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EXTENDING THE USE OF A HIGHLY NUTRITIOUS UNDERUTILISED TARO *(COLOCASIA ESCULENTA)* TUBER BY DEVELOPMENT OF TUTTI FRUITY

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ABSTRACT

Tutti Fruity or Indian candied fruits are made from various chopped fruits and vegetables, and it is used in Cakes, Bun, Muffins, Cookies, Bread, and Custard & Ice-Cream. In this present work Taro (*Colocasia esculenta*) is used to prepare, because Taro is found to be highly nutritious and an underutilised tuber which also reduces the sugar level in the body.The raphides (needle like crystals) of calcium oxalate are responsible for the itching and the irritations during the handling and the consumption of Taro (*Colocasia esculenta*) tuber. However, the utilization options of Taro are mainly limited to direct consumption as whole boiled or pounded tuber only, thus making it an underutilized crop. In this literature an effort has made to reduce the itching caused by raphides (Needle like crystals of calcium oxalate) and to develop a new product from Taro (*Colocasia esculenta*) by means of 3 samples (1, 2, 3) in 3 steps (Blanching at 90˚C for 3mins, Boiling at 100˚C for 30mins and 60mins) and sensory evaluation conducted for all 3 samples including control sample. All 3 samples (1, 2 and 3) are subdivided into 10, 5 and 4 sub samples respectively and each subsample is assigned with a particular alphabet. Samples(1a,1b,1c,1d,1e,1f,1g,1h,1i) blanched at 90˚C for 3mins with Tamarind pulp at concentrations of 5%(1a), 10%(1b), 15%(1c), 20%(1d), 25%(1e), 30%(1f),40%(1g), 50%(1h), 60%(1i) and sample(1j) blanched in water at 90˚C for 3mins.Samples (2a,2b,2c,2d) boiled at 100˚C for 60mins with Tamarind pulp at concentrations of 30%(2a), 40%(2b), 50%(2c), 60%(2d) and Sample(2e) boiled in Water at 100˚C for 60mins. Samples (3a,3b) boiled at 100˚C for 30mins with Salt solution at concentrations of 2.5%(3a), 5%(3b) and samples(3c,3d) boiled at 100˚C for 60mins with Salt solution at concentrations of 2.5%(3c), 5%(3d). The sensory evaluation showed that Tutti Fruity made from Sample2d boiled at 100˚C for 60mins at 60% concentration of Tamarind pulp is superior in overall acceptability at 1% significance level ($p<0.01$) when compared to control sample. Sample1i blanched at 90˚C for 3mins at 60% concentration of Tamarind pulp and Sample 3f boiled at 100˚C in water for 60mins are inferior to sample2d. Sample2d was accepted and superior to all samples in overall acceptability and maximum number of panel members i.e., 26 panel members out of 30 found that there was no itching after consumption of Sample 2d.

KEYWORDS: Taro *(Colocasia esculenta)*, Tamarind pulp, Salt solution, Tutti Fruity, Physicochemical properties, Sensory evaluation, Ranking Test, Fiducial limits.

INTRODUCTION

Taros *(Colocasia spp.)* are stem tubers which are native to India and Malay Peninsula and are now cultivated throughout in both the tropical and subtropical regions of the world. In fact, among seven species of *Colocasia* which are originated from Asia, *Colocasia esculenta* is the most grown in India, Indonesia and other Southeast Asian countries (Ihekoronye *et al.,* 1985). Taro yields high quantities of energy and protein. The soft white-fleshed Taro corms, usually called Taro roots, are highly valued as a staple food and are eaten boiled, fried, roasted, fermented or turned into flour ("fufu" in West Africa), bread and biscuits. Low-grade corms are also used for alcohol production (Safo Kantaka *et al.,* 2004; Wilson *et al.,* 1996).

Due to their oxalate content, it is recommended to soak, wash or cook Taro corms and dry before consumption (Pheng Buntha *et al.,* 2008a; Babayemi *et al.,* 2009).

In India all the plant parts of *Colocasia esculenta* are used as vegetable as well as medicinal purpose among the rural peoples. It is also a source of economic increment to the farmers. The plant is also referred as a commercial crop. Many flavonoids and steroids have been isolated from *Colocasia esculenta* Linn. The plant is grown in India for especially its corm, leaves etc. India is marked as a center of origin of this plant (Onwueme *et al.*, 1994). In addition, taros have also been important crops in Hawaii, Japan, Egypt, Ghana and Nigeria.

Most taro cultivars taste acrid and can cause swelling of lips, mouth and throat if they are eaten raw (Bradbury *et al.*, 1998). The acridity of taro is thought to be concentrated in the outer layers of the corm and may be largely removed by peeling off a thick layer followed by prolonged boiling (Sakai *et al.*, 1983). This acridity is learned to be caused by calcium oxalate presents as fine needle-like crystals or raphides, which can penetrate soft skin (Bradbury *et al.*, 1998). Thereafter an irritant presents on the raphides, probably a protease can cause discomfort in the tissue (Paull *et al.*, 1999). The two common toxic effect of oxalate poisonings are (1) acute poisoning, resulting in hypocalcaemia (low calcium levels in the blood serum) after ingestion of high levels of soluble oxalates, and (2) (more commonly) chronic poisoning in which calcium oxalate crystals are deposited in the kidneys, resulting in renal disorder (kidneys fail to adequately filter metabolic wastes from blood). In addition, the presence of oxalate in foods has also been implicated in reducing the bioavailability of essential minerals such as calcium (Kelsav *et al.*, 1985).

The oxalates are widely distributed in the plants in readily water-soluble forms, such as potassium, sodium, and ammonium oxalate and as insoluble needle like calcium oxalate crystal (Smith *et al.*, 1982). Since calcium may also present in the plants in the form of soluble calcium oxalate crystals. Boiling can reduce the soluble oxalate content of a food if the cooking water is discarded, while soaking, germination and fermentation will also reduce the content of soluble oxalates (Noonan *et al.*, 1999). In contrast, baking a food will cause an effective concentration of oxalates in the food due to the loss of water from the baked food (Noonan *et al.*, 1999).

Taro corm is served either as staple or mixed with other vegetables, usually after cooking. Iwuoha *et al.*, (1995) suggested that appropriate cooking may reduce the harsh and sharp irritation in the throat and mouth. Cooking may improve digestibility, promote palatability, improves keeping quality, and also makes root crops safer to eat (FAO *et al.*, 1990). The types of cooking methods (boiling, pressure cooking and baking) differ in many areas of the world and also vary with the ethnic background of the family (Bhandari *et al.*, 2006). Fresh taro corm is difficult to store and is vulnerable to deterioration during storage. Because it is regarded as a health food and is a staple food extensively eaten in the Pacific Islands and in the rural areas of India, it is feasible to develop a stable form of taro products to fulfill the health food market. One of the best ways to preserve it is by processing it into flour and/or starch (Perez *et al.*, 2005).

Fig 1: Taro *(Colocasia esculenta)* corm.

Table 1: Proximate Composition of Taro corm on fresh weight basis.

Component	**Content**
Moisture	63-85%
Carbohydrate (mostly starch)	13-29%
Protein	1.4-3.0%
Fat	0.16-0.36%
Crude Fibre	0.60-1.18%
Ash	0.60-1.3%
Vitamin C	7-9 mg/100 g
Thiamine	0.18 mg/100 g
Riboflavin	0.04 mg/100 g
Niacin	0.9 mg/100 g

Source: Onwueme *et al.*, 1994

Table 2: Percentage composition of Taro corm Carbohydrate.

Carbohydrate	%
Starch	77.9
Pentosans	2.6
Crude Fibre	1.4
Dextrin	0.5
Reducing sugars	0.5
Sucrose	0.1

Source: Onwueme *et al.*, 1994

Study has revealed that the solubility of calcium oxalate in water increases with increasing temperature (Goodenough *et al.*, 1973) and that the decomposition reaction of calcium oxalate crystals into calcium oxide also occurs rapidly at high temperatures (Schempf *et al.*, 1965).

The change in boiling time led to a significant ($P<0.05$) reduction in the moisture, reducing sugars, total sugars, crude fat, crude fiber, total phenolic compound contents and iodine affinity of starch, whereas the total carbohydrate content, water absorption capacity, water solubility index, paste clarity and foam capacity increased significantly ($p<0.05$). The crude protein and total ash contents of the flours from taro corm were not affected significantly ($p<0.05$) by the change in boiling time. Taro corm flours exhibited highest total carbohydrate, crude fiber, total ash contents, water absorption capacity, iodine affinity of starch and lowest crude protein and fat contents, foaming capacity and water solubility index (Amon *et al.*, 2011).

MATERIALS AND METHODS

Collection and preparation of Taro corm

The Taro *(Colocasia esculenta)* was purchased from local Supermarket at Masabtank, Hyderabad Telangana state. The Taro is cleaned by running tap water to remove dirt and extraneous matter and then peeled by using normal kitchen peeler and then cut into uniform size cubes.

Preparation of Tutti Fruity from Taro corms

Preparation of the Tutti Fruity from the Taro is carried out by the method described by [5] with some modifications. 100gms of chopped Taro cubes were taken in pre-washed, sanitized, clean and pre-weighed stainless steel vessel and undergone different treatments at different concentrations with tamarind pulp and salt solution.

Samples(1a,1b,1c,1d,1e,1f,1g,1h,1i) blanched at 90˚C for 3mins with Tamarind pulp at concentrations of 5%(1a), 10%(1b), 15%(1c), 20%(1d), 25%(1e), 30%(1f), 40%(1g), 50%(1h), 60%(1i) and sample(1j) blanched in water at 90˚C for 3mins.Samples (2a,2b,2c,2d) boiled at 100˚C for 60mins with Tamarind pulp at concentrations of 30%(2a), 40%(2b), 50%(2c), 60%(2d) and Sample(2e) boiled in Water at 100˚C for 60mins. Samples (3a,3b) boiled at 100˚C for 30mins with Salt solution at concentrations of 2.5%(3a), 5%(3b) and samples(3c,3d) boiled at 100˚C for 60mins with Salt solution at concentrations of 2.5%(3c), 5%(3d). Each Sample was composed of 100gms of Taro cubes. Specific amounts of Tamarind and Salt was suspended in water and mixed.

Blanching of Taro cubes is to prevent enzymatic browning and to determine the presence of itching when treated with Tamarind pulp at different concentrations as well as boiling with water, salt solution and tamarind pulp. After every treatment, Taro cubes are removed from the heat and let it stand in the stainless steel vessel for 5mins to cool the water or solution to 60˚C, drained the cubes and then dipped in cold water to remove hindrance of tamarind and salt stick on the surface of the cubes. The cubes are then immersed in sugar syrup made from water and sugar with 70% by weight of the cubes. The sugar syrup concentration made up to 75° Brix from an initial of 60° Brix by using digital Refractometer, the heating is done on low medium flame to get desired degree Brix. After the final degree Brix, the sugar syrup removed from the heat and cooled. To this syrup 0.5gms red colour (1ppm as per FSSA act) added and mixed. The sugar syrup with Taro cubes is kept for around 12-24 hours so that the sugar syrup totally absorbed by the cubes, after that Taro cubes drained from the syrup and spread over a Tray and dried at 60˚C in a tray drier for 10-20 minutes, cooled and packed in polythene bag.

Table 3: Step1 (Blanching with Tamarind pulp and Water at 90˚C for 3mins).

Sample 1	Treated with	Concentration	Method applied
a	Tamarind Pulp	5%	Blanching at 90˚C for 3mins
b	Tamarind Pulp	10%	Blanching at 90˚C for 3mins
c	Tamarind Pulp	15%	Blanching at 90˚C for 3mins
d	Tamarind Pulp	20%	Blanching at 90˚C for 3mins
e	Tamarind Pulp	25%	Blanching at 90˚C for 3mins
f	Tamarind Pulp	30%	Blanching at 90˚C for 3mins
g	Tamarind Pulp	40%	Blanching at 90˚C for 3mins
h	Tamarind Pulp	50%	Blanching at 90˚C for 3mins
i	Tamarind Pulp	60%	Blanching at 90˚C for 3mins
j	Water	100%	Blanching at 90˚C for 3mins

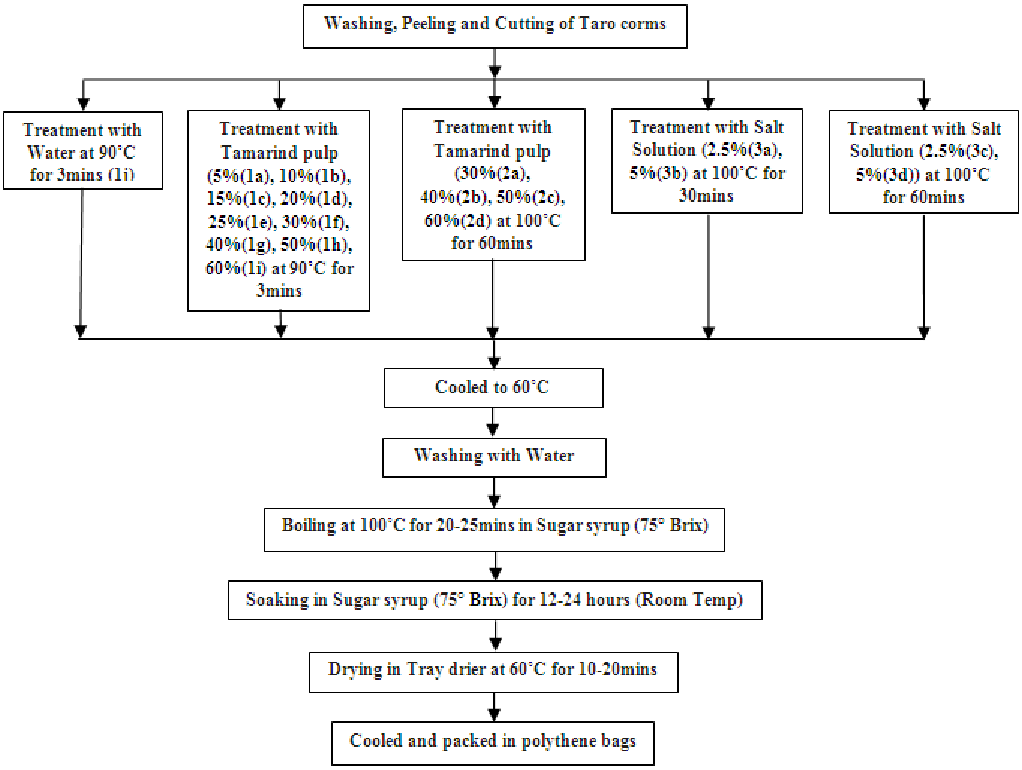
Table 4: Step2 (Boiling in Tamarind pulp and Water at 100˚C for 60mins).

Sample 2	Treated with	Concentration	Method applied
a	Tamarind Pulp	30%	Boiling at 100˚C for 60mins
b	Tamarind Pulp	40%	Boiling at 100˚C for 60mins
c	Tamarind Pulp	50%	Boiling at 100˚C for 60mins
d	Tamarind Pulp	60%	Boiling at 100˚C for 60mins
e	Water	100%	Boiling at 100˚C for 60mins

Table 5: Step3 (Boiling in Salt solution at 100˚C for 30mins and 60mins).

Sample 3	Treated with	Concentration	Method applied
a	Salt Solution	2.5%	Boiling at 100˚C for 30mins
b	Salt Solution	5%	Boiling at 100˚C for 30mins
c	Salt Solution	2.5%	Boiling at 100˚C for 60mins
d	Salt Solution	5%	Boiling at 100˚C for 60mins

The process flow chart as follows



Sensory evaluation

Samples were served in the sealed and closely packed polythene pouches. The pouches were labelled with alphabetical order for each sample codes. Panelists were provided with evaluation card and coded samples.The order of presentation of the samples along with control sample was randomized across subjects. Subjects judged a maximum of 10 samples in first session, in second session 5 samples and in third session 4 samples were presented. The sensory panel n=30 (untrained) was composed of 25 under graduate students and 5 non teaching members working in the institution.

Each participant evaluated all 20 Tutti Fruity samples (1a to 1j, 2a to 2e and 3a to 3d) including Control sample to rate the sensory attributes of flavour, texture, taste, appearance, presence of itching and overall acceptability using a 9 - point hedonic scale suggested by Ranganna *et al.*,(2001): 9-like extremely, 8-like Very Much, 7-Like moderately, 6-Like slightly, 5-Neither like or dislike, 4-Dislike Slightly, 3-Dislike Moderately, 2-Dislike Very Much, 1-Dislike Extremely. Groups of 30 panellists were used in every instant for the sensory evaluation exercise. Necessary precautions were taken to prevent carryover of presence of itching during the test by ensuring that panellists rinsed their mouth properly with clean drinking water after evaluating each Tutti Fruity.

Fig 2: Control sample.

Fig 3: Samples of Step 1. (Blanching in Tamarind pulp and Water at 90^{o}C for 3mins)

Fig 4: Samples of Step 2. (Boiling in Tamarind pulp and Water at 100^{o}C for 60mins)

Fig 5: Samples of Step 3. (Boiling in Salt solution at 100^{o}C for 30mins and 60mins)

Ranking test using Fiducial limits

Experimental data were analyzed by ranking method and fiducial limits were used to compare the mean of the control sample with all the samples. Comparisons among samples were analyzed using the ranking method and the significant differences among samples means were determined using fiducial limits at $p \leq 0.05$. Fiducial limits test was used for mean separation and the results were expressed as mean ± standard deviation.

RESULTS

The result of the Taro Tutti Fruity made from different samples by different steps is shown in Tables of Mean value of all samples, Rank of all samples and the fiducial limits of control sample to determine the significance. Pie chart represents mean value of all samples and Bar graph represents rank of all samples.The fiducial limits test shows that after determining fiducial limits of control sample, Sample 2d (boiled at 100^{o}C for 60mins with 60% concentration of Tamarind pulp) is significantly superior at 1% ($p<0.01$) level compared to all samples. This shows that boiling of Taro corms in 60% concentration of tamarind pulp reduces the itching by removing the raphides (needle like crystals of calcium oxalate). Therefore it can be concluded that the raphides of calcium oxalate which leads to itching can be reduced by prolonged boiling of Taro corms with different concentrations of tamarind pulp and is the most appropriate time and concentration to reduce itching after consumption of Taro corms.

DISCUSSION

The need to improve the value of roots especially those are underutilised, like Taro is timely in recognition that local roots are the basis for the diets. Hence the need to explore various options for extending the Taro uses.

Product development is the key to increase root crop consumption in general and Taro in particular. Taro is a particularly suitable raw material for product development since it is bland and essentially without color.

In the light of the above, the Taro corm processed with different methods was determined in order to ascertain its suitability and acceptability in making Tutti Fruity. The overall acceptability of Taro Tutti Fruity is compared with the commercially available or papaya Tutti Fruity.

Table 6: Sensory evaluation of Taro Tutti Fruity (Mean ± Standard deviation).

S.No	Samples	Flavour	Texture	Taste	Appearance	Presence of itching yes/no	Overall Acceptability
1	Control	1.5±0.5	1.4±0.5	1.4±0.5	1.43±0.5	30no	1.4±0.5
2	1a	4.3±1.34	3.97±1.15	3.83±1.11	4.1±1.24	3no-27yes	3.93±1.37
3	1b	4.1±1.32	4.37±1.32	3.57±1.38	4.1±1.24	21no-9yes	4.23±1.1
4	1c	4.23±1.04	4.83±0.95	4.2±1.4	4.57±1	12no-18yes	4.73±1.52
5	1d	4.87±1.04	4.6±1	4.17±1.53	4.13±1.33	7no-23yes	4.47±1.3
6	1e	4.17±1.6	5.77±1.7	4.03±1.32	4.73±1.31	18no-12yes	4.37±1.2

7	1f	4.27±1.08	5.47±2.11	4.17±1.26	4.7±1.44	10no-20yes	5.2±1.6
8	1g	4.33±1.12	5.83±1.7	4.03±1.27	4.9±1.42	10no-20yes	4.97±1.54
9	1h	3.93±0.8	4.33±1.5	3.73±1.3	4.43±0.93	6no-24yes	4.6±1.3
10	1i	1.9±0.71	1.77±0.72	1.9±0.75	1.83±0.7	25no-5yes	1.63±0.7
11	1j	3.97±1.21	4.4±1.19	4±0.8	3.47±1	30yes	4.67±1.3
12	2a	2.7±0.74	3.4±1.1	1.73±0.94	2.67±0.92	30yes	3.37±1.03
13	2b	2.43±0.9	2.13±0.9	1.83±0.8	2.8±1	18no-12y	3.6±1.03
14	2c	2.37±0.8	2.83±0.91	2.73±0.9	3.37±1.12	8no-22yes	3.17±0.94
15	2d	1.8±0.61	1.7±0.7	1.83±0.7	2.17±0.65	26no-4yes	1.57±0.6
16	2e	2.1 ± 0.9	3.4 ± 1.16	2.03 ± 0.71	3.73 ± 0.8	23no-7yes	1.67 ± 0.71
17	3a	8.6±0.81	4.93±1.4	8.83±0.74	4.6±1	30yes	8.13±1.43
18	3b	8.63±0.8	4.77±2.2	8.83±0.74	4.87±1.13	30yes	7.9±1.42
19	3c	8.73±0.94	4.6±2.04	8.8±0.8	4.87±1.75	1no-29yes	7.97±1.42
20	3d	8.67±1.12	4.83±1.05	8.73±0.94	4.67±1.06	30yes	7.6±1.92

Table 8: Mean value of all samples in terms of Overall acceptability parameter by Sensory evaluation.

S. No	Sample	Mean
1	Control	1.37
2	1a	3.93
3	1b	4.23
4	1c	4.73
5	1d	4.47
6	1e	4.37
7	1f	5.2
8	1g	4.97
9	1h	4.6
10	1i	1.63
11	1j	4.67
12	2a	3.37
13	2b	3.6
14	2c	3.17
15	2d	1.57
16	2e	1.67
17	3a	8.13
18	3b	7.9
19	3c	7.97
20	3d	7.6

Pie chart for mean value of all samples in terms of Overall acceptability parameter by Sensory evaluation

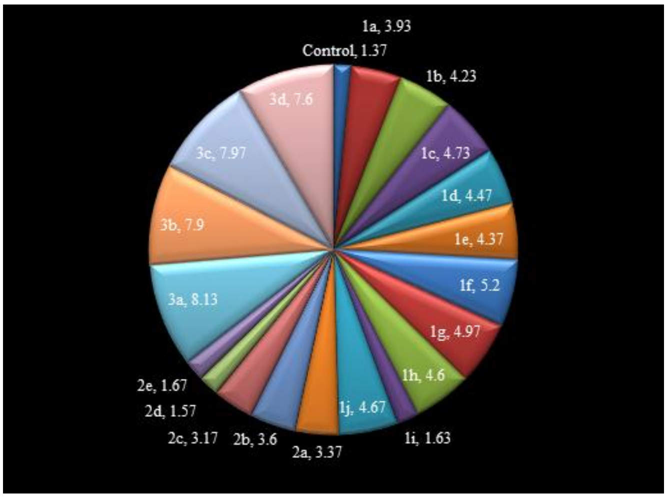
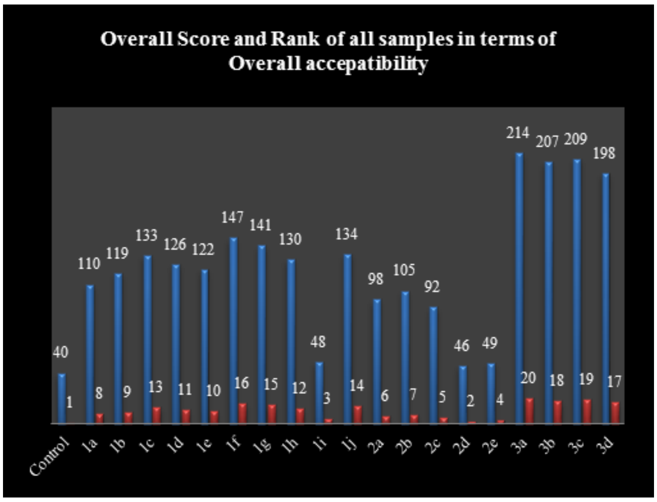


Table 9: Overall Score and Rank of all samples in terms of Overall acceptability by Sensory evaluation.

S. No	Sample	Overall Score	Rank
1	Control	40	1
2	1a	110	8
3	1b	119	9
4	1c	133	13
5	1d	126	11
6	1e	122	10
7	1f	147	16
8	1g	141	15
9	1h	130	12
10	1i	48	3
11	1j	134	14
12	2a	98	6
13	2b	105	7
14	2c	92	5
15	2d	46	2
16	2e	49	4
17	3a	214	20
18	3b	207	18
19	3c	209	19
20	3d	198	17

Bar graph for Overall Rank of all samples in terms of Overall acceptability parameter by Sensory evaluation



CONCLUSIONS

This study shows that the Tutti Fruity made from sample 2d (60% concentration of Tamarind pulp boiled at 100^{o}C for 60mins) is similar to that of market or commercial Tutti Fruity and panellist found that there was no itching after consumption of sample 2d. Also, Tutti Fruity made from sample 1i (60% concentration of Tamarind pulp blanched at 90^{o}C for 3mins) is acceptable by panel members. Hence the use of Taro Tutti Fruity should be further explored and used in used in Cakes, Bun, Muffins, Cookies, Bread, and Custard & Ice-Cream. This will extend as well as increase the utilisation options for this underutilised tuber beyond its current basic use. This diversification in the value chain for Taro can also become an increased source of income for Taro farmers and processors.

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