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Development of value added food products from tropical tubers

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ABSTRACT

A study was conducted to develop value added food products from tropical tubers. Among the minor tubers, Amorphophallus paeoniifolius, Typhonium trilobatum and colocasia esculenta were selected and subjected to different pre-treatments and standardized value added products. The sensory evaluation and nutritional analysis showed that the products developed by using tubers were acceptable up to 30 per cent incorporation. The standardized products from the selected tubers can be explored cottage industries for income generation and employment opportunities. Tuber crops have a prominent role in feeding the world and these crops are going to be an important component in food security system in the coming decades.

***Keywords*:** Tropical tubers, value added food products

Roots and tubers are the third important food for human after cereals and grain legumes, it constitute either stable or subsidiary food for about one fifth of the word population. These crops are known to supply cheap source of energy especially for the weaker sections of the population. India's population having touched 100 million, still depends on agriculture as the primary occupation. The population growth is expected to reach 1560 million by 2020 if still there will be 23 percent of people are below poverty line. In spite of the increasing production and availability of food grains, there will be a net shortage of nearly 26 million tonnes by 2020. This is an equivalent of 80 tones of roots and tubers (Edison, 2006)

The ever increasing population level coupled with rapidly shrinking cultivable area and increasing fragile resources lead to inadequate supply of food to the people. In order to meet this unfortunate scenario, tuber crops constitute the important link to fit the food security gap and alleviate hunger and combat malnutrition to a sizeable percentage. World Health Organization estimate that in many of the under developed and developed countries several nutritional disorders are prevalent. These nutritional disorders are due to insufficient intake of protein, vitamin A, vitamin C and calcium which could be easily alleviated by adequate supply and consumption of roots and tubers (Padmaja *et al.*, 2013)

The importance and dietary fibre in tubers is well recognized. Dietary fibre reduces the serum cholesterol, prevents colon cancer and maintains good intestinal health as well as it provides prophylactic action for cardio vascular diseases, diabetes and obesity (Pugalendhi *et al*., 2013). The tuber crops were broadly classified as temperature and tropical groups. Potato is primarily a temperature crop, where as the tropical tuber crops are tapioca (cassava), sweet potato, aroids (elephant footyam, taro, tannia and gaint taro), yams (greater yam, lesser yam, african yam) and other minor tubers namely chinease potato, arrow root and yam bean.

Among the aroids, elephant foot yam (*Amorphophallus paeoniifolius*), Bengal arum or karunai kilangu (*Typhonium trilobatum*) and taro or old cocoyam (*Colocasia esculenta*) are an important tropical minor tuber crops. As a primary staple, they form the major energy source for a vast segment of population in South pacific and Africa. As a secondary staple or vegetable, these crops find wider acceptability in most of the countries including India. Nutritionally, these tubers are rich in carbohydrate, vitamins and minerals. But the minor tubers under aroids such as elephant foot yam, Bengal arum (karunai kilangu) and taro are not exploded for industrial uses and they are cultivated in a small pocket and used only as vegetables. To make them important component in our food security systems of this minor tubers. It is necessary to develop value added products. Development of value added products of these tubers to enhance the potential uses within the food industry for the replacement of traditional forms and carbohydrates and produce entirely new products from the selected tubers such as elephant footyam, karunai kilangu and taro

MATERIALS AND METHODS

Good quality tubers of elephant foot yam, Bengal arum-karunai kilangu (*Tryphonium trilobactum)*

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and taro (*Colocasia esculenta*) were purchased from local market from Madurai district, Tamilnadu, India for processing into flour and also for standardization of value added products.

Pre- processing of selected tubers for prevention of browning and aridity

The selected tubers were cleaned well under running water for three to four times to remove the adhering sand on the skin and damaged parts if any. After washing, the tubers were surface dried and peeled by using knife. In the selected tubers browning and acridity are the major problem. For Prevention of browning and aridity from the selected tubers different treatments were tried namely blanching for 5 minutes (T_1), soaking at 1 percent potassium meta bisulphate for 30 minutes (T_2), soaking at 1 percent citric acid for 30 minutes (T_3), soaking at 2 percent hydrochloric acid for 30 minutes (T_4), soaking at 2 percent tartaric acid for 30 minutes (T_5), soaking in 2 percent citric acid for 30 minutes (T_6), soaking at 2 percent salt in cold water (T_{7a}), and hot water for 30 mins (T_{7b}), soaking in 2 % baking soda in cold water (T_{8a}), and hot water for 30 min (T_{8b}), soaking at 2 percent tamarind juice (3 g in 5 ml of water) for 30 minutes (T_9), soaking at 2 percent lime juice for 30 minutes (T_{10}), steaming for 10 minutes (T_{11}), open cooking (500 ml water for 10 minutes) (T_{12}), pressure cooking 5 minutes (T_{13}), soaking at butter milk (300ml) over night (T_{14}), soaking at 1 percent citric acid for one hour (T_{15}), soaking at 1 percent citric acid for two hours (T_{16}).

Processing of selected tubers in to flour

After the pre treatment, the tubers were washed in tap water and cut into (1 -2 mm) cubes. The cubes were blanched for 5 minutes, blanching helps to kill the harmful microorganisms, soften the cell walls, speed up the drying process and increase the shelf life & to prevent fresh odour in the processed tuber flour. After blanching the tuber cubes were spread on the trays and were dried in the dehydrator. The cabinet drier was pre heated at 80° C and the trays were loaded with tuber cubes and it was kept in the cabinet dryer. The temperature was maintained at 80° C for 4 hours. The dried cube were subjected to milling process by using pulverizer, to obtain the fine flour was sieved by using the sieve (SSS. No. 80). The details of preparation of flour from the selected tubers are given in fig.- 1.

Selection → Washing → Peeling → Cutting (large cubes) → Soaking elephant foot yam (1 % citric acid, 1 hr for elephant foot yam and taro, 2 hrs for karunai kizhangu)

↓

Milling ← Drying (80°C, 4 min) ← Blanching (5 min) ← Cutting cubes in 2mm ← Washing (2 times)

↓

Flour → Roasting (80°C, 5 hrs) → Packing

Fig. 1: Processing of tuber in the form of flour

Standardization of value added products

Puffed snack

Puffed snack was standardized by incorporating (elephant foot yam, karunai kizhangu and Taro) flour at different level of 10, 20 and 30 percent. The details of processing of puffed snack is given in table 1.

Table 1: Standardization of puffed snack

Ingredients	C	T1	T2	T3
Tuber flour (g)	-	10	20	30
Maize flour (g)	100	90	80	70
Pepper powder (g)	2	2	2	2
Water (ml)	10	10	10	10
Salt	2	2	2	2

Papad

Papad was standardized using (elephant foot yam, karunai kizhangu and taro) flour at different incorporation of 10, 20 and 30 percent. The details of processing of papad is given in table- 2.

Table 2: Standardization of papad

Ingredients	C	T1	T2	T3
Tuber flour (g)	-	10	20	30
Black gram flour (g)	100	90	80	70
Salt	5	5	5	5
Water (ml)	40	40	40	40
Sodium bicarbonate (g)	1	1	1	1
Oil (g)	5	5	5	5

Note: C = control

Maize flour + tuber flour → Mixing (10% moisture) → Tempering for one hour → Mixing → Extruder after pre heating twin screw extruder to 100° C

↓

Puffed snack → Cooling → Packing (polyethylene and metalized polypropylene) → Storing

Fig. 2: Processing of puffed snack

Mixing elephant foot yam flour (or) Karunai kizhangu flour (or) taro flour+ black gram flour + sodium bicarbonate → Adding water (40ml) and salt (5g) → Dough making → Making into → Flattening drying (shade)

↓

Packing → Storing

Fig. 3: Preparation of papad

Sensory evaluation of standardized value added products

Sensory evaluation provides an index of overall acceptability of foodstuffs, which depend on its appearance, flour, taste, texture, aftertaste, and overall acceptability. To ensure the acceptability of the modified recipes, they were subjected to evaluation by composite scoring for their sensory qualities. The standardized value added products were prepared and presented to a panel of 15 judges. Specific sensory characteristics of each product (appearance, color, flavor, taste, texture and overall acceptability) were rated separately using hedonic scale on a scale of 1 to 9. Scores were defined as follows: 1- dislike extremely, bad; 9- like extremely, excellent. Numerical averages were then calculated for a composite test score (Swaminathan 1980)

Physical properties of standardized value added products

Bulk Density

The bulk density was calculated by measuring the actual dimensions of extrudates (AACC, 2000). The diameter and length of extrudates were measured using Vernier caliper. The weight per unit length of extrudate was determined by weighing measured length (about 1 cm). the bulk density was then calculated using the following formula, assuming a cylindrical shape of extrudate.

$$\rho_b = \frac{4}{\pi l d^2}$$

Where ρ_b is bulk density (g/cm^3), I is the length per gram of the extrudates (cm/g) and d is diameter of the extrudates (cm). Five pieces of extrudates were randomly selected and average taken.

Water solubility index and water absorption index

Water solubility (WSI) and water absorption indices of extruded products were determind by a modification of the method of Anderson *et al.* (1969). The extrudates samples were ground and sieved through 500 μm sieves. Distilled water (10 ml) at 25° C was placed in a tarred centrifuge tube and 0.5 g of extrudate was dispersed in the water. Care was taken to avoid lumping in order to produce smooth dispersion. After standing for 30 min (with intermittent shaking every 5 min), the sample was centrifuged (Roto Silenta II, Hettich, Tuttlingen, Germany) at 1800 × g for 15 min. the supernatant was decanted into a tarred aluminum pan and dried at 105°C until get a constant weight. The weight of the gel remaining in the centrifuge tube was noted. The results were expressed as the average of two measurements.

$$WAI\left(\frac{g}{g}\right) = \frac{Weight\ of\ grain\ of\ gel}{Dry\ weight\ of\ extrudate}$$

$$WAI(\%) = \frac{Weight\ of\ solid\ in\ supernatant}{Weight\ of\ dry\ samples\ in\ the\ original\ sample}\ \mathbf{x\ 100}$$

The weight, diameter and thickness of the papad were determined. Weight of the papad was measured using an electronic balance (model: OPAL ISO 9001: 2008 certified) having least of 10 mg. Diameter was assessed having a least count of 0.01 mm thickness was calculated by using screw gauge having count of 0.1 mm

Nutrient analysis of value added products

Based on the acceptability score, the standardized value added products from minor tubers were analysed for its proximate composition using AOCA (1984) method.

Estimation of calcium oxalate

Edible aroid (*Colocasia* and *Amorphophallus*) accumulate oxalic acid in the form of free oxalate & bound oxalate (mainly as calcium oxalate). The presence of calcium oxalate has been attributed to be one of the major causes of acridity. Hence to prevent acridity different pre treatments were tried. Among the 16 treatments tried, soaking in citric acid at 1 percent level for one hour was found to be effective in preventing browning and acridity in elephant foot yam & taro flour by organoleptic evaluation. For Bengal arum (karunai kizhangu) the tubers treated with citric acid at 1 percent for 2 hours was found to be effective in preventing the acridity. Hence the tubers treated with citric acid were used for standardizing different value added products. The presence of calcium oxalate was estimated for the raw (unprocessed) and pretreated flour with citric acid as per the procedure suggested in the AOAC method (1984).

RESULT AND DISCUSSIONS

Pre-processing of selected tubers

The selected tubers soaked in 1% citric acid for one hour (T_{15}) were effective in elephant foot yam and taro. For Bengal arum (karunai kizhangu), the tubers soaked in 1% citric acid for 2 hours (T_{16}) was found to be effective in reducing the acridity and browning. It was found that processed flour had bright color and good aroma in organoleptic evaluation.

Sundaresan (2005) reported that citric acid and tartaric acid at 1% concentration were found to be effective in reducing the acridity and oxalate levels. However citric acid was found to be a better choice as it imparted a bright colour to the cooked sample. Soaking of tubers in solvents prior to boiling was also found to be equally effective in reducing the acridity. Nearly 75% calcium oxalate was lost in treatment with citric acid and tartaric acid.

Estimation of calcium oxalate

The calcium content in the fresh and pre processing tuber flour was analyzed. The details are presented in table 3.

Table 3: Presence of calcium oxalate content in fresh and processed tuber flour

Tuber	Calcium oxalate	
	Fresh tuber flour	Pre processed tuber flour
Elephant foot yam	0.14	0.05
Bengal arum (karunai kizhangu)	0.25	0.09
Taro	0.20	0.08

From the table it was found that the calcium oxalate content in fresh tuber was 0.14% in elephant foot yam, in karunai kizhangu 0.25% and in taro 0.20%, respectively. The processed (soaking the tubers in citric acid followed by blanching, drying and roasting) tuber flour was subjected to determine the presence of calcium oxalate. It was found that elephant foot yam flour had 0.05%, karunai kizhangu flour contained 0.09% and in taro flour had 0.08 percent calcium oxalate. The reduction in acridity was noticed.

The reduction in oxalate content may be due to different treatment like peeling, washing, dicing, soaking, blanching & roasting. Akapan and umoh (2004) stated in their study that the peel of tubers contain more oxalate than the peeled tubers. Buntha *et al*. (2008) also reported that the acridity of taro can be reduced by peeling, grating, soaking and fermentation. Huang *et al*. (2007) also found that soaking reduced the concentration of oxalates by 23.5% and by cooking 56.7% Shanthai Kumari *et al.* (2008) further confirmed that the decrease in the anti – nutritional factors like oxalates during soaking may be leaching out of these substances in soaking medium. Boiling may cause considerable cell rupture and facilitate leakage of soluble oxalate into cooking water, Albihn and Savage (2001).

Iwuoa and Kalu (1994) reported, boiling of taro had reduced the oxalate content by 65.7-82.1%, the study conducted by Adane *et al.* (2013) also reported that boiling of taro had reduced the oxalate content by 70.9%. Sundaresan (2005) was found that in fresh tuber of taro cultivars had 0.07-0.15% calcium oxalate content, elephant foot yam had 0.12-0.24 percent and the author concluded that addition of mild organic acid prior to boiling was found to be effective in reducing the acridity more than 75 percent. Incorporation of organic acid in cooking medium provides low PH and facilitates solubilization of calcium oxalate. In the analysis, it was found, that the selected processed tuber flours had 60-64 percent reduction in calcium oxalate by treating by tubers in citric acid.

Organoleptic evaluation of value added products

The prepared puffed snack was organoleptically evaluated, to assess the acceptability, the prepared puffed snack was given to 15 trained judges for organoleptic evaluation using nine point hedonic scale. The result of organoleptic evaluation is given in table 4 and fig. 4.

Table 4: Organoleptic evaluation of puffed snack

Particulars	Control (%)	T_1 (%)	T_2 (%)	T_3 (%)
Colour	85	82	80	85
Texture	84	82	75	83
Flavour	85	80	76	85
Taste	85	83	75	85
Overall acceptability	85	83	80	85

Fig. 4: Popped snacks

Fig. 5: Papad

Based on the organoleptic evaluation thirty percent (T_3) incorporation of elephant food yam flour, karunai kizhangu flour and taro flour incorporated puffed snack had higher acceptability. The product had the overall acceptability score of 85 percent.

Kavya and Reddy (2011) made an attempt to formulate extruded snacks in combination with corn grits, black gram dhal, root and tuber like potato, sweet potato, colocasia and beet root, corn grits, black and gram dhal and tubers were added in the ratio of 60: 20: 20 respectively to produce puffed snacks. The author has concluded that most acceptable based extruded products can be prepared by using tubers. The products need to be explored for commercialization as an innovative snack food to increase the utility of the tubers.

The prepared papad was fried in oil and it was organoleptically evaluated, to assess the consumer acceptability of the product. The prepared papad was given to 15 trained judges for organoleptic evaluation using nine point hedonic scale. The results of organoleptic evaluation are given in table 5 and fig.5.

Table 5: Organoleptic evaluation of papad

Particulars	Control (%)	T_1 (%)	T_2 (%)	T_3 (%)
Colour	95	84	86	93
Texture	94	84	84	93
Flavour	92	80	80	93
Taste	95	80	74	95
Overall acceptability	95	80	80	90

Based on the organoleptic evaluation thirty percent (T_3) incorporation of elephant food yam flour, karunai kizhangu flour and taro flour incorporated papad had higher acceptability. Papad at 50% incorporation of taro was highly accepted by the judges. But while kneading and spreading, the dough texture was sticky, it may be due to the mucilage content in taro flour. The product had the overall acceptability score of 85 percent.

Nutrient content of the value added products

Based on the organoleptic evaluation T_3 sample had higher acceptability score, when compared to other incorporation level of selected tuber flour. Hence proximate composition for the 30% incorporated tuber flour value added products were estimated and presented in table 6.

Table 6: Nutrient content of the standardized tubers products in 100g

Sl. No.	Name of the product	Moisture (%)	Carbohydrate (g)	Protein (g)	Fat (g)	Fiber (g)	-carotene (µg)
Elephant foot yam							
1.	Puffed snack	23.61	5.52	0.36	0.03	0.24	78.0
2.	Papad	6.20	45.42	4.90	4.23	3.50	142.1
Karunai kizhangu							
1.	Puffed snack	20.97	7.8	0.42	0.03	0.3	23.4
2.	Papad	6.5	52.10	5.1	3.7	4.1	87.5
Taro							
1.	Puffed snack	21.93	6.33	0.90	0.03	0.30	12.4
2.	Papad	6.40	43.50	3.70	3.50	3.80	64.1

Table 7: Mineral content of the standardized products

Sl. No.	Name of the product	Calcium (mg)	Phosphorus (mg)	Iron (mg)	Magnesium (mg)	Potassium (mg)	Zinc (µg)
Elephant foot yam							
1.	Puffed snack	30.00	251.56	2.01	100.50	197.98	2.30
2.	Papad	119.80	267.70	2.54	88.00	50.24	1.10
Karunai kizhangu							
1.	Puffed snack	23.92	255.60	2.11	104.82	270.00	2.47
2.	Papad	115.30	265.5	2.72	93.1	119.04	1.23
Taro							
1.	Puffed snack	25.70	282.65	1.92	107.98	361.63	2.41
2.	Papad	115.00	295.50	2.50	95.40	210.50	1.10

The standardized puffed snack was prepared from three different minor tubers such as elephant foot yam, karunai kizhangu and taro. The results indicated that moisture content of elephant foot yam product was high compared to karunai kizhangu and taro products. Karunai kizhangu flour exhibit maximum carbohydrate content at (7.77 g) followed by elephant foot yam and taro. The values of fat in all the products were equal. Fibre content of karunai kizhangu and taro was equal and it was lower in elephant foot yam. Highest amount of beta carotene was obtained from elephant foot yam when compared to karunai kizhangu and taro.

Mineral content of the standardized products

The mineral content of the standardized products are presented below in table 7. From the table it was observed calcium content was higher in elephant foot yam puffed snack followed by karunai kizhangu and taro. Higher amount of phosphorous, magnesium and potassium content were observed in taro products and lower in elephant foot yam. Karunai kizhangu had high amount of iron and zinc.

Papad prepared from elephant foot yam flour contain high amount of moisture followed by karunai kizhangu had taro. Carbohydrate content of karunai kizhangu papad was high to elephant foot yam and taro. Protein content was more in taro, karunai kizangu and elephant foot yam papads. But there is no change in fat content of papad prepared from the three tubers flour *i.e.* all the three tubers showed the equal fat content (0.03g). equal amount of fibre content was present in karunai kizhangu and taro papads, but in elephant foot yam papads contained less amount of fibre. Beta carotene content of elephant foot yam papad was higher compared to karunai kizhangu and taro. Calcium content was highly presented in elephant foot yam papad. The highest amount of phosphoros, magnesium, potassium were found in taro papads followed by karunai kizhangu and elephant foot yam. Karunai kizhangu papad contain higher amount of iron and zinc compared to others.

Diversification for the production of value added products is one of the methods to retain the minor tubers in the existing cropping systems. This will directly or indirectly lead to generation of employment opportunities. The standardized foods from the selected tubers can be exploded at the cottage industries level. Tuber crops have a prominent role in feeding the word in the coming decades and these crops are going to be an important component in our food security system.

From the study it can be concluded that by soaking the selected tubers in one per cent citric acid for one hour for elephant foot yam and 2 hrs for taro and karunai kizhangu helps to prevent browning and acridity. The processed tubers can be converted into grits, suji and flour and it can be used for developing different types of value added products. From the study it can be concluded that the selected tubers had the potential to develop puffed snack and papad with 30 percent of tuber flour incorporation.

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