The Pharma Innovation Journal 2022; 11(12): 32-43

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2022; 11(12): 32-43

www.thepharmajournal.com
Received: 17-09-2022
Accepted: 21-10-2022

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Development of the process for preparation of aerial yam (*Dioscorea bulbifera*) cookies with studying changes in the physical and sensory quality parameters during storage

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Abstract
An investigation entitled "Development of the process for preparation of aerial yam (*Dioscorea bulbifera*) cookies with studying changes in the physical and sensory quality parameters 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 physical and sensory qualities initially and during 10, 20 and 30 days of storage. The physical parameters except diameter, all other parameters such as thickness and volume of the cookies decreased with the increase in the level of aerial yam flour in the cookies. An increase in L* values with decrease in the a* and b* value for colour of the cookies was observed during storage. 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 sensory 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, colour, sensory 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.

The D.B.S.K.K.V., Dapoli, Dist. Ratnagiri has developed aerial yam variety, named on Konkan Kalika (KKVDb-1). It produces high marketable yield, bulbs with pale yellowish flesh colour, good taste and cooking quality, tolerant to disease and pests and it is released for cultivation in Konkan region of Maharashtra. The improved variety shows a yield potential of 4 to 5 tonnes/ha.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) [17, 31]. 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) [9].

Most of the yams are consumed after being cooked or processed. In general, yams are prepared at home on the basis of convenience and taste preference rather than retention of nutrient and health-promoting compounds (Masrizal, *et al.*, 1997) [13]. Moreover, yams are always cooked before being eaten. Yam's nutrients and functional properties appear to be influenced by cooking methods. However, there is no consistent information on the effects of thermal treatments on the properties of its constituents. 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) [28]. 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) [6].

Cookies hold an important position in snack food industry due to variety in taste, crispiness and digestibility. Cookies are made in a variety of style using an array of ingredients including sugars, spices, chocolates, butter, peanut butter, nuts or dried fruits. (Waheed, *et al.*, 2010) [30]. Cookies are ideal for nutrient availability, palatability, compactness and convenience. They differ from other bakery products like bread and cakes because of having low moisture content, comparatively free from microbial spoilage and long shelf life of the product (Wade, 1988) [29].

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 following objectives.

1) To study the physical and sensory parameters of aerial yam powder
2) To prepare and evaluate aerial yam cookies
3) To study storage behaviour of aerial yam cookies

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, 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 (*Dios coria 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

B. 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°C 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.

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

2.3.2. Colour (L*, a* and b*)

The colour of aerial yam powder was measured by using a Colorimeter (Konica Minolta, Japan CR-400), and expressed in 'L* value' represented the brightness from black (0) to white (100), 'a* value' represented the colour of green (-) and red (+) and 'b*value' represented the colour of yellow (+) and blue (-) values.

2.3.3. 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.

2.3.3.1. Moisture (%)

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

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

Total soluble solids were determined with the help of Hand

Refracto meter (Atago India instrument pvt. Ltd, Mumbai) and was expressed in ^{0}Brix.

2.3.3.3. 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). 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) [20]. The results were expressed as per cent anhydrous citric acid.

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

2.3.3.4. Reducing sugars (%)
The reducing sugars were determined by method of Lane and Eynon (1923) [12] as reported by Ranganna (1986) [19] 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.

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

2.3.3.5. Total sugars (%)
Total sugar content was determined by method of Lane and Eynon (1923) [12] as reported by Ranganna (1986) [19] 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.

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

2.3.3.6. 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°C 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.

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

2.3.3.7. 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°C to 100°C, cooled in a desciccators and weighed. The content was expressed as percentage (AOAC, 1975) [1].

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

2.3.3.8. 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°C to 100°C and weighed. The crucible was heated in muffle furnace at 525°C for 2-3 hrs. Cooled and weighed again. The difference in the weights represented the weight of crude fibre, Ranganna (1986) [19].

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

2.4. 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°C for 25 minutes. After baking, the cookies were cooled at room temperature and then packed in 400 guage LDPE (Low Density Polyethylene) bag.

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

2.6. Physical parameters of aerial yam cookies
2.6.1 Colour (L*,a*, b*)
The colour of aerial yam powder was measured by using a Colorimeter (Konica Minolta, Japan CR-400), and expressed in ‘L*’ represented the brightness from black (0) to white (100), ‘a*’ represented the colour of red (+) and green (-) and ‘b*’ represented the colour of yellow (+) and blue (-) values.

2.6.2 Diameter
The diameter was measured in centimeter by means of vernier caliper.

2.6.3 Thickness
The thickness of cookies was measured using vernier caliper and expressed in cm.

2.6.4 Volume
Volume of cookies was determined as the area of the biscuits multiplied by thickness.

$$\textbf{Volume (cm}^3\textbf{)} = \frac{d^2\pi T}{4}$$

T=Average thickness of biscuit (mm)
d= Diameter of biscuit (mm)

2.7 Changes in the sensory quality parameters of the aerial yam powder cookies
Aerial yam powder cookies were evaluated for their organoleptic qualities like colour, flavour, texture and overall acceptability on a hedonic scale (Amerine *et al.*, 1965) [2] as given below.

Sr. No.	Organoleptic Score	Rating
1.	9	Like extremely
2.	8	Like very much
3.	7	Like moderately
4.	6	Like slightly
5.	5	Neither like nor dislike
6.	4	Dislike slightly
7.	3	Dislike moderately
8.	2	Dislike very much
9.	1	Dislike extremely

The overall rating was obtained by averaging the score for colour, flavour and texture of aerial yam powder cookies. The sample with score of 5.5 and above was rated as acceptable.

2.8 Statistical analysis
The data collected on physical parameters of aerial yam powder such as recovery, colour (L*, a* and b*) were represented as mean values. The physical parameters as well as data collected on the changes in physical parameters and sensory qualities of aerial yam powder cookies during storage were statistically analysed by the standard procedure given by (Panse and Sukhatme, 1985) [18] 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.

2.9. 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°C 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°C temperature for 25 min.
↓
Cooling
↓
Packaging
↓
Storage (at ambient temperature)

3. Results and Discussion
The research project entitled "Development of the process for preparation of aerial yam (*Dioscorea bulbifera*) cookies" 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) 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) reported 77.66 ± 1.25, -0.45 ± 0.01 and 19 ± 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) [10] 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° Brix.
Onuegbu *et al.* (2010) [16] 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) [15] 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) [4] 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) [10] 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) [26] 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) [10] who reported that the aerial yam flour contained 0.56 to 0.69 per cent crude fiber. Srivastava *et al.* (2012) [26] reported that the crude fiber content of sweet potato flour was 1.038 per cent.

3.3. Physical parameters of aerial yam powder cookies
3.3.1. Diameter (cm)
The results presented in Table 2 and Fig.1 indicates that the diameter of cookies was changed after baking and it was varied according to treatment.

Table 2: Effect of different levels of aerial yam flour on diameter (cm) of aerial yam cookies

Treatment	Diameter (cm)
T_1	4.22
T_2	4.25
T_3	4.35
T_4	4.43
T_5	4.53
Mean	4.36
S.E. m ±	0.02
C.D at 5%	0.06

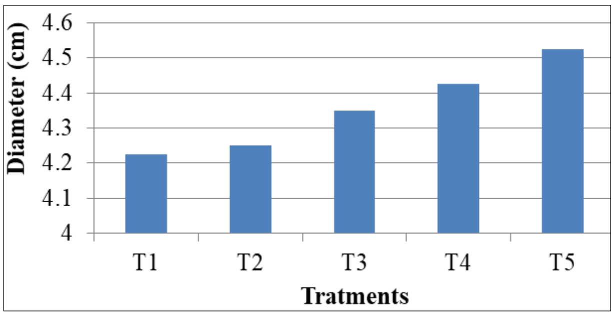

Fig 1: Effect of different levels of aerial yam flour on diameter (cm) aerial yam cookies

Among all the treatments, the highest (4.53 cm) mean of diameter was found in T_5 (50% AYF) which was significantly superior to rest of the treatments, followed by the treatments T_4 (40% AYF) and T_3 (30% AYF) while the lowest mean diameter (4.22 cm) was noticed in the treatment T_1, followed by the treatment T_2 (4.25).Diameter was increased with the level of aerial yam powder. The changes in diameter of cookies might be due to variable proportions of aerial yam powder in the cookies.
Similar observation was reported by Igbabul *et al.* (2015) [5, 8] who noticed that the diameter of the cookies increased with addition of cocoyam and African yam bean flours. The diameter was ranged from 6.48 to 6.82 cm.

3.3.2. Thickness (cm):
It is revealed from the data presented in Table 3 and graphically illustrated in Fig. 2 that the thickness of cookies exhibited significant variations due to the treatments.

Table 3: Effect of different levels of aerial yam flour on thickness (cm) of aerial yam cookies

Treatment	Thickness (cm)
T_1	1.13
T_2	1.05
T_3	0.99
T_4	0.93
T_5	0.86
Mean	0.99
S.E. m ±	0.01
C.D (5%)	0.03

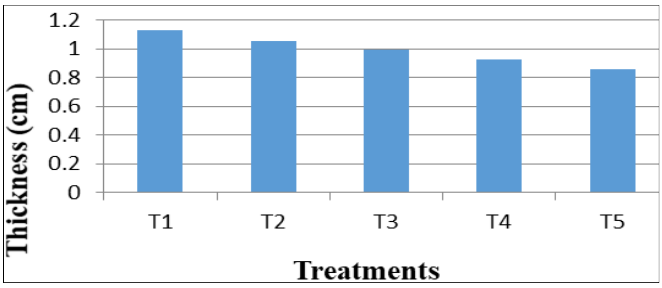

Fig 2: Effect different levels of aerial yam flour on thickness (cm) of aerial yam cookies

The thickness of cookies was decreased with increased level of aerial yam powder. The treatment T_1 *i.e* plain refined wheat flour cookies recorded highest (1.13 cm) thickness and the lowest (0.86 cm) in the treatment T_5 (50% AYF). This might be attributed to the increased level of aerial yam powder in the cookies.
The similar results are observed by Sobhan *et al.* (2014) [25] who reported that the thickness of cassava flour cookies was 0.63 to 0.64 cm. Bibiana *et al.* (2015) [5, 8] reported that the thickness of biscuit prepared from wheat - African yam bean - cocoyam flour blend cookies was 0.45 to 0.55 cm.

3.3.3. Volume (cm^3):
It is evident from the data presented in Table 4 and illustrated in Fig.3 that the treatment T_1 (100% *Maida*) *i.e.* control recorded maximum (15.84 cm^3) volume of the cookies whereas it was minimum (13.79cm^3) in the treatment T_5 (50% AYF).

Table 4: Effect of different levels of aerial yam flour on volume (cm^3) of aerial yam cookies

Treatment	Volume (cm^3)
T_1	15.84
T_2	14.95
T_3	14.73
T_4	14.29
T_5	13.79
Mean	14.72
S.E. m ±	0.22
C.D (5%)	0.63

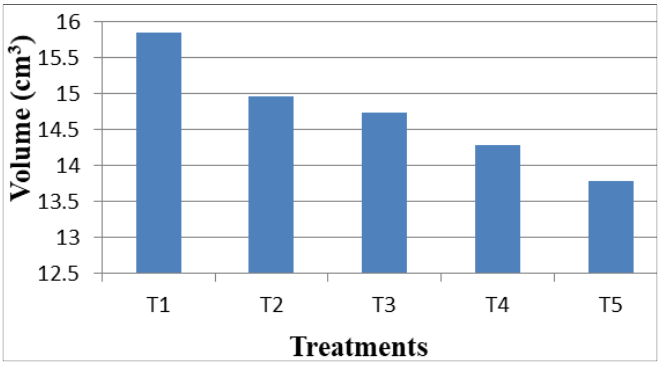

Fig 3: Effect different levels of aerial yam flour on volume (cm3) of aerial yam cookies

There was a significant decrease in the volume of cookies with higher proportion of aerial yam flour in the cookies. The results were in conformity with the results reported by Srivastava *et al.* (2012) [26] who observed a decrease in volume of sweet potato flour incorporated biscuits which would be due to higher fiber content in the cookies.

3.4 Changes in physical parameters of aerial yam powder cookies during storage at ambient conditions
3.4.1 Colour (L*, a* and b* value)
Colour is one of the most important quality parameters of product. The colour parameters are represented by L* (lightness), a* (redness) and b* (yellowness) values.

3.4.1.1 L* value for colour
The data presented in Table 5 and Fig. 4 with respect to the L* value for colour of the aerial yam powder cookies indicates the significant differences due to five different treatments as well as storage period.
The treatment T_1 (100% *Maida*) recorded highest (92.07) mean L* value for colour, which was significantly superior to rest of the treatments, followed by the treatments T_2 (20% AYF) (83.67) and T_3 (30% AYF) (80.59). The lowest (73.05) mean L* value for colour was observed in the treatment T_5 (50% AYF). Thus, it is evident from the data that the L* value declined with increase in the relative proportion of aerial yam powder in the product.

Table 5: Effect of different levels of aerial yam flour on L* value for colour of aerial yam cookies during storage at ambient conditions

Treatments	L* value for colour Storage period (Days)				
	0	10	20	30	Mean
T_1	91.05	92.42	92.41	92.40	92.07
T_2	81.76	83.35	84.34	85.25	83.67
T_3	79.24	79.78	81.05	82.28	80.59
T_4	76.31	77.41	78.40	79.29	77.85
T_5	71.86	72.81	73.50	74.03	73.05
Mean	80.04	81.15	81.94	82.65	
		S.E.m ±		C.D. at 5 %	
Treatment (T)		0.46		1.34	
Storage (S)		0.52		1.50	
Interaction (TXS)		0.90		NS	

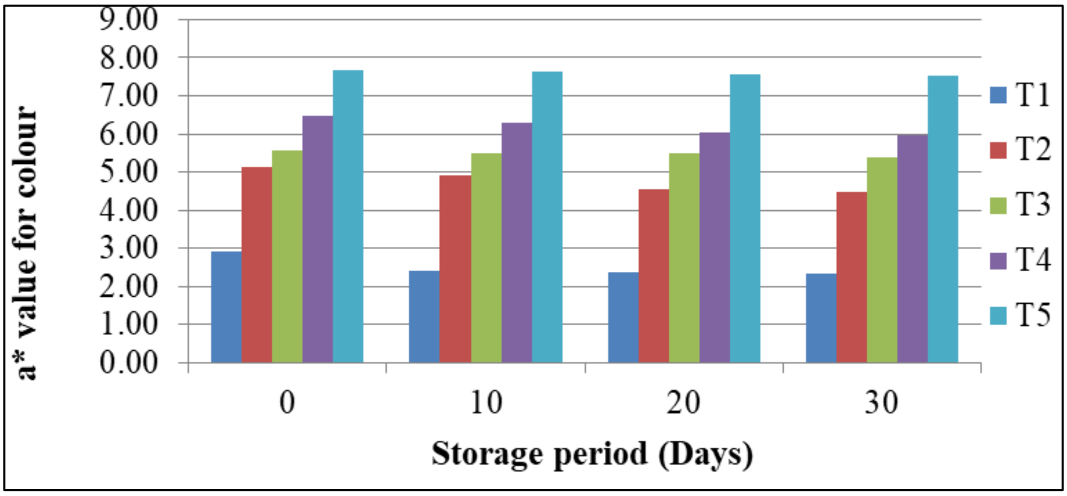

Fig 4: Effect of different levels of aerial yam flour on L* value for colour of aerial yam cookies during storage at ambient conditions

It was observed from the data that there was an increasing trend in L* value of aerial yam cookies during 1 month of storage period. The colour L* value varied significantly during storage irrespective of the treatments. The lowest mean (80.04) colour L* value was recorded at 0 day of storage and the highest (82.65) mean colour L* value was observed at 30 days of storage. Thus, increasing trend in L* value for colour was noticed up to 30 days of storage. This might be due to the fading of the colour of product during storage. The interaction between treatments and the storage period was found statistically non-significant. The decrease in the L* value was recorded as there was an increase in the level of aerial yam content. This may be due to the fact that the cookies with higher levels of aerial yam powder increased the browning of the cookies, thereby, exhibited lower L* values for colour.

L* value was recorded to determine lightness of cookies which decreased significantly with corresponding increase in the amount of powder of aerial yam in the cookies. Similar decreasing trend of L* value for colour with increasing the proportion of flour was reported by Singh *et al*. (2008) in sweet potato flour cookies.

3.4.1.2 a* value for colour

The details represented in Table 6 and depicted in Fig. 5 exhibit the colour a* value of aerial yam cookies. It is observed from the data that the colour a* value varied significantly due to the treatments and storage period.

Table 6: Effect of different levels of aerial yam flour on a* value for colour of aerial yam cookies during storage at ambient conditions

Treatments	a* value for colour Storage period (Days)				
	0	10	20	30	Mean
T_1	2.90	2.40	2.38	2.34	2.50
T_2	5.14	4.9	4.53	4.46	4.76
T_3	5.54	5.48	5.47	5.37	5.47
T_4	6.47	6.31	6.04	5.98	6.20
T_5	7.66	7.62	7.55	7.52	7.59
Mean	5.54	5.34	5.20	5.14	
		S.E.m ±		C.D. at 5 %	
Treatment (T)		0.08		0.25	
Storage (S)		0.09		0.28	
Interaction (TXS)		0.17		NS	

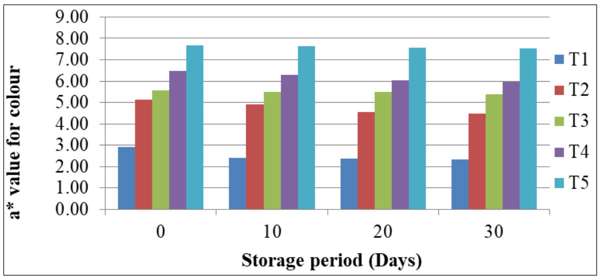

Fig 5: Effect of different levels of aerial yam flour on a* value for colour of aerial yam cookies during storage at ambient conditions

There was a significant effect of proportion of *maida* and aerial yam powder on a* value of the cookies. As the

percentage of powder increased, the a* value for colour of cookies also increased. The treatment T_5 (50% AYF) recorded highest mean a* value (7.59) for colour while the lowest a* value for colour (2.50) was noticed in the treatment T_1 (100% *Maida*) and the colour a* value varied significantly during storage irrespective of the treatments. The incorporation of jackfruit bulb powder had a darkning effect on the cookies as reported by Hosamani *et al.* (2016) [7]. As per the storage study, the colour a* value for colour of cookies decreased during storage period of 30 days. The highest (5.54) mean a* value for colour was recorded at 0 day of storage and the lowest (5.14) mean a* value for colour was observed at 30 days of storage. A significant decline in the a* value for colour was noticed after 20 days of storage. The a* value for colour recorded initially (0 day) was at par with that of at 10 days of storage. The interaction effects related to a* value for colour between treatment and the storage period were found statistically non-significant. The increase in a* value was noticed with increase in the aerial yam powder in the cookies. The increased aerial yam powder content in the cookies resulted into the darkening of the aerial yam cookies.
The identical observations to this are also reported by Hosamani *et al.* (2016) [7] who reported an increasing trend in carrot, jackfruit, aonla powder biscuits for a* values.

3.4.1.3 b* value for colour
It is observed from the data presented in Table 7 and Fig. 6 that there are significant variations in b* value for colour due to the treatments for the samples analyzed over the storage period of 30 days.
A significant effect of different levels of aerial yam powder was noticed on the b* value for colour of the cookies. As the percentage of powder increased, the b* value also increased. The treatment T_5 (50% AYF) recorded highest mean a* value (32.22) for colour which was at par with T_4 (40% AYF) (32.04), while the lowest b* value for colour (27.90) was noticed in the treatment T_1 (100% *Maida*). The treatment T2 (20% AYF) (30.63) and T_3 (30% AYF) (31.05) were at par with each other. The colour b* value varied significantly during storage irrespective of the treatments. It is clear from the data that, the colour b* value decreased during storage of 30 days. The highest (31.11) mean b* value for colour was recorded at 0 day of storage and the lowest (30.31) mean b* value for colour was observed at 30 days of storage. The interaction effects related to b* value for colour of the product between treatment and the storage period were found statistically non-significant.

Table 7: Effect of different levels of aerial yam flour on b* value for colour of aerial yam cookies during storage at ambient conditions

Treatments	b* value for colour				
	Storage period (Days)				
	0	10	20	30	Mean
T_1	28.17	28.03	27.91	27.48	27.90
T_2	31.17	30.89	30.83	29.61	30.63
T_3	31.29	31.28	31.13	30.48	31.05
T_4	32.42	32.20	31.58	31.96	32.04
T_5	32.51	32.41	31.98	31.99	32.22
Mean	31.11	30.96	30.69	30.31	
	S.E.m ±		C.D. at 5 %		
Treatment (T)	0.22		0.64		
Storage (S)	0.25		0.71		
Interaction (TXS)	0.43		NS		

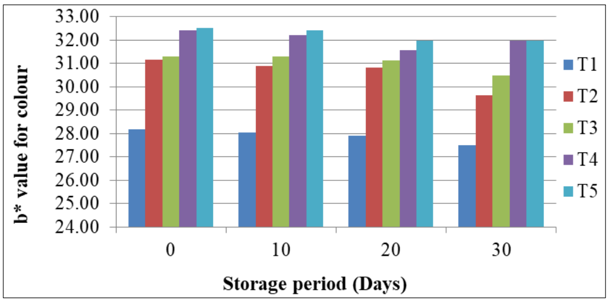

Fig 6: Effect of different levels of aerial yam flour on b* value for colour of aerial yam cookies during storage at ambient conditions

The identical observations to this are also reported by Singh *et al*. (2008) in sweet potato flour cookies.

3.5 Changes in sensory qualities of aerial yam powder cookies during storage
The cookies prepared from different levels of aerial yam powder were subjected to sensory evaluation for colour, flavour, texture and overall acceptability at 0, 10, 20 and 30 days interval during storage. Cookies were evaluated for their sensory characteristics by a panel of trained judges on 9 point score card.

3.5.1 Colour
The results on the changes in colour score of aerial yam cookies as influenced by treatments and storage period are presented in Table 8 and graphically illustrated in Fig.7.
It could be noticed from the data that the results with respect to the changes in the sensory score for colour of the aerial yam cookies prepared by four different aerial yam flour levels were statistically significant. From the sensory score, it was observed that the mean colour score of the aerial yam cookies was significantly higher (7.69) in the treatment T_2 i.e. (20% AYF), which was at par with T_3 (30% AYF) and T_1 (100% *Maida*) while mean colour score was lowest (7.16) in the treatment T_5 i.e. (50% AYF). The treatment T_1 (100% *Maida*) was at par with the treatment T_4 (40% AYF) and T_1 (7.25). It is clear from the data that the higher (40% to 50%) levels of aerial yam powder significantly lowered the sensory score for colour.

Table 8: Changes in sensory score for colour of aerial yam powder cookies during storage at ambient conditions

Treatments	Sensory score for colour				
	Storage period (Days)				
	0	10	20	30	Mean
T_1	7.37	7.25	7.25	7.12	7.25
T_2	7.75	8.0	7.63	7.37	7.69
T_3	7.75	8.0	7.5	7.38	7.66
T_4	7.50	7.25	7.13	7.00	7.22
T_5	7.5	7.25	6.88	7.00	7.16
Mean	7.58	7.55	7.28	7.18	
	S.E.m ±		C.D. at 5 %		
Treatment (T)	0.15		0.45		
Storage (S)	0.17		NS		
Interaction (TXS)	0.30		NS		

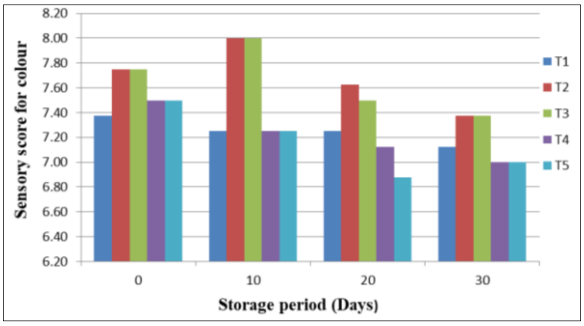

Fig 7: Changes in sensory score for colour of aerial yam cookies during storage at ambient conditions

The score for colour decreased non-significantly during storage. Maximum (7.58) mean colour score was observed at initial day of storage while minimum (7.18) mean colour score was observed at the end of 30 days of storage, however, results more statistically non-significant. The interaction effect between treatments and storage period was also found to be statistically non-significant.

Similar decreasing trend of sensory score for colour was reported by Saeed *et al*. (2012) [23] in cookies prepared with sweet potato flour.

3.5.2. Flavour

Flavour is also a very important organoleptic parameter and the data on the changes in the flavour score of aerial yam cookies as influenced by treatments and storage period are presented in Table 9 and graphically illustrated in Fig.8.

Table 9: Changes in sensory score for flavour of aerial yam powder cookies during storage at ambient conditions

Treatments	Sensory score for flavour				
	Storage period (Days)				
	0	10	20	30	Mean
T_1	7.70	7.37	7.07	6.75	7.23
T_2	8.12	7.80	7.58	7.25	7.69
T_3	7.63	7.30	7.00	6.88	7.20
T_4	7.25	6.88	6.63	6.38	6.78
T_5	7.12	6.75	6.45	6.18	6.63
Mean	7.57	7.22	6.95	6.69	
		S.E.m ±		C.D. at 5 %	
Treatment (T)		0.13		0.38	
Storage (S)		0.15		0.43	
Interaction (TXS)		0.26		NS	

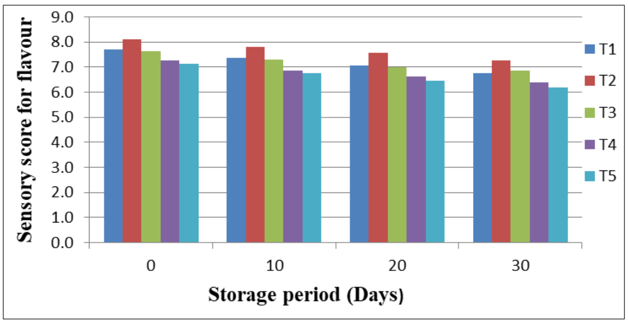

Fig 8: Changes in sensory score for flavour of aerial yam cookies during storage at ambient conditions

It is revealed from the data that there were significant variations in sensory score for flavour due to the treatments during storage. From the sensory score, it was observed that the mean flavour score was significantly highest (7.69) in the treatment T_2 i.e. (20% AYF), followed by the treatment T_1 (100 % Maida) with 7.23 sensory score which was at par with the treatment T_3 (30% AYF) with 7.20 sensory score for flavour. While mean flavour score was lowest (6.63) in the treatments T_5 i.e. (50% AYF), followed by the treatment T_4 (40% AYF). Increasing the aerial yam flour levels adversely affected the score for flavour of the aerial yam cookies. The product with higher level of aerial yam flour was not much liked by the sensory panel. The score for flavour decreased significantly during storage. Maximum (7.57) mean flavour score was observed at initial day of storage while minimum (6.69) mean flavour score was recorded at the end of 30 days of storage. The interaction between treatments and storage period was found to be statistically non- significant.

Similar decreasing trend in sensory score for flavour score was reported by Saeed *et al.* (2012) [23] in the sweet potato flour cookies.

3.5.3 Texture

The results related to the changes in the organoleptic score for texture of aerial yam cookies as influenced by treatments and storage period are presented in Table 10 and graphically illustrated in Fig. 9.

Table 10: Changes in sensory score for texture of aerial yam powder cookies during storage at ambient conditions

Treatments	Sensory score for texture				
	Storage period (Days)				
	0	10	20	30	Mean
T_1	7.63	7.37	7.00	6.88	7.22
T_2	8.25	7.87	7.63	7.37	7.78
T_3	7.63	7.38	7.00	6.88	7.22
T_4	7.13	6.95	6.70	6.35	6.78
T_5	6.87	6.58	6.33	6.05	6.46
Mean	7.50	7.23	6.93	6.71	
		S.E.m ±		C.D. at 5 %	
Treatment (T)		0.10		0.30	
Storage (S)		0.11		0.33	
Interaction (TXS)		0.20		NS	

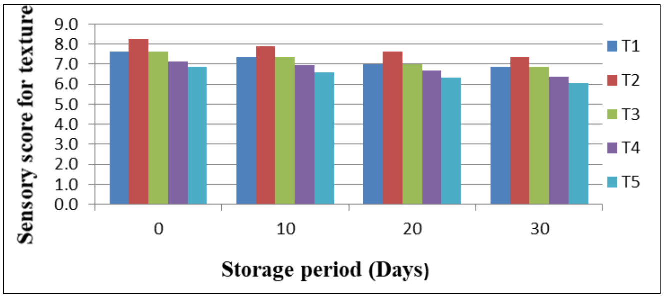

Fig 9: Changes in sensory score for texture of aerial yam cookies during storage at ambient conditions

It could be noticed from the data that the changes in the sensory score for texture of the aerial yam cookies prepared by using 4 different aerial yam flour levels were statistically significant. Moreover, the storage period also significantly influenced the texture of the aerial yam cookies irrespective of the treatments. The statistical analysis of sensory score for texture of aerial yam cookies reveals that there was a significant difference in mean score for texture among the treatments. Maximum (7.78) mean score for texture was obtained by the treatment T_2 (20% AYF) which was followed by the treatment T_1 (100% *Maida*) (7.22) and T_3 (30% AYF)

(7.22). Minimum (6.46) mean score for texture of aerial yam cookies was recorded in the treatment T_5 (50% AYF), followed by the treatment T_4 (40% AYF).The sensory score for texture declined with increase in the level of aerial yam flour in the cookies. The score for texture of aerial yam cookies decreased significantly throughout the storage period of 30 days. The maximum (7.50) mean texture score was observed at initial day of storage while minimum (6.71) mean score for texture was observed at the end of 30 days of storage. A decline in the sensory score for texture might be due to the significant increase in the moisture content of the aerial yam flour during storage at ambient temperature.
Similar decreasing trend in sensory score for texture was reported by Mehta (2013) [14] in biscuits.

3.5.4 Overall acceptability
Overall acceptability for any product includes average organoleptic score for colour, flavour and texture. The data on the changes in the overall acceptability score of aerial yam cookies as influenced by treatments and storage period are presented in Table 11 and graphically illustrated in Fig.10.

Table 11: Changes in sensory score for overall acceptability of aerial yam powder cookies during storage at ambient conditions

Treatments	Sensory score for overall acceptability				
	Storage period (Days)				
	0	10	20	30	Mean
T_1	7.57	7.33	7.10	6.91	7.23
T_2	8.03	7.88	7.60	7.33	7.72
T_3	7.66	7.56	7.16	7.04	7.36
T_4	7.29	7.02	6.82	6.57	6.92
T_5	7.16	6.86	6.55	6.41	6.74
Mean	7.54	7.33	7.05	6.85	
	S.E.m ±		C.D. at 5 %		
Treatment (T)	0.10		0.29		
Storage (S)	0.11		0.32		
Interaction (TXS)	0.19		NS		

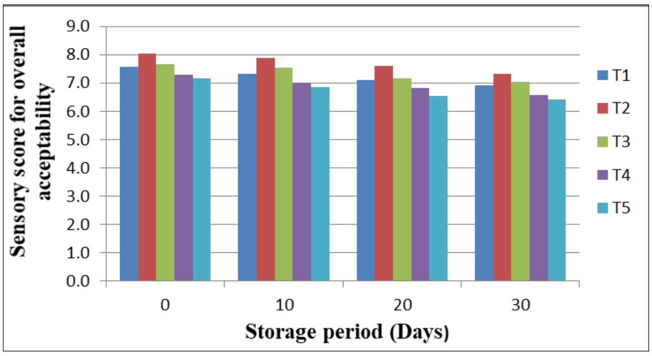

Fig 10: Changes in sensory score for overall acceptability of aerial yam cookies during storage at ambient conditions

It is revealed from the data that there was a significant variation in the overall acceptability score due to the treatments for the samples analyzed over the storage period of 30 days. From the sensory score, it is observed that the mean overall acceptability score was considerably higher in the treatment T_2 (20% AYF) (7.72), followed by the treatment T_3 (30% AYF) (7.36) which was at par with the treatment T_1 (100 % *maida*) (7.23). While mean acceptability score was recorded the lowest (6.74) in the treatment T_5 *i.e.* the cookies with 50% AYF however, it was at par with the treatment T_4 (40% AYF) (6.92). It is evident from the data that good quality cookies could be prepared by incorporating 20 per cent aerial yam flour in the cookies. The score for overall acceptability decreased significantly during storage. The maximum (7.54) mean overall acceptability score was observed at initial day of storage while minimum (6.85) mean overall acceptability score was recorded at 30 days of storage. The decrease in the overall acceptability of the product was due to loss of colour, flavour as well as the texture of the aerial yam cookies during storage. The interaction between treatments and storage period was found to be statistically non-significant.
Similar decreasing trend in sensory score for overall acceptability was reported by Mehta (2013) [14] in biscuits and Saeed *et al*. (2012) [23] in sweet potato cookies.

3.6 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 "Development of the process for preparation of aerial yam (*Dioscorea bulbifera*) cookies with studying changes in the physical and sensory quality parameters during storage" was carried out to assess effect of different levels of aerial yam powder and *maida* in the cookies on physical and sensory characteristics of aerial yam powder cookies. The aerial yam powder cookies prepared from different treatments were evaluated for their physical and sensory qualities. 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.

	0 day of storage	**10th day of storage**	**20th day of storage**	**30th day of storage**
T_1				
T_2				
T_3				
T_4				
T_5				
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, 10th, 20th and 30 th days of storage at ambient temperature

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