			Fry (Salt 2.0%)			Fry Alum (1.5%)			Dry (Salt 1.5%)			Dry (Alum 2.0%)			Fry (Salt 1.5%)			Fry Alum (2.0%)		
	1st	2nd	Pooled	1st	2nd	Pooled	1st	2nd	Pooled	1st	2nd	Pooled	1st	2nd	Pooled	1st	2nd	Pooled	1st	2nd	Pooled	1st	2nd	Pooled
0	4.35	4.41	4.38	4.33	4.39	4.36	2.38	2.43	2.41	2.41	2.45	2.43	3.53	3.61	3.57	3.49	3.58	3.54	2.88	2.93	2.91	2.91	2.96	2.94
1	2.77	2.83	2.80	2.71	2.81	2.76	1.30	1.49	1.40	1.33	1.52	1.43	2.44	2.58	2.51	2.31	2.59	2.45	1.53	1.61	1.57	1.70	1.62	1.66
2	2.11	2.17	2.14	2.11	2.14	2.12	0.99	1.07	1.03	0.99	1.08	1.04	1.61	1.74	1.68	1.71	1.88	1.80	1.03	1.11	1.07	1.21	1.19	1.20
3	1.78	1.97	1.88	1.78	1.98	1.88	0.91	0.98	0.95	0.91	0.99	0.95	1.23	1.35	1.29	1.34	1.37	1.36	0.87	0.90	0.88	0.91	0.91	0.91
4	1.49	1.68	1.59	1.49	1.68	1.59	0.86	0.92	0.89	0.87	0.93	0.90	0.95	1.05	1.00	0.98	1.11	1.05	0.86	0.79	0.83	0.88	0.82	0.85
5	1.30	1.47	1.39	1.31	1.48	1.39	0.81	0.87	0.84	0.82	0.88	0.85	0.89	0.96	0.93	0.90	1.00	0.95	0.82	0.74	0.78	0.83	0.78	0.81
6	1.17	1.32	1.25	1.17	1.32	1.25	0.77	0.82	0.80	0.78	0.83	0.80	0.85	0.89	0.87	0.86	0.90	0.88	0.77	0.69	0.73	0.79	0.73	0.76
7	1.03	1.19	1.11	1.04	1.20	1.12	0.73	0.78	0.76	0.74	0.79	0.77	0.80	0.85	0.83	0.81	0.86	0.84	0.74	0.66	0.70	0.76	0.69	0.73
8	0.91	1.07	0.99	0.91	1.08	1.00	0.69	0.74	0.72	0.70	0.75	0.73	0.75	0.81	0.78	0.77	0.82	0.79	0.71	0.62	0.67	0.73	0.66	0.69
9	0.83	0.95	0.89	0.84	0.96	0.90	0.66	0.71	0.69	0.67	0.73	0.70	0.71	0.77	0.74	0.72	0.78	0.75	0.68	0.61	0.65	0.70	0.62	0.66
10	0.72	0.82	0.77	0.72	0.83	0.78	0.63	0.68	0.66	0.64	0.70	0.67	0.68	0.74	0.71	0.69	0.76	0.72	0.67	0.59	0.63	0.69	0.60	0.64
11	0.69	0.73	0.71	0.69	0.73	0.71	0.60	0.65	0.63	0.61	0.67	0.64	0.65	0.72	0.68	0.66	0.73	0.70	0.65	0.58	0.62	0.67	0.59	0.63
12	0.65	0.68	0.67	0.67	0.69	0.68	0.58	0.63	0.61	0.59	0.65	0.62	0.62	0.70	0.66	0.64	0.72	0.68	0.64	0.57	0.60	0.66	0.58	0.62
13	0.62	0.65	0.64	0.63	0.66	0.64	0.56	0.61	0.59	0.58	0.64	0.61	0.61	0.68	0.65	0.62	0.70	0.66	0.62	0.56	0.59	0.64	0.58	0.61
Mean	1.46	1.57	1.51	1.46	1.57	1.51	0.89	0.96	0.92	0.90	0.97	0.94	1.17	1.25	1.21	1.18	1.27	1.23	0.96	0.93	0.94	1.01	0.95	0.98
	CD 0.05	S Ed		CD 0.05	S Ed		CD 0.05	S Ed		CD 0.05	S Ed		CD 0.05	S Ed		CD 0.05	S Ed		CD 0.05	S Ed		CD 0.05	S Ed	
M	0.438	0.218	**	0.383	0.191	**	0.314	0.156	**	0.367	0.183	**	0.259	0.128	**	0.289	0.144	**	0.301	0.150	**	0.234	0.117	**
Y	0.165	0.083	**	0.145	0.072	NS	0.118	0.059	NS	0.138	0.069	NS	0.097	0.048	NS	0.109	0.054	NS	0.114	0.057	NS	0.088	0.044	NS
MY	0.619	0.309	**	0.542	0.271	NS	0.444	0.222	NS	0.519	0.259	NS	0.365	0.182	NS	0.408	0.204	NS	0.426	0.212	NS	0.331	0.165	NS

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

Table 4 — Changes in β-carotene (μg/100g) in elephant foot yam dry fry cubes during storage

MAS/cv.	BCA-1												IGAM-1											
	Dry (Salt 2%)			Dry (Alum 1.5%)			Fry (Salt 2.0%)			Fry Alum (1.5%)			Dry (Salt 1.5%)			Dry (Alum 2.0%)			Fry (Salt 1.5%)			Fry Alum (2.0%)		
	1st	2nd	Pooled	1st	2nd	Pooled	1st	2nd	Pooled	1st	2nd	Pooled	1st	2nd	Pooled	1st	2nd	Pooled	1st	2nd	Pooled	1st	2nd	Pooled
0	72.13	71.82	71.97	71.98	72.61	72.30	58.11	57.77	57.94	59.14	59.93	59.53	68.84	69.20	69.02	78.11	77.61	77.86	63.98	64.10	64.04	73.58	73.10	73.34
1	72.01	71.78	71.90	71.24	71.50	71.37	55.28	54.30	54.79	58.00	57.89	57.95	66.95	67.30	67.12	76.67	76.10	76.39	63.39	63.42	63.41	72.00	71.55	71.78
2	71.97	71.70	71.84	70.18	71.32	70.75	53.89	53.25	53.57	51.02	49.46	50.24	64.13	64.30	64.21	74.81	74.14	74.48	62.22	61.43	61.83	69.32	68.92	69.12
3	71.57	71.25	71.41	69.77	69.97	69.87	50.05	49.71	49.88	49.12	47.65	48.38	61.49	61.56	61.52	71.01	70.14	70.57	60.12	59.35	59.74	67.46	66.90	67.18
4	71.02	70.87	70.95	68.01	67.96	67.99	47.11	46.30	46.71	48.79	47.38	48.09	60.02	59.67	59.84	69.33	68.60	68.96	57.87	56.72	57.30	65.57	64.56	65.07
5	70.79	70.67	70.73	64.97	64.60	64.79	44.68	43.56	44.12	46.35	45.20	45.77	58.04	57.80	57.92	68.21	67.65	67.93	55.55	54.63	55.09	61.35	60.69	61.02
6	70.01	68.32	69.17	58.12	57.96	58.04	43.21	42.15	42.68	41.13	40.65	40.89	56.87	56.53	56.70	62.93	61.80	62.37	52.80	51.32	52.06	59.12	58.72	58.92
7	68.13	63.64	65.88	53.98	53.10	53.54	40.03	39.78	39.91	40.56	40.32	40.44	56.50	56.35	56.43	60.34	59.37	59.85	50.12	48.95	49.53	58.57	57.84	58.21
8	64.45	60.36	62.41	52.02	51.29	51.65	38.35	37.54	37.94	39.04	38.94	38.99	54.21	53.89	54.05	54.45	54.21	54.33	48.99	47.68	48.34	57.74	56.28	57.01
9	61.30	60.23	60.77	50.01	49.65	49.83	33.78	32.49	33.14	36.98	36.72	36.85	52.38	51.90	52.14	52.13	51.54	51.83	46.23	45.62	45.93	56.02	55.43	55.73
10	58.98	58.50	58.74	47.53	46.10	46.82	31.99	31.54	31.77	35.89	35.67	35.78	49.04	48.60	48.82	50.18	49.56	49.87	45.12	44.67	44.89	50.04	48.95	49.49
11	54.04	53.64	53.84	42.12	41.32	41.72	30.12	29.78	29.95	33.00	32.56	32.78	47.90	47.61	47.76	44.11	43.76	43.94	44.89	44.45	44.67	48.34	46.75	47.54
12	49.88	53.60	51.74	39.87	39.10	39.49	29.01	28.30	28.66	31.32	31.05	31.19	44.11	43.57	43.84	43.08	42.05	42.56	42.65	41.36	42.01	44.21	45.37	44.79
13	41.23	40.18	40.71	37.10	36.96	37.03	27.93	27.68	27.81	30.02	29.81	29.92	39.32	39.13	39.23	39.15	38.99	39.07	37.76	36.36	37.06	42.98	43.16	43.07
Mean	64.11	63.33	63.72	56.92	56.67	56.80	41.68	41.01	41.35	42.88	42.37	42.63	55.70	55.53	55.61	60.32	59.68	60.00	52.26	51.43	51.85	59.02	58.44	58.73
	CD 0.05	S Ed		CD 0.05	S Ed		CD 0.05	S Ed		CD 0.05	S Ed		CD 0.05	S Ed		CD 0.05	S Ed		CD 0.05	S Ed		CD 0.05	S Ed	
M	15.773	7.873	**	11.904	5.942	**	12.668	6.324	**	11.382	5.681	**	12.758	6.368	**	11.482	5.731	**	12.703	6.341	**	12.331	6.155	**
Y	5.961	2.976	NS	4.499	2.246	NS	4.788	2.390	NS	4.302	2.147	NS	4.822	2.407	NS	4.339	2.166	NS	4.801	2.397	NS	4.661	2.327	NS
MY	22.306	11.135	NS	16.835	8.404	NS	17.915	8.943	NS	16.096	8.035	NS	18.043	9.006	NS	16.238	8.106	NS	17.965	8.967	NS	17.439	8.705	NS

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

Table 5 — Changes in Total Phenol (mg/100g) in elephant foot yam dry fry cubes during storage

MAS/cv.	BCA-1												IGAM-1											
	Dry (Salt 2%)			Dry (Alum 1.5%)			Fry (Salt 2.0%)			Fry Alum (1.5%)			Dry (Salt 1.5%)			Dry (Alum 2.0%)			Fry (Salt 1.5%)			Fry Alum (2.0%)		
	1st	2nd	Pooled	1st	2nd	Pooled	1st	2nd	Pooled	1st	2nd	Pooled	1st	2nd	Pooled	1st	2nd	Pooled	1st	2nd	Pooled	1st	2nd	Pooled
0	66.49	56.49	61.49	49.34	52.21	50.78	48.19	49.68	48.94	41.22	42.70	41.96	48.99	49.72	49.35	42.36	43.90	43.13	41.59	42.46	42.03	38.67	39.45	39.06
1	64.11	54.11	59.11	48.35	51.18	49.76	47.29	48.39	47.84	39.82	39.99	39.91	47.82	48.21	48.02	41.02	41.78	41.40	38.16	39.13	38.65	37.28	38.15	37.72
2	62.32	52.32	57.32	46.21	48.87	47.54	44.76	45.41	45.09	36.87	37.15	37.01	46.83	45.90	46.36	39.86	39.98	39.92	37.32	38.30	37.81	35.26	35.50	35.38
3	59.53	49.53	54.53	43.67	44.36	44.02	41.74	42.28	42.01	34.48	34.68	34.58	43.71	44.23	43.97	38.74	38.88	38.81	36.39	37.46	36.93	33.41	33.13	33.27
4	57.53	47.53	52.53	41.29	42.65	41.97	38.49	39.98	39.24	32.81	32.99	32.90	42.13	43.41	42.77	37.21	37.98	37.60	34.28	34.76	34.52	31.82	31.21	31.52
5	56.65	46.65	51.65	38.57	40.58	39.58	37.56	38.56	38.06	31.27	31.87	31.57	41.08	42.53	41.81	34.82	35.12	34.97	32.17	32.55	32.36	30.18	29.99	30.08
6	54.11	44.11	49.11	37.32	39.19	38.26	35.48	37.91	36.70	27.46	28.02	27.74	38.96	40.36	39.66	32.61	33.00	32.81	31.07	30.90	30.99	28.36	28.13	28.24
7	49.73	39.73	44.73	35.89	37.76	36.83	32.91	33.42	33.17	26.39	26.70	26.55	37.95	39.40	38.68	31.03	30.99	31.01	27.89	27.60	27.75	26.82	26.41	26.62
8	46.71	36.71	41.71	32.87	33.74	33.31	31.28	31.77	31.53	24.18	24.06	24.12	36.23	38.22	37.22	28.93	29.17	29.05	26.11	26.04	26.08	25.67	25.12	25.39
9	45.32	35.32	40.32	31.43	32.65	32.04	29.61	30.10	29.86	23.72	23.52	23.62	34.72	35.29	35.00	26.71	27.51	27.11	24.71	25.11	24.91	23.78	24.07	23.93
10	43.67	33.67	38.67	28.73	30.56	29.64	27.78	28.27	28.03	21.63	21.12	21.38	32.81	33.10	32.96	25.29	25.83	25.56	23.78	23.99	23.88	21.72	22.45	22.09
11	40.87	30.87	35.87	25.89	26.12	26.01	26.31	27.41	26.86	19.29	18.98	19.14	31.32	31.67	31.50	23.81	24.12	23.96	21.45	21.69	21.57	19.37	20.78	20.08
12	37.98	27.98	32.98	23.35	24.00	23.68	23.45	24.21	23.83	18.59	18.32	18.45	29.63	29.44	29.53	21.62	21.22	21.42	19.38	19.19	19.29	17.37	17.99	17.68
13	36.69	26.69	31.69	21.73	22.11	21.92	22.83	23.09	22.96	17.21	16.98	17.10	27.50	27.42	27.46	19.82	19.42	19.62	17.37	17.06	17.22	16.39	16.88	16.63
Mean	51.55	41.55	46.55	36.05	37.57	36.81	34.83	35.75	35.29	28.21	28.36	28.29	38.55	39.21	38.88	31.70	32.06	31.88	29.41	29.73	29.57	27.58	27.80	27.69
	CD 0.05	S Ed		CD 0.05	S Ed		CD 0.05	S Ed		CD 0.05	S Ed		CD 0.05	S Ed		CD 0.05	S Ed		CD 0.05	S Ed		CD 0.05	S Ed	
M	13.811	6.894	**	10.810	5.396	**	10.114	5.049	**	9.282	4.633	**	10.423	5.203	*	8.075	4.031	**	8.586	4.286	**	8.236	4.111	**
Y	5.220	2.606	**	4.085	2.039	NS	3.823	1.908	NS	3.508	1.751	NS	3.939	1.966	NS	3.052	1.523	NS	3.245	1.620	NS	3.113	1.554	NS
MY	19.531	9.749	NS	15.287	7.631	NS	14.304	7.140	NS	13.126	6.552	NS	14.741	7.358	NS	11.420	5.700	NS	12.144	6.062	NS	11.648	5.184	NS

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

Table 6 — Changes in Organoleptic value (9 point hedonic scale) in elephant foot yam dry fry cubes during storage

MAS/cv.	BCA-1												IGAM-1											
	Dry (Salt 2%)			Dry (Alum 1.5%)			Fry (Salt 2.0%)			Fry Alum (1.5%)			Dry (Salt 1.5%)			Dry (Alum 2.0%)			Fry (Salt 1.5%)			Fry Alum (2.0%)		
	1st	2nd	Pooled	1st	2nd	Pooled	1st	2nd	Pooled	1st	2nd	Pooled	1st	2nd	Pooled	1st	2nd	Pooled	1st	2nd	Pooled	1st	2nd	Pooled
0	8.42	8.67	8.55	8.26	8.45	8.36	8.54	8.78	8.66	8.62	8.78	8.70	8.42	8.67	8.55	7.74	8.33	8.04	8.56	8.67	8.62	8.22	8.56	8.39
1	8.33	8.44	8.39	8.02	8.34	8.18	8.33	8.66	8.50	8.54	8.67	8.61	8.33	8.56	8.45	7.47	8.09	7.78	8.33	8.52	8.43	8.03	8.33	8.18
2	8.01	8.33	8.17	7.88	8.33	8.11	8.12	8.33	8.23	8.33	8.56	8.45	7.98	8.43	8.21	7.34	7.86	7.60	8.12	8.33	8.23	7.88	8.21	8.05
3	7.56	8.06	7.81	7.73	7.78	7.76	7.82	7.89	7.86	7.89	8.43	8.16	7.67	8.03	7.85	6.87	7.56	7.22	7.88	7.79	7.84	7.65	7.79	7.72
4	7.33	7.98	7.66	7.45	7.56	7.51	7.56	7.56	7.56	7.56	8.33	7.95	7.54	7.88	7.71	6.67	7.43	7.05	7.67	7.67	7.67	7.43	7.65	7.54
5	7.12	7.78	7.45	7.33	7.42	7.38	7.33	7.43	7.38	7.43	7.87	7.65	7.23	7.65	7.44	6.34	7.23	6.79	7.43	7.45	7.44	7.33	7.34	7.34
6	6.89	7.63	7.26	6.88	7.01	6.95	7.07	7.21	7.14	7.02	7.45	7.24	6.78	7.34	7.06	6.07	6.93	6.50	7.23	7.03	7.13	6.89	7.08	6.99
7	6.56	7.33	6.95	6.57	6.88	6.73	6.79	6.87	6.83	6.87	7.23	7.05	6.64	7.21	6.93	5.89	6.89	6.39	6.88	6.57	6.73	6.63	6.87	6.75
8	6.02	6.76	6.39	6.33	6.46	6.40	6.63	6.56	6.60	6.56	6.98	6.77	6.34	6.93	6.64	5.78	6.56	6.17	6.34	6.44	6.39	6.33	6.78	6.56
9	5.34	6.45	5.90	5.98	6.26	6.12	6.33	6.34	6.34	6.42	6.67	6.55	5.89	6.67	6.28	5.68	6.32	6.00	6.21	6.23	6.22	5.78	6.56	6.17
10	5.21	6.33	5.77	5.67	5.89	5.78	5.67	5.67	5.67	5.78	6.54	6.16	5.67	6.45	6.06	5.33	5.78	5.56	5.89	5.89	5.89	5.45	6.34	5.90
11	4.78	5.86	5.32	5.23	5.78	5.51	5.45	5.32	5.39	5.52	6.03	5.78	5.34	6.32	5.83	5.01	5.65	5.33	5.76	5.65	5.71	5.23	6.03	5.63
12	4.33	5.67	5.00	4.45	5.45	4.95	5.23	4.54	4.89	5.07	5.87	5.47	5.21	5.85	5.53	4.87	5.23	5.05	5.43	5.34	5.39	4.87	5.76	5.32
13	4.02	5.45	4.74	4.33	5.22	4.78	4.78	4.33	4.56	4.87	5.45	5.16	4.86	5.43	5.15	4.52	4.78	4.65	5.12	5.22	5.17	4.76	5.33	5.05
Mean	6.42	7.20	6.81	6.58	6.92	6.75	6.83	6.82	6.83	6.89	7.35	7.12	6.71	7.24	6.98	6.11	6.76	6.44	6.92	6.91	6.92	6.61	7.05	6.83
	CD 0.05	S Ed		CD 0.05	S Ed		CD 0.05	S Ed		CD 0.05	S Ed		CD 0.05	S Ed		CD 0.05	S Ed		CD 0.05	S Ed		CD 0.05	S Ed	
M	0.853	0.425	**	0.811	0.404	**	0.764	0.381	**	1.009	0.503	**	0.811	0.404	**	0.677	0.337	**	0.723	0.360	**	0.656	0.327	**
Y	0.334	0.167	**	0.318	0.158	NS	0.299	0.149	NS	0.396	0.527	NS	0.318	0.158	**	0.265	0.132	**	0.283	0.141	NS	0.257	0.128	**
MY	1.206	0.601	NS	1.147	0.572	NS	1.080	0.538	NS	1.427	1.901	NS	1.147	0.572	NS	0.957	0.477	NS	1.022	0.509	NS	0.928	0.463	NS

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

stage 0 and 13 MAS (Table 6). Organoleptic scores were judged based on 9 points Hedonic Scale in which up to '4.5' rank (like slightly) of the products were considered somewhat acceptable by the panel of judges. In this study, the product was considered suitable based on an overall acceptability rating of 4.5 and above by the panelist. A similar finding was also observed in elephant foot yam flour[1].

Conclusion

Diversification in terms of value added products is one of the methods to retain the elephant foot yam in the existing cropping systems. It can be concluded that soaking the selected tubers in 2% salt for 5 h prevents browning and acridity at a maximum level and *cv*., BCA-1 dry cubes salt (2%) with nutritive and antioxidant value. Convertion of raw tubers into processed products of high culinary, nutritious foods enhances the profitability of elephant foot yam cultivation. Functional food products developed from elephant foot yam are gradually penetrating the markets in India, China and other Southeast Asian countries. The standardized foods from the selected cultivars of elephant foot yam can be exploited at the cottage industry level.

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Conflict of Interest

The authors declare no conflict of interests.

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