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The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2022; SP-11(12): 797-808

www.thepharmajournal.com
Received: 04-09-2022
Accepted: 06-10-2022

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To study the changes in chemical and microbial quality parameters of aerial yam (*Dioscorea bulbifera*) cookies during storage

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Abstract
An investigation entitled, To study the "changes in chemical and microbial quality parameters of aerial yam (*Dioscorea bulbifera*) cookies during storage" was undertaken at the Department of Fruit, Vegetable and Flower Crops, Faculty of Post-Harvest Management, Dr. B.S. Konkan Krishi Vidyapeeth, Dapoli, District Ratnagiri, during the year 2017-2018. The study aimed to standardize the recipe for the aerial yam cookies from aerial yam flour and to study the storage behaviour of aerial yam cookies at ambient conditions. For this experiment, the Factorial Completely Randomized Design (F.C.R.D.) was used. The experiment was carried out with five treatments comprising of different proportions of aerial yam flour and maida i.e. 0:100, 20:80, 30:70, 40:60, 50:50 in the aerial yam cookies and the product was analysed for chemical and biological qualities initially and during 10, 20 and 30 days of storage. The present study revealed that all the chemical parameters except moisture and reducing sugars, all other chemical parameters such as TSS, titrable acidity, total sugars, ash, crude fat and crude fiber content exhibited a decreasing trend during storage period of 30 days at ambient condition. From the results of present studies, it can be concluded that the aerial yam cookies could be stored up to 30 days at ambient condition, when packed in 400 gauge low density polyethylene (LDEP). Based on the chemical qualities and economics, the aerial yam cookies could be prepared by using 20 per cent aerial yam flour level with higher overall acceptability.

Keywords: Aerial yam, cookies, chemical, microbial qualities and storage, etc.

1. Introduction

Aerial yam *(Dioscorea bulbifera),* also known as air potatoes, is a member of the yam species often considered as a wild species of yam native to Africa and Asia. It is one of the most widely spread yams across the world. Unlike traditional yam, bitter yam produces aerial bulbs, which look like potatoes.

West-Africa and parts of East, Central and Southern Africa (FAO, 1999) are the primary cultivation areas, producing about 95 percent of the world yam production, followed by Southeast Asia including China, Japan and Oceania. Only a few species of yams are cultivated as food crops. Yam is an excellent source of starch, which provides caloric energy (Coursey, 1973). *Dioscorea bulbifera* is available in two varieties, the edible and non-edible. The edible varieties are cultivated and widely distributed in West Africa, West Indies, South Pacific, and South East Asia (FAO, 1985; Survey, 2012). *Dioscorea bulbifera* is among the most important tuber crops in West Africa. It is included in the roots and tubers, which are widely distributed throughout the tropics with only a few in the temperate regions of the world (Coursey, 1967; FAO, 1996). The bulbils of aerial yam have a hard skin which is peeled off after cooking. Commercial development of aerial yam is almost nonexistent, perhaps because the plant is only known in remote, normally poverty-stricken areas. Even though there are limitations on the quantities of aerial yam, an advantage is that the bulbs have long shelf life and can be kept almost indefinitely (Mbaya *et al*., 2013).

Aerial yam has been discovered to be of nutritional and medicinal importance. It is rich in protein, fibres and minerals. They are very good for traditional folk medicine (Onwueme, 1978; Walter, 2010) [20, 37]. Yet, it is not a staple food, and it is not relevant in food industries. The chemical composition of aerial yam includes moisture which ranges from 63 to 67 per cent, 1-12 to 1.5per cent protein, 0.04per cent fat, 0.70 to 1.0per cent fibre, 1.08 to 1.5per cent ash and carbohydrates varying from 22 to 33 per cent which constitute the bulk of the dry matter content of the aerial yam. It also contains toxic substance such as dioscorine and saponin which can be destroyed during processing (Iwuoha and Nwakanma, 2002) [12].

The *Dioscorea bulbifera* can be prepared and processed into edible food by boiling, frying or roasting or eaten as cooked vegetables as the case may be. Aerial yam can be made into paste after boiling and eaten with soup or canned as well be processed into various forms such as crisps and chips or flakes (Degras, 1993).

Baking Industry is considered as one of the major segments of food processing in India. Baked products are gaining popularity because of their availability, ready to eat convenience and reasonably good shelf life (Vijayakumar, *et al*., 2013) [34]. Among different bakery products, cookies constitute the most popular group. Cookies were first invented as a food. They could be kept for a long time because they are a dry food product. These are an important food product used as snacks by children and adults (Dhankar, 2013) [8].

The aerial yam can be processed into powder form which may be utilized in the preparation of value added product such as cookies. Hence, to explore the utilization of aerial yam powder for cookies making the present study undertaken with the mentioned objective.

2. Material and Method

The material used and the different methods adopted for preparation and analysis are discussed in this chapter.

2.1 Experimental material

The aerial yam tubers required for conducting research were procured from the farm of Central Experiment Station, Wakawali, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, and Dapoli. The fresh, mature tubers were selected and brought to laboratory for conducting the research.

Other ingredients such as refined wheat flour, sugar, fat (Dalda), baking powder as well as 400 guage LDPE bags were procured form local market, Roha.

2.1.1 Experimental details

1. Crop: Aerial yam (*Dioscoria bulbifera*).
2. Design: F.C.R.D.
3. Number of treatments combinations: 5 × 4= 20.
4. Replications: 4.

2.1.2 Details of treatments

The treatments comprised of 5 different proportions of *maida* and aerial yam flour in cookies and four storage periods as sub treatments.

A. Main treatment: Different proportions of *maida* and aerial yam powder

Treatments	Maida		Aerial yam powder
T_1	100	:	0
T_2	80	:	20
T_3	70	:	30
T_4	60	:	40
T_5	50	:	50

A. Sub treatments

Sub treatments		Storage period (Days)
S-1	:	0 Day
S-2	:	10 Days
S-3	:	20 Days
S-4	:	30 Days

2.2 Method

2.2.1 Preparation of aerial yam powder

2.2.1.1 Blanching of aerial yam

The aerial yam bulbils were washed with clean water to remove dust, dirt and other undesirable material. The yams were then sorted and cut into two halves. The pieces were then blanched with hot water for 60 minutes to remove the bitter compound from the slices and for easy peeling.

2.2.1.2 Grating

After blanching the yam pieces were peeled and grated manually for drying.

2.2.1.3 Cabinet drying

The grated aerial yam pulp was dried at 60 ℃ for 6 hrs.

2.2.1.4 Grinding

The dried grated yam pulp was then powdered in grinder and was sieved through 500 microns sieve to get fine powder which was used for the preparation of cookies.

2.2.1.5 Packaging

The fine aerial yam powder was then packed in 400 guage LDPE bags, which was then stored for further investigation.

2.3 Physical parameters of aerial yam powder

2.3.1 Recovery (%)

The recovery of aerial yam powder was estimated based on weight of aerial yam pulp and final weight of aerial yam powder after drying as given below.

$$\text{Recovery (\%)} = \frac{\text{Initial weight of aerial yam pulp} - \text{Final weight of aerial yam pulp after drying}}{\text{Initial weight of aerial yam pulp}} \times 100$$

2.4 Chemical parameters of aerial yam powder

The aerial yam powder was analyzed for the chemical parameters such as the moisture, T.S.S, titratable acidity, reducing and total sugars, ash, crude fat and crude fibre content by using standard procedures as stated below.

2.4.1 Moisture (%)

The moisture content was measured directly by using Contech moisture analyzer (Model CA-123) at 100 ℃ temperature and expressed as per cent moisture content on electronic display directly.

2.4.2 Total soluble solids (TSS) (°B)

Total soluble solids were determined with the help of Hand Refractometer (Atago India instruments Pvt. Ltd, Mumbai) and was expressed in ^{0}Brix.

2.4.3 Titratable acidity (%)

A known quantity of sample was titrated against 0.1 N sodium hydroxide (NAOH) solution using phenolphthalein as an indicator (A.O.A.C., 1975) [1]. The sample of known quantity with 20 ml distilled water was transferred to 100 ml volumetric flask, made up the volume and filtered. A known volume of aliquot (10 ml) was titrated against 0.1 N sodium hydroxide (NAOH) solution using phenolphthalein as an indicator (Ranganna, 2003) [25]. The results were expressed as per cent anhydrous citric acid.

$$\text{Titratable acidity (\%)} = \frac{\text{Titre reading} \times \text{Normality of alkali} \times \text{Volume make up} \times \text{Equivalent weight of acid}}{\text{weight of sample taken} \times \text{Volume of sample taken for estimation} \times 1000} \times 100$$

2.4.4 Reducing sugars (%)

The reducing sugars were determined by method of Lane and Eynon (1923) [4] as reported by Ranganna (1986) [24] as follows. Ten ml of sample was taken in 250 ml volumetric flask. To this, 100 ml of distilled water was added and the contents were neutralized by 1N sodium hydroxide. Then, 2 ml of 45 per cent lead acetate was added to it. The contents were mixed well and kept for 10 minutes and 2 ml of potassium oxalate was added to it to precipitate the excess of lead. The volume was then made to 250 ml with distilled water and solution was filtered through filter paper. This filtrate was used for determination of reducing sugars by titrating it against the boiling mixture of Fehling 'A' and Fehling 'B' (5 ml each) using methylene blue as an indicator to brick red end point. The results were expressed on per cent basis.

$$\text{Reducing sugars (\%)} = \frac{\text{Factor} \times \text{Dilution}}{\text{Titre reading} \times \text{Weight of sample taken}} \times 100$$

2.4.5. Total sugars (%)

Total sugar content was determined by method of Lane and Eynon (1923) [4] as reported by Ranganna (1986) [24] as follows. For inversion at room temperature, a 50 ml aliquot of clarified deleaded solution was transferred to 250 ml volumetric flask, to which, 10 ml of 50 per cent HCL was added and then allowed to stand at room temperature for 24 hrs. It was then neutralized with 40 per cent NaOH solution. The volume of neutralized aliquot was made to 250 ml with distilled water. This aliquot was used for determination of total sugar by titrating it against the boiling mixture of Fehling 'A' and Fehling 'B' (5 ml each) using methylene blue as an indicator to a brick red end point. The results were expressed on per cent basis.

$$\text{Total sugars (\%)} = \frac{\text{Factor X Dilution}}{\text{Titre reading X Weight of sample}} \text{X } 100$$

2.4.6 Ash (%)

The tare weight of silica dishes (7-8 cm dia) were noted and 5 g of the sample was weighed into each silica dish. The contents were ignited on a Bunsen burner and the material was ashed at not more than 525 ℃ for 4 to 6 hrs., in a muffle furnace. The dishes were cooled and weighed. The difference in weights represented the total ash content and was expressed as percentage.

$$\text{Ash (\%)} = \frac{\text{Weight of crucible with ash} - \text{Weight of crucible}}{\text{Weight of sample (g)}} \times 100$$

2.4.7 Crude fat (%)

Crude fat was estimated as crude ether extract of the dry material. The dry sample (5 g) was weighed accurately into a thimble and plugged with cotton. The thimble was then placed in a soxhlet apparatus and extracted with anhydrous ether for 3 hrs. The ether was then evaporated and the flask with the residue dried in an oven at 80 ℃ to 100 ℃, cooled in a desciccators and weighed. The content was expressed as percentage (A.O.A.C, 1975) [1].

$$\text{Crude fat (\%)} = \frac{\text{Weight of ether extract}}{\text{Weight of sample taken}} \times 100$$

2.4.8 Crude fibre (%)

About 2-5 g of moisture and fat free sample was weighed into a 500 ml beaker and a 200 ml of boiling 0.25 N sulphuric acid was added to the mixture and boiled for 30 min keeping the volume constant by addition of water at frequent intervals. The mixture was filtered through a muslin cloth and then transferred to the same beaker and 200 ml boiling 0.313 N (1.25%) NaOH was added. After boiling 30 min, the mixture was filtered through muslin cloth. The residue was washed with hot water till free from alkali, followed by washing with alcohol and ether. It was then transferred to crucible, dried overnight at 80 ℃ to 100 ℃ and weighed. The crucible was heated in muffle furnace at 525 ℃ for 2-3 hrs. Cooled and weighed again. The difference in the weights represented the weight of crude fibre, Ranganna (1986) [24].

$$\text{Crude fiber (g/100g)} = \frac{100 - (\text{Moisture} + \text{Fat}) \times \text{Weight of fibre}}{\text{Weight of sample taken (Moisture + Fat free sample)}} \times 100$$

2.5 Preparation of aerial yam powder cookies

For the preparation of cookies, the fat and sugar were weighed accurately as per treatment. The fat and sugar were creamed and creaming was continued till it became light and fluffy.

Then, the refined wheat flour and aerial yam powder was added in different proportions as per the treatments along with 0.49 per cent baking powder into creaming mass and it was thoroughly mixed to make homogenous mixture to form dough.

Cookies were then baked in oven at 180 ℃ for 25 minutes. After baking, the cookies were cooled at room temperature and then packed in 400 guage LDPE (Low Density Polyethylene) bag.

2.6 Storage behaviour

The cookies were stored at ambient conditions to study the storage behaviour of the product with respect to the changes in chemical and microbial qualities during storage. The product was evaluated immediately after preparation and at an interval of 10 days up to 30 days of storage.

2.7 Chemical parameters of aerial yam cookies

The aerial yam powder was analyzed for the moisture, TSS, titratable acidity, reducing sugars, crude fat, crude fibre and ash content by standard procedures as described in 2.4.

2.8 Microbial analysis

The microbial analysis of the aerial yam powder cookies was carried out at 0 day and after 30 days of storage as per the method described by Kiiyukia (2003) [3].

2.8.1 Bacteria

Nutrient Agar media was prepared by weighing required quantity of nutrient agar and diluted with double distilled water to known volume. The media was then autoclaved at 121 ℃ for 20 minutes. When the temperature of media reached to 40 ℃, it was used for plating.

The plating was carried out with 0.1 ml sample in sterile petri plates under the Laminar Air Flow. The sample of each treatment was taken on a separate petri plate, followed by pouring of approximately 20 ml of media (35-40 ℃) on the sample and mixing was done by tilting plate properly. Plates were sealed with para film and incubated at 37 ℃ for 48 hrs. To check bacterial count. Total microbial plate count was measured in colony forming unit/gram (cfu/g).

2.8.2 Fungi
Potato dextrose agar media was prepared for the colony count of fungi. Plates were sealed with para film and incubated at 37 ℃ and kept for 5-6 days at room temperature for fungal count. The total microbial plate count was measured in colony forming unit/gram initially and at the end of storage of period of 30 days.

2.9 Statistical analysis
The data collected on chemical parameters viz., moisture, T.S.S., acidity, sugars, crude fat, crude fiber and ash were represented as mean values. The data collected on the changes in chemical parameters and microbial count qualities of aerial yam powder cookies during storage were statistically analysed by the standard procedure given by (Panse and Sukhatme, 1985) [21] using Factorial Completely Randomized Design and valid conclusions were drawn only on significant differences between treatment mean at 0.05 per cent level of significance.

2.10 Economics of the aerial yam powder cookies
The economics of the product was worked out by considering existing rates of various inputs such as cost of raw material, labour, fuel, chemicals, packaging material, depreciation charges (repairing charge) and interest on the fixed capital. The gross returns as per the treatments were worked out by considering prevailing market price. The sale price of the product was calculated by adding 20 per cent profit margins to the cost of product for different treatments of the experiment.

Flow Chart-I
Preparation of aerial yam flour

Selection of aerial yam
↓
Washing
↓
Blanching for 60 min
↓
Peeling
↓
Grating
↓
Drying of grated pulp at 60 ℃ for 6 hrs.
↓
Grinding
↓
Sieving
↓
Aerial yam flour
↓
Packaging
↓
Sealing
↓
Storage (at ambient temperature)

Flow Chart-II
Preparation of aerial yam cookies

Preparation of composite mixture of sugar and fat
↓
Mixing of aerial yam flour and *maida* as per the treatment
↓
Addition of baking powder
↓
Moulding
↓
Baking at 180 ℃ temperature for 25 min.
↓
Cooling
↓
Packaging
↓
Storage (at ambient temperature)

3. Results and Discussion
The research project entitled to study the "changes in chemical and microbial quality parameters of aerial yam (*Dioscorea bulbifera*) cookies during storage" was undertaken in the Department of Post-Harvest Management of Fruit, Vegetable and Flower Crops, Post Graduate Institute of Post-Harvest Management, Killa-Roha, during the year 2017-2018. The results of the experiment under study are presented and discussed in this chapter.

3.1 Physical parameters of aerial yam powder
3.1.1 Recovery (%)
The recovery of aerial yam powder was 19.39 per cent as per the data presented in Table 1.

Anjali and Sadhna (2016) [5] mentioned that recovery of elephant foot yam powder was 22.79 per cent.

3.1.2 Colour
It is observed from Table 1 that the colour L*, a* and b* values of aerial yam powder were 81.45, 6.76 and 40.66, respectively.

Rita and Felix (2016) [26] reported 77.66 $\pm$ 1.25, -0.45 $\pm$ 0.01 and 19 $\pm$ 0.91 colour L*, a* and b* values of the aerial yam flour respectively.

3.2 Chemical parameters of aerial yam flour
In the present investigation, the chemical parameters of aerial yam flour were studied before preparation of cookies. The moisture content, total soluble solids, sugars (reducing and total sugars), ash, crude fat and crude fibre were estimated as per the standard methods described in the Chapter-III. Data in relation to the estimated values for chemical parameters are furnished in the Table 1.

Table 1: Physical and chemical parameters of aerial yam powder

Sr. No.	Particulars	Mean*
A. Physical parameters		
1.	Recovery (%)	19.39
2.	Colour	
	L* Value	81.45
	a* value	6.76
	b*value	40.66
B. Chemical parameters		
1.	Moisture (%)	8.69
2.	T.S.S. (^{0}B)	16
3.	Titratable acidity (%)	0.03
4.	Reducing sugars (%)	0.84
5.	Total sugars (%)	6.75
6.	Ash (%)	0.045
7.	Crude fat (%)	0.86
8.	Crude fiber (%)	0.80

*The values are the means of three observations.

3.2.1 Moisture (%)
The results presented in Table 1 indicate that the average moisture content of aerial yam powder was 8.69 per cent.
Kayode *et al.* (2017) [14] reported that the moisture content in aerial yam powder was 7.66 to 10.60 per cent.

3.2.2 Total soluble solids (TSS) (°B)
Total soluble solid content is one the important factors to determine the quality of flour. The results presented in Table 1 indicated that the total soluble solid content of aerial yam flour was found to be 16^0 Brix.
Onuegbu *et al.* (2010) [19] recorded 15.10 per cent total soluble solids in flour from tubers of three leaved yam.

3.2.3 Titratable acidity (%)
It is observed from the data presented in Table 1 that the titratable acidity of aerial yam flour was 0.03 per cent. The result was in accordance with the results reported by Olatunde (2015) [18] who observed 0.13 per cent acidity in sweet potato flour.

3.2.4 Reducing sugars (%)
The reducing sugar content in aerial yam flour was 0.84 per cent as presented in Table 1. The observation in accordance with this finding was also reported by Jacques *et al.* (2016) who noticed that the reducing sugar content of aerial yam flour was 0.48±0.03 per cent.

3.2.5 Total sugars (%)
It could be revealed from the data presented in Table 1 that the total sugar content of aerial yam flour was 6.75 per cent. Identical observation was also reported by Assa *et al.* (2014) [6] who recorded 12.51 per cent total sugars in yam. Jacques *et al.* (2016) reported that the total sugar content of aerial yam flour was 3.26±0.04 per cent.

3.2.6 Ash (%)
The data presented in Table 1 reflected 0.045 per cent ash content of aerial yam flour. The finding was similar to the observations of Kayode *et al.* (2017) [14] who reported that the ash content in aerial yam flour was 0.05 to 1.76 per cent.

3.2.7 Crude fat (%)
The data pertaining to the mean crude fat content in the aerial yam powder was 0.86 per cent as presented in Table 1. The observation in accordance with these findings was reported by Ojinnaka *et al.* (2017) who observed that the crude fat content in the aerial yam flour was 0.98 per cent. Srivastava *et al.* (2012) [31] reported that the fat content of sweet potato flour was 0.52 per cent.

3.2.8 Crude fiber (%)
The crude fat content in the aerial yam flour was 0.80 per cent as presented in Table 1. Similar observations were also reported by Kayode *et al.* (2017) [14] who reported that the aerial yam flour contained 0.56 to 0.69 per cent crude fiber. Srivastava *et al.* (2012) [31] reported that the crude fiber content of sweet potato flour was 1.038 per cent.

3.3 Changes in chemical parameters of aerial yam powder cookies during storage at ambient conditions
3.3.1 Moisture (%)
It is evident from the data presented in Table 2 and graphically depicted in Fig. 1 that the moisture content in aerial yam cookies increased significantly during storage. It is clear from the data that the maximum (4.98%) moisture content was noticed in the treatment T_5 (50% AYF), followed by the treatments T_4 (40% AYF) (4.55) and T_3 (30% AYF) (4.18). The treatment T_1 (100% *Maida)* showed minimum (3.81%) moisture content, followed by the treatment T_2 (20% AYF) (3.95). The moisture level of cookies increased when aerial yam flour increased from 0 to 50 per cent. Hosamani *et al.*, (2017) also reported that increasing level of jackfruit or carrot flour increase the moisture content in the biscuits. During the storage, moisture content in the cookies showed an increasing trend irrespective of the treatment. The minimum value of moisture of cookies i.e. 3.99 per cent was recorded initially at 0 day of storage, which was increased to 4.64 per cent at the end of storage period of 30 days.

Table 2: Effect of different levels of aerial yam flour on moisture (%) content of aerial yam cookies during storage at ambient conditions

Treatments	Moisture (%)				
	Storage period (Days)				
	0	10	20	30	Mean
T_1	3.62	3.74	3.87	4.03	3.81
T_2	3.78	3.83	3.97	4.20	3.95
T_3	3.83	4.09	4.27	4.55	4.18
T_4	4.19	4.40	4.65	4.98	4.55
T_5	4.52	4.87	5.08	5.45	4.98
Mean	3.99	4.18	4.37	4.64	
	S.E.m±		C.D. at 5%		
Treatment (T)	0.03		0.11		
Storage (S)	0.04		0.12		
Interaction (TXS)	0.07		NS		

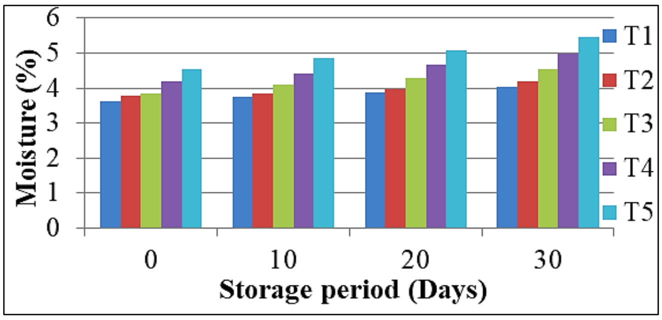


Fig 1: Effect of different levels of aerial yam flour on moisture (%) content of aerial yam cookies during storage at ambient conditions

The moisture content of cookies increased linearly with increase in the proportion of aerial yam flour in the cookies. This is attributed to high water binding capacity of aerial yam flour which retained higher moisture content in the ultimate product. Similar trend of increase in moisture during storage has been recorded by Pawar (2016) [22] who prepared cookies from sapota pomace.

3.3.2. Total soluble solids (TSS) (°B)

The data pertaining to the changes in the total soluble solids content of aerial yam cookies during storage are presented in Table 3 and graphically depicted in Fig. 2.

Table 3: Effect of different levels of aerial yam flour on total soluble solids (^{O}B) of aerial yam cookies during storage at ambient conditions

Treatments	TSS (^{0}B)				
	Storage period (Days)				
	0	10	20	30	Mean
T_1	34.75	34.7	33.95	33.20	34.15
T_2	36.4	36.25	36.15	35.95	36.19
T_3	36.85	36.55	36.35	36.05	36.45
T_4	36.95	36.70	36.40	36.10	36.54
T_5	37	36.85	36.50	36.40	36.69
Mean	36.39	36.21	35.87	35.54	
	S.E.m±	C.D. at 5%			
Treatment (T)	0.10	0.31			
Storage (S)	0.12	0.34			
Interaction (TXS)	0.21	NS			

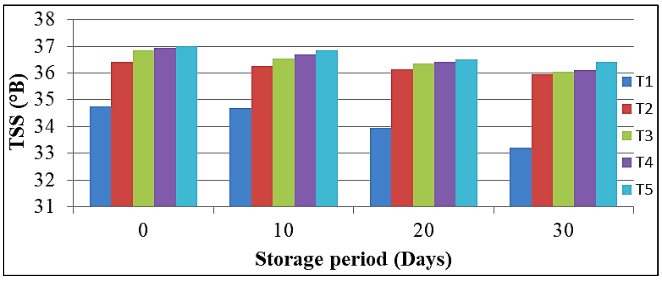


Fig 2: Effect of different levels of aerial yam flour on total soluble solids (^{O}B) of aerial yam cookies during storage at ambient conditions

Among all the treatments, the highest mean TSS (36.69°B) was found in the treatment T_5 (50% AYF), however, it was at par with the treatments T_4 (40% AYF) and T_3 (30% AYF) with 36.54°B and 36.45°B TSS, respectively. The lowest mean TSS (34.15 °B) was noticed in the treatment T_1 (100% *Maida*). The treatments T_2 (20% AYF) (36.19) and T_3 (30% AYF) (36.45). As the level of aerial yam flour in the cookies increased, the TSS of the cookies also increased. At the end of storage, there was a significant decline in the TSS level of the treatments. At initial stage i.e. 0 day, the highest mean TSS (36.39°B) of the cookies was noticed while the lowest mean TSS (35.54°B) was recorded at 30 days of storage. A decline in TSS of cookies might be due to rise in moisture content of the cookies during storage.

The interaction between treatment and storage with respect to TSS level was found to be statistically non-significant at the end of 30 days of storage period. The similar trend was recorded by Pawar (2016) [22] who studied the sapota pomace cookies and also by Dhumal (2016) [9] in the sweet potato cookies.

3.3.3 Titratable acidity (%)

The results on the changes in the titratable acidity of aerial yam powder cookies during storage with respect to treatments are presented in Table 4. and depicted in Fig. 3. It was observed that the titratable acidity of aerial yam powder cookies varied significantly with different treatments as well as the storage period.

Table 4: Effect of different levels of aerial yam flour on titratable acidity (%) of aerial yam cookies during storage at ambient conditions

Treatments	Titratable acidity (%)				
	Storage period (Days)				
	0	10	20	30	Mean
T_1	0.075	0.072	0.065	0.049	0.065
T_2	0.081	0.075	0.070	0.069	0.074
T_3	0.090	0.074	0.078	0.076	0.081
T_4	0.098	0.092	0.086	0.080	0.089
T_5	0.101	0.096	0.091	0.084	0.093
Mean	0.089	0.083	0.078	0.072	
	S.E.m±	C.D. at 5 %			
Treatment (T)	0.0015	0.004			
Storage (S)	0.0016	0.005			
Interaction (TXS)	0.0029	NS			

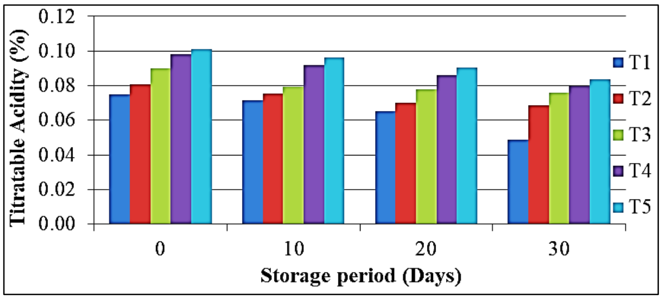


Fig 3: Effect of different levels of aerial yam flour on titratable acidity (%) of aerial yam cookies during storage at ambient conditions

Among the treatments, the treatment T_5 (50% AYF) was significantly superior to other treatments and showed maximum (0.093%) mean acidity which was at par with the treatment T_4 (0.089%). While treatment T_1 (100% *Maida*) showed minimum (0.065%) mean acidity of the aerial yam cookies followed by the treatment T_2 (0.074%). It is also clear from the data that the titratable acidity of the cookies increased significantly with increase in the proportion of aerial yam powder in the cookies. It is evident from the data that the mean acidity gradually decreased with the increase in the storage period. The highest mean acidity (0.089%) was observed at the initial 0 day of the storage and the lowest mean acidity (0.072%) was observed at end of 30 days of storage under ambient conditions. A decline in titratable acidity of cookies might be due to the increase in moisture content of the cookies during storage. The interaction effects between storage and treatment were found significantly non-significant.

The similar trend was recorded by Dhumal (2016) [9] who studied the storage behaviour of the sweet potato cookies.

3.3.4. Reducing sugars (%)

The data presented in Table 5 and graphically presented in Fig. 4 indicate that the treatments as well as storage period exhibited significant changes in reducing sugars content of the aerial yam cookies.

Table 5: Effect of different levels of aerial yam flour on reducing sugars (%) of aerial yam cookies during storage at ambient conditions

Treatments	Reducing sugars (%)				
	Storage period (Days)				
	0	10	20	30	Mean
T_1	0.85	0.90	0.98	1.06	0.95
T_2	0.91	0.98	1.08	1.15	1.03
T_3	0.95	1.03	1.12	1.22	1.08
T_4	0.98	1.07	1.18	1.28	1.13
T_5	1.03	1.13	1.24	1.35	1.19
Mean	0.94	1.03	1.12	1.21	
	S.E.m±		C.D. at 5%		
Treatment (T)	0.003		0.010		
Storage (S)	0.004		0.011		
Interaction (TXS)	0.007		0.021		

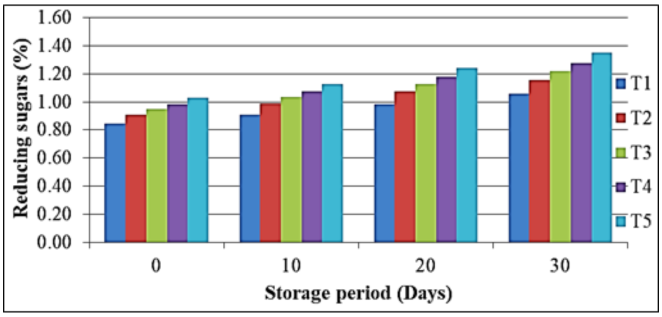


Fig 4: Effect of different levels of aerial yam flour on reducing sugar (%) of aerial yam cookies during storage at ambient conditions

The treatment T_5 (50% AYF) recorded maximum mean reducing sugars (1.19%), followed by the treatments T_3 (30% AYF) and T_4 (40% AYF), while it was minimum (0.95%) in the treatment T_1 (100% *Maida*), followed by the treatment T_2 (20% AYF). It is clear from the data, the reducing sugar content increased with rise in the proportion of aerial yam powder in the product. As regards storage period, there was an increase in the reducing sugar content during storage. The highest mean reducing sugar content (1.21%) was observed at 30 days of storage, while the lowest mean reducing sugar content (0.94%) was recorded initially i.e. 0 day of storage. The interaction between treatments and storage showed a significant variation at 5 per cent level of significance in reducing sugars of aerial yam cookies. The highest (1.35%) reducing sugar content was observed in the treatment T_5 (50% AYF) at 30 days of storage and lowest (0.85%) reducing sugar content was noticed in the treatment T_1 (100% *Maida*) at initial day of storage.

The reducing sugars of aerial yam cookies increased significantly during storage. The increase in reducing sugars was probably due to acid hydrolysis of sucrose during storage. The similar trend was recorded by Pawar (2016) [22] who studied sapota pomace cookies and also by Varvdekar (2016) [33] in lesser yam cookies.

3.3.5 Total sugars (%)

It is evident from the data presented in Table 6 and graphically presented in Fig. 5 that the total sugar content of cookies exhibited variation due to the treatment and decreased significantly during storage.

Table 6: Effect of different levels of aerial yam flour on total sugars (%) content of aerial yam cookies during storage at ambient conditions

Treatments	Total sugars (%)				
	Storage period (Days)				
	0	10	20	30	Mean
T_1	21.37	20.41	18.21	17.05	19.27
T_2	22.69	21.30	19.49	18.63	20.53
T_3	23.04	22.19	20.20	19.5	21.24
T_4	25.28	23.19	21.39	19.92	22.45
T_5	26.85	24.58	22.80	20.14	23.60
Mean	23.85	22.34	20.42	19.05	
	S.E.m±		C.D. at 5%		
Treatment (T)	0.09		0.27		
Storage (S)	0.11		0.31		
Interaction (TXS)	0.19		0.54		

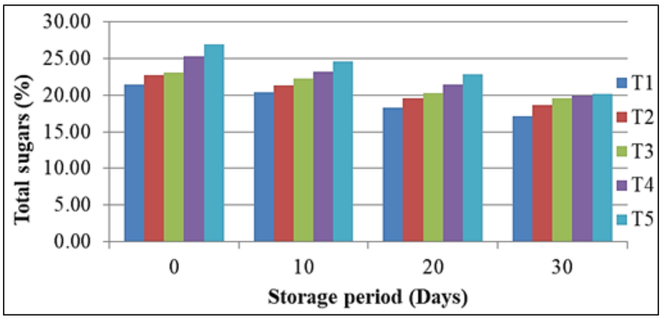


Fig 5: Effect of different levels of aerial yam flour on total sugars (%) content of aerial yam cookies during storage at ambient conditions

The variation in total sugars due to different treatments was found significant. The treatment T_5 (50% AYF) recorded the highest (23.60%) mean total sugars which was followed by the treatment T_4 (40% AYF) (22.45%), whereas, the treatment T_1 (100% *Maida*) recorded significantly lowest (19.27%) mean total sugar content, followed by the treatment T_2 (20% AYF) (20.53%). The total sugar content in the cookies increased with rise in the level of aerial yam powder. This might due to the fact that the aerial yam powder is rich in total sugars as referred previously. The total sugar content decreased significantly from 23.85 per cent at the time of preparation to 19.05 per cent after 30 days of storage. A decrease in total sugar might be due to increase moisture during storage. A significant decrease in the total sugar content of the product was also noticed by Hosamani (2016) [10] in jackfruit and carrot powder incorporated biscuits and Joshi (2017) [13] in cashew apple pomace powder cookies.

The interaction between treatments and storage showed a significant variation at 5 per cent level of significance in total sugars of aerial yam cookies. The maximum (26.35%) total sugars were recorded by the treatment T_5 (26.35%) at 0 days of storage, whereas it was lowest (17.05%) in the treatment T_1 (17.05%) at 30 days of storage at ambient conditions.

3.3.6 Ash (%)

It is evident from the data presented in Table 7 and graphically presented in Fig. 6 that the ash content in aerial yam cookies increased significantly with increase in aerial yam powder in the cookies and exhibited significant variation during storage.

Table 7: Effect of different levels of aerial yam flour on ash (%) content of aerial yam potato cookies during storage at ambient conditions

Treatments	Ash (%)				
	Storage period (Days)				
	0	**10**	**20**	**30**	**Mean**
T_1	0.53	0.48	0.43	0.63	0.52
T_2	1.00	0.98	0.90	0.86	0.94
T_3	1.31	1.29	1.23	1.20	1.26
T_4	1.72	1.69	1.64	1.60	1.66
T_5	2.03	1.93	1.90	1.86	1.93
Mean	1.32	1.28	1.22	1.23	
	S.E.m±		**C.D. at 5%**		
Treatment (T)	0.03		0.09		
Storage (S)	0.03		0.01		
Interaction (TXS)	0.065		NS		

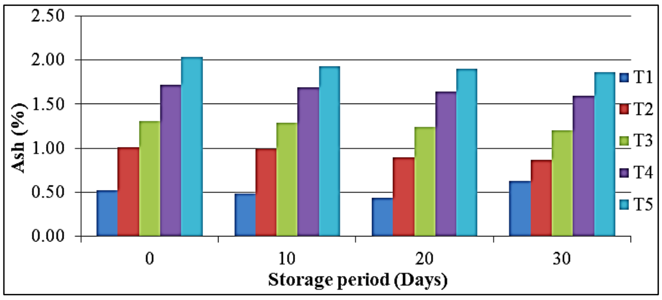


Fig 6: Effect of different levels of aerial yam flour on ash (%) content of aerial yam cookies during storage at ambient conditions

It is clear from the data that the maximum (1.93%) ash content was noticed in the treatment T_5 (50% AYF), followed by the treatments T_4 (40% AYF) and T_3 (30% AYF) with 1.66 and 1.26 per cent ash content, respectively. The treatment T_1 (100% *Maida*) showed minimum (0.52%) ash content, followed by the treatment T_2 (20% AYF) with 0.94 per cent ash content. The ash content of the cookies increased significantly due to higher ash content of aerial yam flour and also due to externally added fat during cookies preparation. During the storage, the ash content of the cookies showed the decreasing trend. The maximum value of ash of cookies i.e. 1.32 per cent was recorded initially at 0 day of storage, which was decreased to 1.22 per cent up to 20 days of storage period. However, it remained constant at the end of 30 days of storage period. The decline in ash content of aerial yam cookies during storage due to increase in moisture content of the cookies. The similar trend was recorded by Priyanka and Mishra (2015) [23] who studied jamun powder fortified biscuits and Dhumal (2016) [9] in sweet potato powder cookies.

The interaction between treatment and storage period was found non-significant.

3.3.7 Crude fat (%)

It could be observed from the results presented in Table 8 and Fig. 7 that the crude fat of cookies varied significantly with different treatments as well as the storage period.

Table 8: Effect of different levels of aerial yam flour on crude fat (%) content of aerial yam cookies during storage at ambient conditions

Treatments	Crude fat (%)		
	Storage period (Days)		
	0	**30**	**Mean**
T_1	41.75	40.18	40.97
T_2	42.18	40.39	41.28
T_3	42.97	41.91	42.44
T_4	43.58	42.83	43.21
T_5	44.57	43.58	44.08
Mean	43.01	41.78	
		S.E.m±	**C.D. at 5%**
Treatment (T)		0.16	0.47
Storage (S)		0.10	0.30
Interaction (TXS)		0.46	NS

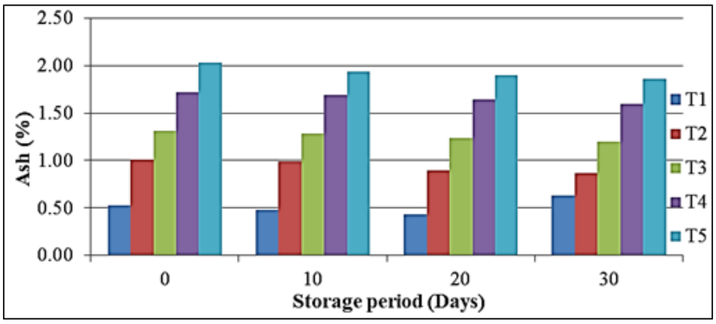


Fig 7: Effect of different levels of aerial yam flour on crude fat (%) content of aerial yam cookies during storage at ambient conditions

It is noticed from the data that the crude fat content of the aerial yam powder cookies was highest (44.08%) in T_5 (50% AYF) treatment, followed by the treatment T_4 (40% AYF) (43.21%). Among the treatments, significantly lowest (40.97%) mean crude fat was noticed in the treatment T_1 (100% *Maida*) which at par with the treatment T_2 (20% AYF) (41.28%). As the aerial yam powder was increased, the crude fat content of the cookies increased significantly. Thorat and Khemnar (2013) [32] also reported that the fat content increased from 26 to 33 per cent with incorporation of jamun seed powder from 20 to 40 per cent in the cookies. It was also noticed from the Table 14 that the mean crude fat content was significantly decreased from initial 43.01 per cent to 41.78 per cent up to 30 days of storage period. The interaction effects between treatments and storage period were found statistically non-significant.

The decrease in the crude fat content might be due to increased activity of lipase enzyme leading to lowering the fat content. Similar trend of decrease in crude fat during storage has been recorded by Wani and Sood (2014) who noticed that the crude fat was decreased from 21.46 to 20.20 during 90 days of storage, in cauliflower leaf powder blended biscuits.

3.3.8 Crude fiber (%)

The crude fiber content of cookies varied significantly with different levels of aerial yam powder in the cookies as well as the storage period as presented in Table 9 and illustrated in Fig. 8.

Table 9: Effect of different levels of aerial yam flour on crude fiber (%) content of aerial yam cookies during storage at ambient conditions

Treatments	Crude fiber (%)		
	Storage period (Days)		
	0	30	Mean
T_1	2.25	1.49	1.87
T_2	5.57	3.54	4.56
T_3	5.87	4.41	5.14
T_4	6.33	4.97	5.65
T_5	6.93	5.59	6.26
Mean	5.39	4.00	
		S.E.m±	C.D. at 5%
Treatment (T)		0.10	0.30
Storage (S)		0.07	*0.19*
Interaction (TXS)		0.30	6.31

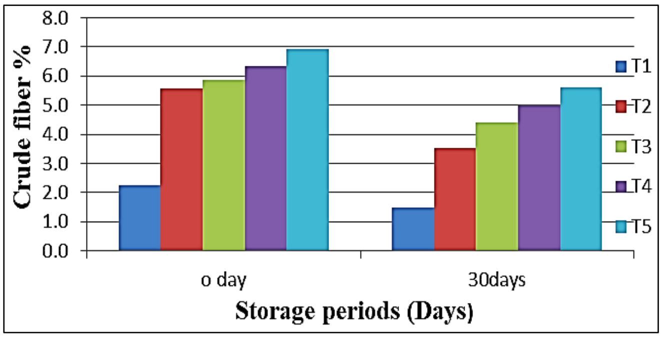


Fig 8: Effect of different levels of aerial yam flour on crude fiber (%) content of aerial yam cookies during storage at ambient conditions

It is noticed from the results that the crude fiber of the aerial yam powder cookies was highest (6.26%) in T_5 (50% AYF) treatment, followed by the treatments T_4 (40% AYF) (5.65%) and T_3 (30% AYF) (5.14%). Among all treatments, the significantly lowest (1.87%) mean crude fiber was noticed in the treatment T_1 (100% *Maida*) which was followed by the treatment T_2 (20% AYF) (4.56%). The crude fiber content of the aerial yam cookies influenced by the level of the aerial yam powder in the cookies. The highest crude fiber content in the treatment T_5 (50% AYF) was due to highest level of fortification with aerial yam powder which is a rich source of crude fiber. The results are in close confirmly with Khapre *et al.* (2015) [15], who studied the standardization of fig fruit (*Ficus carica* L.) powder enriched cookies and its composition. Youssef and Mousa (2012) mentioned an increase in fiber content in biscuits with addition of different amount of citrus peel powder. It was also noticed from the Table 15 that the mean crude fiber was changed during 30 days of storage period. Initially, the crude fiber content was 5.39 per cent and it was 4.00 per cent after 30 days of storage. Identical observations are also recorded by Wani and Sood (2014) in cauliflower leaf powder blended biscuits. Similar result was recorded by Joshi (2017) [13] in cashew apple pomace cookies.

The interaction between treatments and storage showed a significant variation at 5 per cent level of significance with respect to crude fiber of aerial yam cookies. The maximum (6.93%) crude fiber were recorded by the treatment T_5 (6.93%) at 0 days of storage, whereas it was lowest (1.49%) in the treatment T_1 (1.49%) at 30 days of storage at ambient conditions.

3.4 Microbial analysis of aerial yam cookies

The details of microbial changes are presented in Table 10. The data on microbial spoilage of the aerial yam powder cookies was recorded immediately after preparation of the product and at the end of 30 days of storage.

Table 10: Microbial count of aerial yam powder cookies during storage

Treatments	Microbial count (cfu/g)	
	Storage periods (Days)	
	0	30
T_1	N.D	N.D
T_2	N.D	N.D
T_3	N.D	N.D
T_4	N.D	N.D
T_5	N.D	N.D

N.D*= Not Detectable

It is noticed that the microbial count of aerial yam powder cookies was not influenced by the treatments and storage period. And, microbial growth was not seen during 30 days of storage period.

Analogues observations were recorded by Mehta (2013) [17] who noted that they did not find any bacterial growth in low cost nutritive biscuits with Ayurvedic formulation during 3 week's storage period. Similarly, Yusufu *et al.* (2016) [39] reported that the cookies produced from maize, African yam bean, composite flour were free of microorganisms up to two months of storage at ambient conditions. Also, Dhumal (2016) [9] observed that the microbial count of sweet potato flour cookies was not influenced by the treatments and storage period. Bacteria as well as fungi count did not show any growth during 30 days of storage period.

3.5 Economics of aerial yam cookies

The economics for the preparation of 100 kg aerial yam powder cookies is shown as follows. It could be observed from the data that the total expenditure for production of aerial yam cookies was highest (Rs. 18,010.80) in the treatment T_5 (50% AYF) and lowest (Rs. 11,960.80) in the treatment T_1 (100% *Maida*).

Highest gross returns and net profit of Rs. 21613.00 and Rs. 3602.1, respectively, was found in the treatment T_5 (50% AYF) and the lowest gross returns of Rs. 14353.00 and net profit of Rs. 2392.10 in the treatment T_1 (100% *Maida*). The sale price was maximum (Rs. 21.61) in T_5 (50% AYF) and lowest in the treatment T_1 (100% *Maida*) (Rs. 14.35). The benefit cost ratio was the same i.e. 1.20 for each treatments as the profit margin was considered as 20 per cent to each treatment.

According to the sensory qualities for overall acceptability, the treatment T_2 (20% aerial yam flour level) was the best treatment for the aerial yam cookies.

The working capital, gross returns and net profit for the best treatment i.e. T_2 (20% aerial yam flour level) was Rs. 9664.40, Rs. 17257.00 and Rs. 2876.10, respectively. The sale price for best treatment was Rs. 17.25 per 100g of aerial yam cookies.

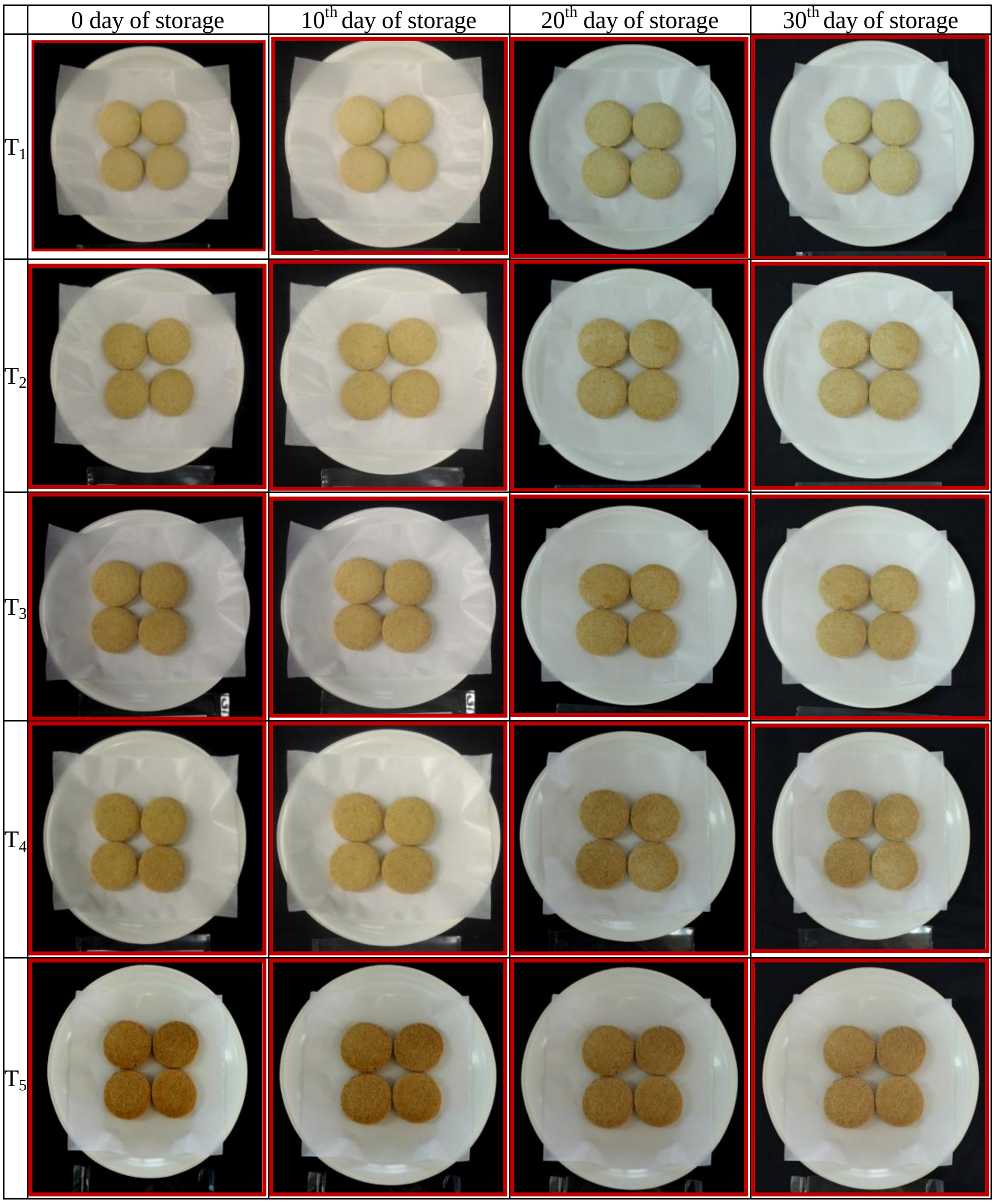
4. Conclusion

An investigation entitled to study the "changes in chemical and microbial quality parameters of aerial yam (*Dioscorea bulbifera*) cookies during storage" was undertaken at the Department of Fruit, was carried out to assess effect of different levels of aerial yam powder and *maida* in the cookies on chemical and microbial characteristics of aerial yam powder cookies. The aerial yam powder cookies prepared from different treatments were evaluated for their chemical parameters such as moisture, T.S.S., reducing sugars, total sugars, crude fat, crude fiber, moisture, ash and also for microbial qualities.

The present study revealed that all the chemical parameters except reducing sugars, the TSS, titratable acidity and total sugars of the cookies, decreased during storage period of 30 days. From the results of present studies, it can be concluded that the aerial yam powder cookies could be stored up to 30 days at ambient condition, when packed in 400 gauge low density polyethylene (LDPE). Good quality aerial yam powder cookies could be prepared by maintaining 20 per cent aerial yam powder level in the product. The nutritional value of the cookies was increased by addition of aerial yam powder.

5. Acknowledgement

I extend my sincere thanks to Dr. Pradip P. Relekar (Guide/Chairman) and to my advisory committee members for giving me proper guidance throughout the course of study. I also sincerely thank PGI-PHM, Killa-Roha (Dr. Balasaheb Sawant Konkan Krishi Vidhyapeeth, Dapoli) for supporting the research financially.



T_1: 100:0 (Maida: AYF) T_2: 80:20 (Maida: AYF)
T_3: 70:30 (Maida: AYF) T_4: 60:40 (Maida: AYF)
T_5: 50:50 (Maida: AYF)

Plate: Effect of treatments and storage period on aerial yam cookies at 0, 10^{th}, 20^{th} and 30^{th} days of storage at ambient temperature

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