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Study on nutritional quality of aerial yam flour

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Abstract
An experiment entitled "Study On Nutritional Quality Of Aerial Yam Flour" was carried out during year 2021-2022 at Post Harvest Technology Laboratory, Horticulture section, College of Agriculture, Nagpur with the experiment, that was laid out in Factorial Completely Randomized Design (FCRD), with two factors, as factor A Soaking pre-treatments *viz.*, T_1 (2% Ascorbic acid), T_2 (4% Ascorbic acid), T_3 (0.5% Citric acid), T_4 (1.0% Citric acid), T_5 (2% Ascorbic acid+ 0.5% Citric acid), T_6 (2% Ascorbic acid + 1.0% Citric acid), T_7 (4% Ascorbic acid + 0.5% Citric acid), T_8 (4% Ascorbic acid + 1.0% Citric acid) and factor B drying methods *viz.*, D_1 (Sun-drying), D_2 (Cabinet tray-drying) with 16 treatment combinations and replicated in thrice. The observations in respect of nutritional analysis of aerial yam flour were recorded from periodically at an interval of 30 days. From the findings, it was observed that, there was a gradual increase in moisture and total soluble solids content of aerial yam flour irrespective of soaking pre-treatments and drying methods used in experimentation. However, ash, protein, crude fibre, fat, carbohydrate and ascorbic acid content of aerial yam flour found to decreased with advancement of storage period.

Keywords: Aerial yam, *Dioscorea bulbifera* L., Cabinet tray drying, Sun drying

Introduction

Aerial yam (*Dioscorea bulbifera* L.) is commonly called as air potato yam or bitter yam. This bulbils bearing yam belongs to the family Dioscoreaceae is unpopular amongst the edible yam species. It is native to tropical Asia and sub-Saharan Africa (Martin, 1974) [8]. About 50 species of Dioscorea are found in India. Their tubers are used by the tribal population of central India as food particularly in Madhya Pradesh, Chhattisgarh, Jharkhand and Orissa (Subasini *et al.*, 2013) [20]. In Maharashtra it is grown as a minor vegetable crop of bulbous group in high rainfall area of Konkan and eastern Vidharbha zone (EVZ). The bulbils are very dark brown in colour and their skin is covered with many wart like rough protuberances. Aerial yam produces large numbers of aerial tubers, potato like growths from the leaf axils. Its composition includes 63-67 percent moisture, 1.1-1.5 percent proteins, 0.04 percent fat, 0.7-1.1 percent fibre, 1.08-1.5 percent ash and 22-33 percent carbohydrates (Nwosu, 2014) [11]. It is a good source of calories and minerals such as iron, calcium and phosphorous (Tindall, 1983) [21]. "Diosgenin" is pharmacologically active component of aerial yam obtained from root and rhizomes which is one of the most costly and important steroidal drug used worldwide for manufacturing of birth control pills and other steroidal formulations (Sharma, 2004) [17]. Aerial yam has been traditionally used to lower glycemic index, thus providing a more sustained form of energy and better protection against obesity and diabetes (Chandra *et al.*, 2012) [5]. Bulbs are used in India to treat piles, dysentery, and syphilis and are applied to ulcers, pain and inflammation (Gupta and Singh, 1976) [6]. The tubers of *D. bulbifera* were used by different tribal communities for intestinal colic problem, relieving dysmenorrhoea, reducing acidity, against rheumatoid arthritis, to relieve intense inflammation, in spasmodic asthma, for menopausal problems, for labor pain and the prevention of early miscarriage and to check diarrhea (Nayak *et al.*, 2004; Bhogaonkar and Kadam, 2006) [10, 4]. Apart from this the most important is nearly all local and tribal communities use the aerial tubers as source of nutrition, especially in food crises and as nutritional aid to regular diet.

The bitterness of aerial yam is due to the compound diosgenin. One cannot consume it raw due to its acridity, but if it is processed and treated chemically one may easily consume it. Because of its high moisture content and high respiration rate, yam is highly perishable. Post harvest losses of yam have been reported to range from 10-50 percent. Yam tubers are usually stored under ambient tropical condition and changes in wholesomeness occurs under such conditions. Diseases and pests infestations during storage also leads to spoilage. Aerial yam flour is very evident in Africa and is used in the production of pounded yam, etc. Flour prepared from aerial yam bulbs has the potential for application in the bakery industry with minimal processing. One potential challenge in yam flour production is the discolouration and darkening of the final product (Akubor, 2013) [1]. This has been attributed to enzymatic reaction due to the presence of water-soluble phenolic substances in yam. Many approaches have been utilized in preventing the discolouration during processing of flour. Some of these are lowering of pH and use of antioxidants like ascorbic acid and citric acid. Some of the antioxidants inhibit browning, this however result in loss of nutrients. Therefore, investigation into the nutritional characteristics of the aerial yam is essential.

Materials and Methods

Aerial yam bulbs were procured from the local market of Gadchiroli, Maharashtra. The aerial yam bulbs were then washed with clean water to remove adhering soil and other undesirable material. The yam bulbs then sorted and hand-peeled using kitchen knife and sliced into sizes of 2 to 3mm in thickness. The slices were soaked in different solutions of Ascorbic acid and Citric acid according to the treatments for 20 mins. after peeling to avoid enzymatic browning and also to remove the bitter compound from the sliced samples. Half of the slices of every treatment samples were subsequently dried in open sun drying condition for 3 days (Pallavi *et al.*, 2016) [13] and half of the slices were dried in tray dryer at 55^0C for 24 hrs. (Singh *et al.*, 2008) [18]. The dried yam slices were milled using locally fabricated hammer mill and screened through 1mm sieve to obtain the powdery yam flour and then packed in HDPE bags and stored in ambient storage condition.

Nutritional analysis of aerial yam flour

The chemical observations were recorded at every 30 days interval upto 90 days. Changes in nutritional composition in terms of moisture, ash, protein, crude fibre, fat, carbohydrate, total soluble solids and ascorbic acid contents of aerial yam flour were determined as per method mentioned by the Association of official Analytical Chemists (1995) [2].

Determination of Moisture

Oven drying method (at 105^0 C for 6 hours) was used to determine the moisture content of the samples.

Determination of Ash

The ash content was determined by ashing in muffle furnace (600^0 C for 6 hours).

Determination of Protein

The protein (N x 6.25) content of the samples was determined by the Kjeldhal method.

Determination of Crude fibre

The crude fibre content was determined by method described by Ranganna (1986) [15].

Determination of Fat

The fat content was determined by the ether extraction using Soxhlet’s apparatus.

Determination of Carbohydrate

Carbohydrate content was determined by substracting the moisture, ash, protein, crude fibre, fat content from 100.

Determination of Total soluble solids

Total soluble solids were determined with help of digital refractometer using Atago RX 1000 digital Refractometer.

Determination of Ascorbic acid

Ascorbic acid content was determined by the titration method described by Ranganna (1986) [15].

Each experiment was repeated in triplicate. The statistical analysis of the data was done by the method described by Panse and Sukhatme (1985) [14] using F.C.R.D. factorial experiment.

Results and Discussion

Moisture Content

The data representing interaction effect of different pre-treatments and drying methods on moisture content of aerial yam flour at ambient storage condition are presented in Table 1 and showed a trend of gradual increase in moisture content throughout the storage period. An interaction effect of different pre-treatments and drying methods on moisture content of aerial yam flour was found to be significant at 30, 60 and 90 days. At 0 day of storage, non-significant differences were recorded. At 30 days of storage, minimum moisture content was recorded in T_3D_2 (8.13%). At 90 days of storage, minimum moisture content was recorded in treatment T_3D_2 (8.36%) and was found significantly superior to all other treatment and maximum in treatment T_2D_1 (11.26%). The increasing trend might be due to gain of moisture by the flour from the atmosphere. Similar results were also observed by Jethva *et al.* (2016) [7] in sweet potato flour and Mittal *et al.* (2019) [9] in pumpkin flour. The gain of moisture was lowest in T_3D_2 i.e., pre-treatment of 0.5% citric acid + cabinet tray drying. Similar results were also observed by Sruthy *et al.* (2020) [19] in banana flour.

Ash Content

The data representing the interaction effect of different pre-treatments and drying methods on ash content of aerial yam flour at ambient storage condition are presented in Table 1. The combine effect of different pre-treatments and drying methods on ash content of aerial yam flour was found non-significant at all stages of observation from 0 day of storage upto the 90th day of storage.

Protein content

The data regarding the interaction effect of different pre-treatments and drying methods on protein content of aerial yam flour are presented in Table 1. An interaction effect of different pre-treatments and drying methods on protein content of aerial yam flour was found to be significant at 30,60 and 90 days. At 0 days of storage, non-significant differences were recorded. At 30 days of storage, maximum protein content was recorded in treatment T_3D_2 (5.51%) and minimum protein content in treatment T_1D_1 (2.82%). At 90 days of storage, protein content of aerial yam flour was maximum in treatment T_3D_2 (5.49%) and minimum in treatment T_1D_1 (2.77%). The decrease in protein content in aerial yam flour with an increase in storage period might be due to denaturation and breakdown into smaller peptides and thus leaching out of nitrogenous compounds due to pre-treatments. Similar results were also registered by Mittal *et al.* (2019) [9] in pumpkin flour and Ogbonnaya and Lawal (2015) [12] in yam flour. The progressive decrease in protein content was notified in all the samples. However, maximum protein content was observed in T_3D_2 *i.e.*, pre-treatment of 0.5% citric acid + cabinet tray drying. Similar results were also observed by Sruthy *et al.* (2020) [19] in banana flour.

Crude fibre content: The data representing interaction effect of different pre-treatments and drying methods on crude fibre content of aerial yam flour are presented in Table 1. An interaction effects of different pre-treatments and drying methods on crude fibre content of aerial yam flour was found to be non-significant at 0, 30, 60 and 90 days of storage.

Table 1: Interaction effect of different pre-treatments and drying methods on nutritional characters of aerial yam flour during storage

Treatments	Moisture (%)				Ash (%)				Protein (%)				Crude fibre (%)			
	0	**30**	**60**	**90**	**0**	**30**	**60**	**90**	**0**	**30**	**60**	**90**	**0**	**30**	**60**	**90**
T_1D_1	8.94	10.80	10.94	11.03	0.91	0.89	0.87	0.86	3.95	2.82	2.80	2.77	0.54	0.51	0.49	0.47
T_1D_2	8.81	10.24	10.34	10.42	1.00	0.97	0.93	0.94	4.27	3.82	3.81	3.79	0.62	0.60	0.59	0.58
T_2D_1	8.98	10.99	11.12	11.26	0.99	0.96	0.95	0.93	4.21	3.18	3.16	3.13	0.79	0.76	0.74	0.72
T_2D_1	8.87	10.35	10.48	10.59	1.10	1.09	1.05	1.04	4.33	3.97	3.96	3.94	0.88	0.86	0.85	0.84
T_3D_1	8.27	8.47	8.53	8.72	1.64	1.59	1.57	1.57	5.25	5.24	5.23	5.19	1.68	1.65	1.62	1.61
T_3D_2	8.03	8.13	8.28	8.36	1.73	1.71	1.69	1.68	5.54	5.51	5.50	5.49	1.76	1.75	1.74	1.72
T_4D_1	8.60	9.65	9.83	9.97	1.31	1.28	1.27	1.26	4.52	4.51	4.49	4.46	1.25	1.23	1.20	1.18
T_4D_2	8.38	8.85	8.97	9.07	1.44	1.42	1.40	1.39	5.20	5.18	5.17	5.15	1.37	1.35	1.34	1.33
T_5D_1	8.82	10.27	10.40	10.52	1.14	1.13	1.12	1.09	4.37	4.04	4.02	3.99	0.96	0.93	0.90	0.89
T_5D_2	8.66	10.05	10.19	10.31	1.26	1.23	1.22	1.20	4.78	4.76	4.74	4.73	1.05	1.04	1.02	1.01
T_6D_1	8.52	9.44	9.62	9.74	1.24	1.21	1.19	1.20	4.27	4.26	4.24	4.21	1.17	1.14	1.13	1.11
T_6D_2	8.45	8.98	9.14	9.28	1.35	1.32	1.31	1.30	4.97	4.95	4.94	4.92	1.26	1.25	1.23	1.22
T_7D_1	8.27	8.43	8.51	8.58	1.53	1.52	1.47	1.46	4.99	4.98	4.96	4.93	1.60	1.57	1.55	1.53
T_7D_2	8.19	8.30	8.42	8.51	1.63	1.61	1.59	1.57	5.32	5.30	5.28	5.27	1.68	1.66	1.65	1.64
T_8D_1	8.34	8.67	8.82	8.96	1.41	1.40	1.39	1.38	4.84	4.83	4.81	4.78	1.45	1.41	1.39	1.38
T_8D_2	8.29	8.60	8.71	8.78	1.53	1.49	1.47	1.45	5.24	5.22	5.20	5.19	1.54	1.52	1.51	1.50
CD (5%)	-	0.06	0.14	0.11	-	-	-	-	-	0.09	0.09	0.09	-	-	-	-

Fat content: The data representing interaction effect of different pre-treatments and drying methods on fat content of aerial yam flour are presented in Table 2. An interaction effect of different pre-treatments and drying methods on fat content of aerial yam flour was found to be non-significant at all stages of observations from 0 day to 90 days of storage.

Carbohydrate content

The data regarding the interaction effect of different pre-treatments and drying methods on carbohydrate content of aerial yam flour are presented in Table 2. An interaction effect of different pre-treatments and drying methods on carbohydrate content of aerial yam flour was found to be significant at 0, 30, 60 and 90 days. At 0 days of storage maximum carbohydrate content was recorded in treatment T_1D_1 (84.84%) and minimum carbohydrate content in treatment T_3D_2 (81.42%). After 90 days of storage, carbohydrate content of aerial yam flour was maximum in treatment T_1D_1 (84.11%) and minimum in treatment T_3D_2 (81.27%). The decrease in carbohydrate content in aerial yam flour with an increase in storage period might be due to increase in moisture content and production of enzyme amylases that catalyze biochemical reactions which breakdown carbohydrates in food. The progressive decrease in carbohydrate content was notified in all the samples. Similar results were also obtained by Arinola *et al.* (2016) [3] in plantain flour.

Total soluble solids

The data pertaining to the interaction effect in respect of total soluble solids content of aerial yam flour as influenced by different pre-treatments and drying methods at ambient storage condition was recorded upto 90 days of storage and presented in Table 2. The combine effect of different pre-treatments and drying methods on total soluble solids content of aerial yam flour was found to be non-significant at all stages of observations from 0 days of storage upto the 90th day of storage.

Ascorbic acid

The data pertaining the interaction effects of different pre-treatments and drying methods on ascorbic acid content of aerial yam flour are presented in Table 2. An interaction effect of different pre-treatments and drying methods on ascorbic acid content of aerial yam flour was found to be significant at 30, 60 and 90 days of storage. At 0 days of storage, non-significant differences were recorded. At 30 days of storage maximum ascorbic acid was found in treatment T_3D_2 (17.86mg/100g) and found significantly superior to all other treatment. At the end of 90 days of storage maximum ascorbic acid was found in treatment T_3D_2 (16.62mg/100g) and minimum ascorbic acids was recorded in T_1D_1 (6.05mg/100g). The decrease in ascorbic acid content in aerial yam flour with an increase in storage period might be due to degradation of ascorbic acid to dehydro ascorbic acid by oxidative enzyme. The progressive decrease in ascorbic acid content was notified in all the samples. Similar results were also obtained by Sahoo *et al.* (2015) [16], Vithu *et al.* (2021) [22] in banana flour.

Table 2: Interaction effect of different pre-treatments and drying methods on nutritional characters of aerial yam flour during storage

Treatments	Fat (%)				Carbohydrate (%)				Total soluble solids (ºB)				Ascorbic acid (mg/100g)			
	0	30	60	90	0	30	60	90	0	30	60	90	0	30	60	90
T_1D_1	0.82	0.79	0.77	0.76	84.84	84.19	84.12	84.11	3.78	3.85	3.92	4.00	8.32	7.48	6.73	6.05
T_1D_2	0.88	0.86	0.85	0.84	84.42	83.51	83.48	83.42	4.00	4.08	4.15	4.23	8.51	8.31	7.01	6.40
T_2D_1	0.87	0.84	0.83	0.81	84.16	83.26	83.20	83.16	3.99	4.06	4.13	4.21	9.52	8.68	7.93	7.25
T_2D_1	0.92	0.90	0.89	0.88	83.90	82.84	82.78	82.69	4.21	4.29	4.36	4.44	9.74	8.87	8.22	7.61
T_3D_1	1.47	1.45	1.42	1.41	81.69	81.61	81.42	80.37	5.60	5.66	5.74	5.82	18.60	17.68	16.93	16.25
T_3D_2	1.52	1.51	1.49	1.48	81.42	81.39	81.31	81.27	6.03	6.09	6.15	6.23	18.71	17.86	17.21	16.62
T_4D_1	1.19	1.16	1.14	1.13	83.13	82.17	82.07	81.99	4.49	4.55	4.62	4.70	13.75	12.93	12.18	11.50
T_4D_2	1.25	1.23	1.22	1.21	82.36	81.97	81.90	81.85	4.71	4.78	4.86	4.93	14.01	13.16	12.51	11.92
T_5D_1	1.03	1.02	1.01	0.97	83.68	82.61	82.56	82.53	4.99	5.05	5.12	5.20	9.75	8.93	8.18	7.50
T_5D_2	1.09	1.07	1.06	1.05	83.16	81.85	81.69	81.68	5.21	5.28	5.34	5.42	10.03	9.16	8.51	7.90
T_6D_1	1.13	1.11	1.09	1.07	83.67	82.85	82.73	82.66	3.49	3.56	3.64	3.72	12.04	11.17	10.43	9.75
T_6D_2	1.19	1.18	1.17	1.15	82.78	82.32	82.20	82.12	3.70	3.77	3.83	3.91	12.21	11.37	10.72	10.11
T_7D_1	1.42	1.40	1.38	1.36	82.19	82.10	82.08	81.99	4.58	4.66	4.73	4.81	15.77	14.93	14.18	13.50
T_7D_2	1.48	1.46	1.45	1.44	81.70	81.66	81.56	81.53	4.81	4.88	4.96	5.04	16.06	15.22	14.57	13.96
T_8D_1	1.32	1.29	1.27	1.26	1.32	1.29	1.27	1.26	5.50	5.56	5.63	5.71	15.81	14.97	14.21	13.50
T_8D_2	1.39	1.38	1.37	1.35	1.39	1.38	1.37	1.35	5.81	5.89	5.97	6.05	16.13	15.28	14.63	14.02
CD (5%)	-	-	-	-	0.15	0.24	0.31	0.31	-	-	-	-	-	0.07	0.07	0.08

All values are mean ± SEM of three replicates.

The test values along the same column carrying different superscripts for each composition contents are significantly different ($p<0.05$) within days.

T_1 D_1 (2% Ascorbic acid+ Sun drying), T_1 D_2 (2% Ascorbic acid+ Cabinet Tray drying), T_2 D_1 (4% Ascorbic acid + Sun drying), T_2 D_2 (4% Ascorbic acid + Cabinet Tray drying), T_3 D_1 (0.5% Citric acid+ Sun drying), T_3 D_2 (0.5% Citric acid + Cabinet Tray drying), T_4 D_1 (1.0% Citric acid + Sun drying), T_4 D_2 (1.0% Citric acid + Cabinet Tray drying), T_5 D_1 (2% Ascorbic acid+ 0.5% Citric acid + Sun drying), T_5 D_2 (2% Ascorbic acid+ 0.5% Citric acid + Cabinet Tray drying), T_6 D_1 (2% Ascorbic acid+ 1.0% Citric acid + Sun drying), T_6 D_2 (2% Ascorbic acid+ 1.0% Citric acid + Cabinet Tray drying), T_7 D_1 (4% Ascorbic acid+ 0.5% Citric acid + Sun drying), T_7 D_2 (4% Ascorbic acid + 0.5% Citric acid + Cabinet Tray drying), T_8 D_1 (4% Ascorbic acid+1.0% Citric acid + Sun drying) and T_8 D_2 (4% Ascorbic acid+1.0% Citric acid + Cabinet Tray drying).

Conclusion

From the above investigation the result obtained from the study that, there was a continuous increase in the moisture and total soluble solids content of aerial yam flour with the advancement of storage period. Whereas, there was a decrease in ash, protein, crude fibre, fat and ascorbic acid content of aerial yam flour. The aerial yam flour prepared from pre-treatment with 0.5% citric acid and cabinet tray drying was found to be superior in terms of moisture, ash, fat, crude fibre, protein, carbohydrate, TSS and ascorbic acid content upto 90th days of storage. The aerial yam flour prepared from pre-treatment with 0.5% citric acid and cabinet tray drying is found with maximum consumer acceptability. The results obtained showed the feasibility of producing nutritious aerial yam flour.

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