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Studies on the effect of different Storage conditions on Keeping quality and Physical properties of Orange Fleshed Sweet potato (*Ipomea batatas* L. Lam) Flour Cake

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ABSTRACT: The shelf life of fresh sweet potato tubers only a few days and they are semi-perishable in nature. This necessitates the development of user-friendly processing techniques for the tubers. If sweet potato is converted in to flour, it can be used to make a variety of foods, products, including baked products. In this study, the effect of different storage conditions on keeping quality and physical properties of orange fleshed sweet potato (*Ipomea batatas* L. Lam) flour cake was investigated. Cakes were prepared by substituting orange fleshed sweet potato flour and wheat flour in standard recipe at different proportions 0, 10, 20, 30, 40 and 50%. The diameter and thickness of cake showed a slight decreasing in trend from 6.175 to 4.979 cm and from 3.80 to 1.64 cm respectively. Moisture content and volume found to decrease from 31.62 to 6.27 per cent and 145.13 to 40.67 g/l respectively. While spread ratio and density increased from 1.63 to 3.04 and 0.145 to 0.625 g/cm^3 respectively with respect to two different storage conditions. In case of instrumental colour values, decrease in trend was observed throughout the storage with respect to *L, increase trend was observed in *a** and *b** values. The *L** (69.14 to 22.85), whereas increase in *a** (3.09 to 4.88) and *b** values varied from 20.74 to 30.66 among different storage conditions. Cakes prepared from F_4 treatment (70% WF + 30% SPF) has shown highest score for overall acceptability compared to other treatments.**

Keywords: Orange fleshed sweet potato (OFSP), Wheat flour (WF), ambient condition, Refrigerated condition, Days after storage (DAS).

INTRODUCTION

Sweet potato (*Ipomoea batatas* L. Lam) is a sweet tasting, starchy root vegetable belongs to genus *Ipomoea* is a member of morning glory family (*Convolvulaceae*). This family group includes about 60 genera and more than 1650 species in that *Ipomoea batatas* has demonstrated its economic significance as food. Although the vines and leaves can also be eaten, the tubers are the primary edible component of this perennial herbaceous plant.

Sweet potato is a common staple food in tropical, subtropical regions and its increased cultivation, consumption attest to its nutritional benefits. Asia and the Pacific islands produce the most sweet potatoes, accounting for 93% of the world's crop (Prathiksha and Naik 2019). In terms of fresh weight, sweet potatoes are ranked as the fifth most important food crop in developing nations after rice, maize, wheat, cassava and as the fourth most important crop in tropical regions. In India the major sweet potato producing states are Odisha, Uttar Pradesh, West Bengal and Kerala. Karnataka is one of the developing states in India for growing sweet potatoes and Belagavi district has the highest sweet potato productivity when compared to other districts.

In several developed nations today, overnutrition rather than undernutrition is a significant public health challenge. On the other hand, from a global standpoint, the main difficulties include limited agricultural technologies, food insecurity, droughts and undernutrition. Many farmers in underdeveloped nations rely heavily on root and tuber crops as a source

of food, nutrition and income (Scott *et al.*, 2000). From this stand point, sweet potato is one such crop which has the nutritional value and also health benefits. Among different genotypes of sweet potato, there is a significant variance in quality criteria, which may be caused by the genotype's genetic makeup and the environment (Ayeleso *et al.*, 2016). Some biofortified varieties like Bhu Sona is rich source of β-carotene content (13 mg/100g) and Bhu Krishna is rich in anthocyanin content (85-90 mg/100g).

Most of the time sweet potatoes are typically eaten baked, boiled, microwaved, steamed or fried and through various value-added products. Sweet potatoes' physical traits and chemical composition would undoubtedly change as a result of these cooking techniques. The sweetness/sugar content of sweet potato tubers is greatly influenced by a number of parameters, including maturity period, storage, amylase potential, curing and baking treatment (Dziedoave *et al.*, 2010; Wang and Kays 2000).

Farmers, crop sellers and crop consumers all struggle with the issue of preserving produced crops. The shelf life of fresh sweet potato tubers is only a few weeks and they are semi-perishable in nature. This necessitates the development of user-friendly processing techniques for the tubers. If sweet potato is used to make the flour, it can be used to make a variety of foods, including baked goods (bread, brownies, cakes, cookies and biscuits), breakfast foods (instant oatmeal, crisp and flake products), noodles, sauces (ketchup, soy sauce), and brewing adjuncts (Van Hal, 2000; Mais and Brennan 2008).

Bhu Sona is the orange fleshed biofortified variety of sweet potato which is developed by ICAR-CTCRI, Thiruvananthapuram, Kerala. It has high β-carotene (13.0 mg/100g) content as compared to 2-3 mg/100g in popular varieties. This helps in controlling of vitamin A deficiency. It is a medium duration crop (100-110 days) and average yield is about 18.8-19.7 t/ha. This variety is suitable for nutritious food processing industries. Use of this biofortified variety can helpful in preparation of sweetened, flavoured carotene rich cake.

Processing of sweet potato into flour is perhaps the most satisfactory method of creating a product that is not only functionally adequate, but also remain for an extended period without spoilage. In case of processed food products, sweet potato flour can contribute natural sweetness, colour and imparts a distinctive, pleasing flavour. So, there is more scope for cultivation and processing or value addition of sweet potato tuber. In light of this, the present study is designed to know the effect of different storage conditions on keeping quality and physical properties of orange fleshed sweet potato flour cake.

MATERIAL AND METHODS

The present study was conducted during 2021-22 in the Department of Post Harvest Technology, Kittur Rani Channamma College of Horticulture, Arabhavi, (UHS, Bagalkot) of Belgaum district in Karnataka state of India.

Procurement of raw materials. Fresh sweet potato tubers of uniform size representing Bhu Sona variety were obtained from the AICRP tuber crop study area at the Regional Horticulture Research and Extension Centre in Dharwad, Karnataka. Selecting uniform mature tubers free of disease and insect infestation was undertaken. The hydrogenated fat (vanaspati), baking powder, wheat flour, sugar, cake gel, oil and eggs were bought from the small grocery store in Gokak, Belagavi district.

Preparation of orange fleshed sweet potato flour. The tubers were cleaned by washing away unwanted debris that had been adhered. Using a hand peeler, the outer skin was peeled off. Using a hand slicer, peeled tubers were cut into slices. The slices were then wrapped in muslin cloths and blanched for one minute at 80°C by immersing in hot water. Slices that had been blanched were air dried for 6 hours at 60°C in a tray dryer and cooled. The flour made from orange-fleshed sweet potato was produced by grinding dried slices in a grinder.

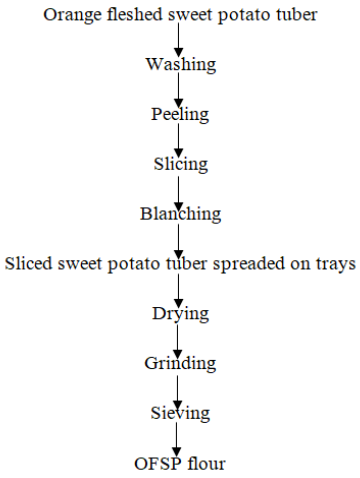

Fig. 1. Flow chart of preparation of orange fleshed sweet potato flour.

Treatment details:

Levels	Wheat Flour (%)	Sweet Potato Flour (%)
F_1	100	0
F_2	90	10
F_3	80	20
F_4	70	30
F_5	60	40
F_6	50	50

Factor 2: Storage condition

Levels	Storage condition
S_1	Refrigerated storage
S_2	Ambient storage

The experiment was laid out in a factorial completely randomized design (FCRD) with 12 treatments in 2 replications.

Preparation of OFSP flour enriched cake. Required quantity of wheat flour, OFSP flour, sugar, baking powder, cake gel, oil and eggs were sieved and mixed well with to make fine cream. Then cake gel and oil were added and beaten properly in one direction to give proper consistency. Further batter was poured into the

cup cake pans which were lined with butter paper. The baking was performed in pre heated oven at 180°C for 20 minutes. Cakes were cooled and packed in punnet boxes, labeled and stored at ambient and refrigerated conditions.

Observations recorded: The following physical parameters were recorded immediately after preparation of sweet potato cakes subjected for different storage conditions were recorded at initial and three days intervals.

Moisture content (%). Using a moisture analyzer, the moisture content of the sweet potato cake was assessed (Model: P1019319, A & D Company Limited, Japan). The electric moisture analyzer was used to dry one gram of sample until it automatically reported a stable moisture content in percentage.

Diameter and Thickness. The diameter and thicknes sof sweet potato cake was measured using digital vernier caliper by placing cake in between the measuring arms of the instrument and values were recorded in centimeter.

Spread ratio. Spread ratio of cake was determined by the ratio of diameter to thickness of cake.

Volume (g/l). Volume of cake was determined as the thickness of cake multiplied by its square of diameter.

Density (g/cm^3). After calculating the volume of cake, density of them was obtained by ratio of mass (g) to volume (cm^3).

Colour (*L* a* b) values.** Using a Colour Flex EZ colorimeter (Model: CFEZ 1919, Hunter Associates Laboratory, Inc., Reston) equipped with a 45 mm diameter aperture, the samples' colour was measured. Utilizing the given black and white tiles, which are two different colour tiles, the device was calibrated. *L** (lightness/darkness), *a** (redness/greenness) and *b** (yellowness/blueness) were used to describe colour.

Organoleptic evaluation (9 point hedonic scale). Organoleptic evaluation of sweet potato cake was carried out on a nine-point hedonic scale using the method of Ranganna (2003) by a semi-trained panel of judges consisting of teachers and post-graduate students of Kittur Rani Channamma College of Horticulture, Arabhavi.

Statistical analysis. The data recorded from the experiment was subjected to statistical analysis in a factorial completely randomized design. Interpretation of the data was carried out in accordance with Panse and Sukhatme (1985). The level of significance used in 'F' test was p=0.01. Critical difference values were calculated wherever 'F' test was significance.

RESULT AND DISCUSSION

Moisture content (%). The mean data showing decrease in moisture percentage of orange fleshed sweet potato flour enriched cake from 31.62 to 6.85 as influenced by flour combinations and storage conditions was observed (Table 1).

Initially irrespective of storage condition significantly, mean moisture per cent increased from F_1 (25.29%) to F_6 (31.62%) with no significant difference in storage condition and their interaction with the composite flour. This might be due to fibre absorbs moisture and as the fibre content increases moisture content also increases. Similar results were reported by Okorie and Onyeneke (2012).

Nine DAS decrease in moisture content with respect to ambient and refrigerated storage conditions noticed irrespective of flour combinations ranging from 27.61 to 11.18 per cent in ambient storage and 27.61 to 12.41 per cent in refrigerated storage condition. The maximum was seen in F_6S_1 (17.57%) and minimum was seen in F_1S_2 (6.27%). The overall effect of storage intervals and treatments as reflected in interaction table signifies that the moisture content decreased from 27.61 to 11.18 per cent during storage period. Retrogradation, which causes water evacuation through a process termed syneresis, could be the main cause of the decreasing moisture content during storage period. Similar results were also obtained by Pohjanheimo *et al.*, 2006; Al-Sayed and Ahmed (2013); Cai *et al.*, 2014 ; Noorlaila *et al.*, 2017.

Diameter (cm). The data on the effect of flour combinations on diameter of OFSP enriched cake as influenced by storage conditions are presented in table 2. Mean diameter of sweet potato cake gradually decreased from 6.175 to 4.992 cm with the increase in storage period.

During initial days irrespective of storage condition significantly mean values of diameter decreased from 6.175 cm (F_1) to 5.299 cm (F_6). There was a decrease in trend with the values of diameter as the level of substitution of OFSP flour increased. This might be due to the decrease in gluten network that prevents it from rising which results in low volume of cake (Bibiana *et al.*, 2014). These results were in line with Adeleke and Odedeji (2010). No significant difference noticed for storage condition and interaction of it with the flour combinations.

Nine DAS highest diameter was seen in F_1S_1 (5.865 cm) followed by F_1S_2 (5.815 cm) and lowest was seen in F_6 (4.979 cm) at ambient condition. Irrespective of flour combinations highest mean diameter noticed in refrigerated (S_1) stored cakes (5.703, 5.632 and 5.443 cm) and minimum noticed in ambient (S_2) stored cakes (5.659, 5.585 and 5.394 cm) at 3, 6 and 9 DAS respectively. The mean values at storage condition were reduced from 5.742 to 5.394 cm. This might be due to loss of moisture as well as chemical constituents such as crude fibre and ash content as the storage period progressed. These results are confirmatory with the findings of Adeleke and Odedeji (2010).

Thickness (cm). Mean thickness of sweet potato cake gradually decreased from 3.80 to 1.66 cm with the increase in storage period (Table 3).

Initially irrespective of storage condition significantly, mean values of thickness decreased from 3.80 cm (F_1) to 2.62 cm (F_6) with no significant difference in storage condition and their interaction with the composite flour treatments. There was a decrease in trend with the values of thickness as the level of substitution of OFSP flour increased. This might be due to the decrease in gluten network that prevents it from rising which results in low volume of cake (Bibiana *et al.*, 2014). These results were in line with Adeleke and Odedeji (2010).

Nine DAS highest thickness was seen in F_1S_1 (3.03 cm) followed by F_1S_2 (2.84 cm) and lowest was seen in F_6 (1.64 cm) at ambient condition. Irrespective of flour combinations highest mean thickness noticed in refrigerated (S_1) stored cakes (3.13, 2.85 and 2.35 cm) and minimum noticed in ambient (S_2) stored cakes (3.01, 2.72 and 2.24 cm) at 3, 6 and 9 DAS respectively. The mean values at storage condition were reduced from 3.26 to 2.24 cm. This might be due to loss of moisture as well as chemical constituents such as crude fibre and ash content as the storage period progressed. These results are confirmatory with the findings of Adeleke and Odedeji (2010).

Spread ratio. The data regarding the effect of flour combinations on spread ratio of OFSP enriched cake as influenced by storage conditions are presented in table 4. Increase trend noticed in mean spread ratio of OFSP enriched cake throughout the storage period from 2.02 to 3.01.

At initial days of storage mean values of spread ratio increased from F_1 (1.63) to F_6 (2.02). The spread ratio of cake gradually increased with the increment of the sweet potato flour. This might be due to decrease in thickness of OFSP flour enriched cake and due to the low protein content of the sweet potato flour (Toan and anh 2018).

Nine DAS highest spread ratio was seen in F_6S_2 (3.04) followed by F_6S_1 (2.98) and lowest was seen in F_1 (1.94) at refrigerated condition. Irrespective of flour combinations significantly, minimum mean spread ratio noticed in refrigerated (S_1) stored cakes (1.84, 2.00 and 2.38) and maximum noticed in ambient (S_2) stored cakes (1.91, 2.09 and 2.46) at 3, 6 and 9 DAS respectively. The mean values at storage condition were increased from 1.78 to 2.46. Increase trend noticed in spread ratio of OFSP flour enriched cake throughout the storage period. This might be due to decrease in diameter and thickness of OFSP flour enriched cake as well as chemical constituents such as crude fibre and ash content as the storage period progressed. Similar results were also obtained by Adeleke and Odedeji (2010).

Volume (g/l). The volume of cake enriched with OFSP flour influenced by flour combinations and storage conditions evident that the mean values of volume showed decrease in trend from 145.13 to 41.42 g/l (Table 5).

Initially irrespective of storage condition significantly, maximum mean volume noticed in F_1 (145.13 g/l) followed by F_2 (131.20 g/l) and minimum was seen in F_6 (73.56 g/l). The mean values have shown decrease trend as the OFSP flour per cent increases. This reduction might be due to the lower gluten level presence during dough formulation while increasing the OFSP flour. Similar results were also obtained by EI-Zainy *et al.* (2010).

Nine DAS highest volume was seen in F_1S_1 (104.40 g/l) followed by F_1S_2 (96.20 g/l) and lowest was seen in F_6 (40.67 g/l) at ambient condition. Irrespective of flour combinations significantly, maximum mean volume was noticed in refrigerated (S_1) stored cakes (103.53, 92.22 and 71.26 g/l) and minimum was noticed in ambient (S_2) stored cakes (92.80, 86.71 and 66.85 g/l) at 3, 6 and 9 DAS respectively. The mean values at storage condition were reduced from 109.47 to 66.85 g/l. The reduction in volume may be due to dilution of gluten, physical interactions and chemical reactions between fibre components, water and gluten (Wanjuu *et al.*, 2018).

Density (g/cm^3). The densityof cake enriched with OFSP flour influenced by flour combinations and storage conditions evident that the mean values of density showed increase in trend from 0.145 to 0.625 as the storage period progressed (Table 6).

Initially irrespective of storage condition significantly, maximum mean density noticed in F_1 (0.415 g/cm^3) followed by F_5 (0.345 g/cm^3) and minimum was seen in F_1 (0.145 g/cm^3). The mean values have shown increase trend as the OFSP flour per cent increases. This might be due to the decrease in gluten network that prevents it from rising which results in low volume of cake (Bibiana *et al.*, 2014).

Significantly, 9 DAS highest density was seen in F_6S_1 (0.625g/cm^3) and lowest was seen in F_1 (0.235 g/cm^3) at ambient condition. Irrespective of flour combinations significantly, maximum mean value was found in refrigerated (S_1) stored cakes (0.308, 0.349 and 0.445 g/cm^3) and minimum was found in ambient (S_2) stored cakes (0.289, 0.334 and 0.422 g/cm^3) at 3, 6 and 9 DAS respectively. The mean values at storage condition were increased from 0.266 to 0.445 g/cm^3. Increase trend noticed in density of OFSP flour enriched cake throughout the storage period. Due to the fiber effect, the air "escapes," leaving the cake denser with a smaller volume (Gewehr *et al.*, 2016).

Colour(*L* a and *b**).** Results of *L* a* b**values of OFSP flour enriched cake are significantly different from each other (Table 7-9) and has shown the decreasing trend in the *L** values and increasing trend in *a*, b**values.

Results from Table 7 shows that initially irrespective of storage condition significantly, maximum *L** value in cake noticed in F_1 (69.14) treatment with 100% wheat flour indicating lighter colour of cake and minimum noticed in F_6 (57.77). *L** value decrease as the level of OFSP flour increases. This might be due to the fact that OFSP flour contain carotene and imparts darker colour compared to wheat flour. As the storage period increases mean *L** value shows significantly decreasing trend and varied from 69.14 to 27.47. At 3, 6 and 9 DAS maximum colour (*L** values) was seen in F_1S_1 (67.86, 66.88 and 56.71, respectively) and minimum noticed in F_6S_2 (50.77, 47.15 and 22.85 respectively).

Results from table 8 shows that initially irrespective of storage condition significantly, maximum mean *a** (redness) value was seen in F_6 (4.09) treatment and minimum was seen in F_1 (3.09) treatment. At 3, 6 and 9 DAS significantly, highest colour (*a** values) was seen in F_6S_1 (4.94, 4.89 and 4.88 respectively) and lowest noticed in F_1S_2 (3.10, 3.18 and 3.16 respectively).

Results from table 9 shows that initially irrespective of storage condition significantly, maximum mean *b** (yellowness) value was seen in F_6 (27.15) treatment and minimum was seen in F_1 (20.74) treatment. At 3, 6 and

9 DAS significantly, maximum colour (*b** values) was seen in F_6S_1 (29.66, 29.61 and 30.66 respectively) and minimum noticed in F_1S_2 (22.57, 23.12 and 24.54 respectively). Here both *a** and *b** values increase with increase in OFSP flour level and increases as the storage period increases.

The substitution of wheat flour with OFSP flour produced redder, yellower and brighter cake (Malavi *et al.,* 2022). The colour change is contributed by β-carotene from the OFSP flour, Maillard browning and caramelization, which are influenced by the distribution of water and the reaction between reducing sugars and amino acids (Lim *et al.,* 2011). Similar observations were also done by earlier researcher Singh *et al.* (2008); Sangnark and Noomhorm (2004).

Overall acceptability. Table 10 shows the effect of flour combinations on overall acceptability of OFSP enriched cake as influenced by storage conditions. The data revealed that throughout the storage period, mean overall acceptability of OFSP enriched cake decreased from 7.58 to 6.45.

Results from table 10 have shown that cake supplemented with 0% of sweet potato flour (F1) had the least mean score (6.98) in overall acceptability at initial irrespective of storage condition and highest noticed in F_4 (7.58). After 9 days of storage score was obtained in F_4 (7.37) stored in refrigerated condition (S_1) and lowest was seen in F_1 (6.24) stored in ambient condition (S_2). Irrespective of flour combinations significantly, maximum mean score noticed in refrigerated (S_1) stored cakes (7.21, 7.16 and 7.11) and minimum noticed in ambient (S_2) stored cakes (7.04, 6.97 and 6.93) at 3, 6 and 9 DAS respectively.

Overall acceptability scores showed a decreasing trend with advancement in storage period from 7.27 to 6.93, might be due to non-enzymatic oxidation process within the cake. A decreasing trend of score during storage has also been noticed in cookies by Endrias *et al.* (2016); Borneo *et al.* (2007); Agrawal *et al.* (2017); Mushtaq *et al.* (2010) and in muffins by Priyanka (2017).

Table 1: Effect of flour combinations on moisture content (%) of orange fleshed sweet potato flour enriched cake as influenced by storage conditions.

Treatments	Days after storage											
	Initial			3			6			9		
	S		Mean	S		Mean	S		Mean	S		Mean
	S_1	S_2		S_1	S_2		S_1	S_2		S_1	S_2	
F_1	25.29	25.29	25.29	20.34	15.43	17.88	12.29	10.17	11.23	7.43	6.27	6.85
F_2	25.69	25.69	25.69	21.36	17.05	19.21	13.36	12.17	12.76	9.38	8.19	8.79
F_3	26.69	26.69	26.69	23.41	18.36	20.89	14.26	13.06	13.66	11.43	10.39	10.91
F_4	27.65	27.65	27.65	25.29	20.44	22.87	16.29	15.35	15.82	13.38	12.42	12.90
F_5	28.70	28.70	28.70	26.09	23.12	24.60	18.44	16.30	17.37	15.28	14.42	14.85
F_6	31.62	31.62	31.62	28.16	25.30	26.73	25.41	22.84	21.62	17.57	15.40	11.80
Mean	**27.61**	**27.61**		**24.11**	**19.95**		**16.67**	**14.98**		**12.41**	**11.18**	
	S.Em±		**C.D.@1%**	**S.Em±**		**C.D.@1%**	**S.Em±**		**C.D.@1%**	**S.Em±**		**C.D.@1%**
F	0.003		0.01	0.005		0.02	0.010		0.04	0.008		0.04
S	0.002		**NS**	0.003		0.01	0.006		0.02	0.005		0.02
F × S	0.004		**NS**	0.007		0.03	0.014		0.06	0.012		0.05

NOTE: **Factor 1**: Composite flour **(F)Factor 2:** Storage condition **(S)**

F_1: 100% Wheat flour + 0% Sweet potato flour
F_2: 90% Wheat flour + 10% Sweet potato flour
F_3: 80% Wheat flour + 20% Sweet potato flour
F_4: 70% Wheat flour + 30% Sweet potato flour
F_5: 60% Wheat flour + 40% Sweet potato flour
F_6: 50% Wheat flour + 50% Sweet potato flour

S_1: Refrigerated
S_2: Ambient
NS – Non Significant

Table 2: Effect of flour combinations on diameter (cm) of orange fleshed sweet potato flour enriched cake as influenced by storage conditions.

Treatments	Days after storage											
	Initial			3			6			9		
	S		Mean	S		Mean	S		Mean	S		Mean
	S_1	S_2		S_1	S_2		S_1	S_2		S_1	S_2	
F_1	6.175	6.175	6.175	6.125	6.079	6.102	6.055	6.01	6.033	5.865	5.815	5.840
F_2	6.015	6.015	6.015	5.967	5.915	5.941	5.895	5.845	5.870	5.710	5.655	5.683
F_3	5.825	5.825	5.825	5.770	5.719	5.745	5.695	5.645	5.670	5.505	5.455	5.480
F_4	5.705	5.705	5.705	5.679	5.639	5.659	5.605	5.565	5.585	5.415	5.375	5.395
F_5	5.435	5.435	5.435	5.409	5.368	5.389	5.345	5.275	5.310	5.155	5.085	5.120
F_6	5.299	5.299	5.299	5.267	5.238	5.253	5.195	5.17	5.183	5.005	4.979	4.992
Mean	**5.742**	**5.742**		**5.703**	**5.659**		**5.632**	**5.585**		**5.443**	**5.394**	
	S.Em±		**C.D. @1%**	**S.Em±**		**C.D. @1%**	**S.Em±**		**C.D. @1%**	**S.Em±**		**C.D. @1%**
F	0.002		0.009	0.002		0.007	0.003		0.014	0.003		0.014
S	0.001		**NS**	0.001		0.004	0.002		0.008	0.002		0.008
F × S	0.003		**NS**	0.002		0.010	0.005		0.020	0.005		0.020

NOTE: **Factor 1**: Composite flour **(F)Factor 2:** Storage condition **(S)**

F_1: 100% Wheat flour + 0% Sweet potato flou
F_2: 90% Wheat flour + 10% Sweet potato flour
F_3: 80% Wheat flour + 20% Sweet potato flour
F_4: 70% Wheat flour + 30% Sweet potato flour
F_5: 60% Wheat flour + 40% Sweet potato flour
F_6: 50% Wheat flour + 50% Sweet potato flour

S_1: Refrigerated
S_2: Ambient
NS – Non Significant

Table 3: Effect of flour combinations on thickness (cm) of orange fleshed sweet potato flour enriched cake as influenced by storage conditions.

Treatments	Days after storage											
	Initial			3			6			9		
	S		Mean	S		Mean	S		Mean	S		Mean
	S_1	S_2		S_1	S_2		S_1	S_2		S_1	S_2	
F_1	3.80	3.80	3.80	3.73	3.61	3.67	3.45	3.33	3.39	3.03	2.84	2.93
F_2	3.62	3.62	3.62	3.49	3.40	3.44	3.18	3.05	3.11	2.67	2.56	2.61
F_3	3.40	3.40	3.40	3.24	3.13	3.18	2.92	2.85	2.88	2.45	2.31	2.38
F_4	3.22	3.22	3.22	3.05	2.94	3.00	2.75	2.68	2.72	2.24	2.17	2.20
F_5	2.92	2.92	2.92	2.73	2.66	2.69	2.51	2.43	2.47	2.02	1.95	1.98
F_6	2.62	2.62	2.62	2.54	2.33	2.43	2.32	2.01	2.16	1.68	1.64	1.66
Mean	**3.26**	**3.26**		**3.13**	**3.01**		**2.85**	**2.72**		**2.35**	**2.24**	
	S.Em±		**C.D. @1%**	**S.Em±**		**C.D. @1%**	**S.Em±**		**C.D. @1%**	**S.Em±**		**C.D.@1%**
F	0.010		0.04	0.003		0.01	0.011		0.05	0.005		0.02
S	0.006		**NS**	0.001		0.01	0.006		0.03	0.003		0.01
F × S	0.014		**NS**	0.004		0.02	0.015		0.07	0.007		0.03

NOTE: **Factor 1**: Composite flour **(F)Factor 2:** Storage condition **(S)**

F_1: 100% Wheat flour + 0% Sweet potato flour
F_2: 90% Wheat flour + 10% Sweet potato flour
F_3: 80% Wheat flour + 20% Sweet potato flour
F_4: 70% Wheat flour + 30% Sweet potato flour
F_5: 60% Wheat flour + 40% Sweet potato flour
F_6: 50% Wheat flour + 50% Sweet potato flour

S_1: Refrigerated
S_2: Ambient
NS – Non Significant

Table 4: Effect of flour combinations on spread ratio of orange fleshed sweet potato flour enriched cake as influenced by storage conditions.

Treatments	Days after storage											
	Initial			3			6			9		
	S		Mean	S		Mean	S		Mean	S		Mean
	S_1	S_2		S_1	S_2		S_1	S_2		S_1	S_2	
F_1	1.63	1.63	1.63	1.64	1.68	1.66	1.76	1.81	1.78	1.94	2.05	2.00
F_2	1.66	1.66	1.66	1.71	1.74	1.73	1.86	1.92	1.89	2.14	2.21	2.18
F_3	1.71	1.71	1.71	1.78	1.83	1.81	1.95	1.98	1.96	2.25	2.36	2.30
F_4	1.77	1.77	1.77	1.86	1.92	1.89	2.04	2.08	2.06	2.42	2.48	2.45
F_5	1.86	1.86	1.86	1.98	2.02	2.00	2.13	2.17	2.15	2.55	2.61	2.58
F_6	2.02	2.02	2.02	2.08	2.25	2.17	2.24	2.57	2.40	2.98	3.04	3.01
Mean	**1.78**	**1.78**		**1.84**	**1.91**		**2.00**	**2.09**		**2.38**	**2.46**	
	S.Em±		**C.D. @1%**	**S.Em±**		**C.D. @1%**	**S.Em±**		**C.D. @1%**	**S.Em±**		**C.D. @1%**
F	0.005		0.02	0.009		0.04	0.008		0.03	0.004		0.02
S	0.003		**NS**	0.005		0.02	0.005		0.02	0.003		0.01
F × S	0.007		**NS**	0.012		0.05	0.011		0.05	0.006		0.03

NOTE: **Factor 1**: Composite flour **(F)Factor 2:** Storage condition **(S)**

F_1: 100% Wheat flour + 0% Sweet potato flour
F_2: 90% Wheat flour + 10% Sweet potato flour
F_3: 80% Wheat flour + 20% Sweet potato flour
F_4: 70% Wheat flour + 30% Sweet potato flour
F_5: 60% Wheat flour + 40% Sweet potato flour
F_6: 50% Wheat flour + 50% Sweet potato flour

S_1: Refrigerated
S_2: Ambient
NS – Non Significant

Table 5: Effect of flour combinations on volume (g/l) of orange fleshed sweet potato flour enriched cake as influenced by storage conditions.

Treatments	Days after storage											
	Initial			3			6			9		
	S		Mean	S		Mean	S		Mean	S		Mean
	S_1	S_2		S_1	S_2		S_1	S_2		S_1	S_2	
F_1	145.13	145.13	145.13	140.16	133.45	136.80	126.65	120.28	123.46	104.40	96.20	100.30
F_2	131.20	131.20	131.20	124.39	119.16	121.78	110.70	104.38	107.54	87.05	82.01	84.53
F_3	115.56	115.56	115.56	107.87	102.41	105.14	94.87	90.98	92.92	74.38	68.87	71.62
F_4	104.98	104.98	104.98	98.40	61.07	79.73	86.55	83.15	84.85	65.80	62.81	64.31
F_5	86.41	86.41	86.41	79.85	76.71	78.28	71.84	67.75	69.80	53.78	50.52	52.15
F_6	73.56	73.56	73.56	70.54	63.98	67.26	62.73	53.73	58.23	42.17	40.67	41.42
Mean	**109.47**	**109.47**		**103.53**	**92.80**		**92.22**	**86.71**		**71.26**	**66.85**	
	S.Em±		**C.D.@1%**	**S.Em±**		**C.D.@1%**	**S.Em±**		**C.D.@1%**	**S.Em±**		**C.D.@1%**
F	0.003		0.01	0.010		0.05	0.010		0.05	0.020		0.09
S	0.002		**NS**	0.006		0.03	0.006		0.03	0.012		0.05
F × S	0.004		**NS**	0.015		0.06	0.015		0.06	0.029		0.13

NOTE: **Factor 1**: Composite flour **(F)Factor 2:** Storage condition **(S)**

F_1: 100% Wheat flour + 0% Sweet potato flour
F_2: 90% Wheat flour + 10% Sweet potato flour
F_3: 80% Wheat flour + 20% Sweet potato flour
F_4: 70% Wheat flour + 30% Sweet potato flour
F_5: 60% Wheat flour + 40% Sweet potato flour
F_6: 50% Wheat flour + 50% Sweet potato flour

S_1: Refrigerated
S_2: Ambient
NS – Non Significant

Table 6: Effect of flour combinations on density (g/cm^3) of orange fleshed sweet potato flour enriched cake as influenced by storage conditions.

Treatments	Days after storage											
	Initial			3			6			9		
	S		Mean	S		Mean	S		Mean	S		Mean
	S_1	S_2		S_1	S_2		S_1	S_2		S_1	S_2	
F_1	0.145	0.145	0.145	0.189	0.169	0.179	0.215	0.185	0.200	0.265	0.235	0.250
F_2	0.199	0.199	0.199	0.229	0.209	0.219	0.255	0.239	0.247	0.339	0.305	0.322
F_3	0.225	0.225	0.225	0.269	0.250	0.259	0.329	0.309	0.319	0.423	0.375	0.399
F_4	0.265	0.265	0.265	0.310	0.289	0.299	0.348	0.340	0.344	0.455	0.445	0.450
F_5	0.345	0.345	0.345	0.379	0.370	0.375	0.429	0.419	0.425	0.565	0.555	0.560
F_6	0.415	0.415	0.415	0.470	0.445	0.458	0.519	0.509	0.515	0.625	0.615	0.620
Mean	**0.266**	**0.266**		**0.308**	**0.289**		**0.349**	**0.334**		**0.445**	**0.422**	
	S.Em±		**C.D.@1%**	**S.Em±**		**C.D.@1%**	**S.Em±**		**C.D.@1%**	**S.Em±**		**C.D.@1%**
F	0.003		0.012	0.001		0.005	0.002		0.008	0.003		0.014
S	0.002		**NS**	0.001		0.003	0.001		0.005	0.002		0.008
F × S	0.004		**NS**	0.002		0.007	0.003		0.011	0.005		0.020

NOTE: **Factor 1**: Composite flour **(F)Factor 2:** Storage condition **(S)**

F_1: 100% Wheat flour + 0% Sweet potato flour
F_2: 90% Wheat flour + 10% Sweet potato flour
F_3: 80% Wheat flour + 20% Sweet potato flour
F_4: 70% Wheat flour + 30% Sweet potato flour
F_5: 60% Wheat flour + 40% Sweet potato flour
F_6: 50% Wheat flour + 50% Sweet potato flour

S_1: Refrigerated
S_2: Ambient
NS – Non Significant

Table 7: Effect of flour combinations on *L colour values of orange fleshed sweet potato flour enriched cake as influenced by storage conditions.**

Treatments	Days after storage											
	Initial			3			6			9		
	S		Mean	S		Mean	S		Mean	S		Mean
	S_1	S_2		S_1	S_2		S_1	S_2		S_1	S_2	
F_1	69.90	68.38	69.14	67.86	65.47	66.66	66.88	64.11	65.49	56.71	55.45	56.08
F_2	68.54	67.03	67.79	67.01	64.08	65.54	66.00	63.75	64.87	51.57	48.61	50.09
F_3	67.81	64.81	66.31	65.92	63.76	64.84	64.60	63.07	63.83	48.19	44.86	46.52
F_4	66.60	60.67	63.64	64.55	62.08	63.31	62.90	57.96	60.43	44.75	42.04	43.40
F_5	60.29	60.13	60.21	61.42	57.57	59.49	60.58	57.93	59.25	43.76	37.06	40.41
F_6	57.58	57.95	57.77	60.32	50.77	55.54	59.77	47.15	53.46	32.10	22.85	27.47
Mean	**65.12**	**63.16**		**65.06**	**60.01**		**63.45**	**59.59**		**46.18**	**41.81**	
	S.Em±		**C.D@1%**	**S.Em±**		**C.D@1%**	**S.Em±**		**C.D@1%**	**S.Em±**		**C.D@1%**
F	1.317		5.69	0.014		0.06	0.010		0.04	0.051		0.22
S	0.761		**NS**	0.008		0.04	0.006		0.02	0.029		0.13
F × S	1.863		**NS**	0.020		0.09	0.013		0.06	0.072		0.31

NOTE: **Factor 1**: Composite flour **(F)Factor 2:** Storage condition **(S)**

F_1: 100% Wheat flour + 0% Sweet potato flour
F_2: 90% Wheat flour + 10% Sweet potato flour
F_3: 80% Wheat flour + 20% Sweet potato flour
F_4: 70% Wheat flour + 30% Sweet potato flour
F_5: 60% Wheat flour + 40% Sweet potato flour
F_6: 50% Wheat flour + 50% Sweet potato flour

S_1: Refrigerated
S_2: Ambient
NS – Non Significant

Table 8: Effect of flour combinations on *a colour values of orange fleshed sweet potato flour enriched cake as influenced by storage conditions.**

Treatments	Days after storage											
	Initial			3			6			9		
	S		Mean	S		Mean	S		Mean	S		Mean
	S_1	S_2		S_1	S_2		S_1	S_2		S_1	S_2	
F_1	3.14	3.05	3.09	3.63	3.10	3.36	4.09	3.18	3.63	4.16	3.16	3.66
F_2	3.26	3.09	3.17	4.14	3.11	3.62	4.15	3.29	3.72	4.17	4.01	4.09
F_3	3.62	3.39	3.50	4.29	3.39	3.84	4.49	3.35	3.92	4.52	4.40	4.46
F_4	3.76	3.40	3.58	4.31	3.50	3.90	4.69	3.38	4.04	4.71	4.66	4.68
F_5	3.97	3.89	3.93	4.53	3.89	4.21	4.77	3.76	4.27	4.81	4.82	4.81
F_6	4.21	3.98	4.09	4.94	3.99	4.46	4.89	4.07	4.48	4.88	4.86	4.87
Mean	**3.66**	**3.46**		**4.30**	**3.50**		**4.51**	**4.16**		**4.54**	**4.32**	
	S.Em±		**C.D@1%**	**S.Em±**		**C.D@1%**	**S.Em±**		**C.D@1%**	**S.Em±**		**C.D@1%**
F	0.203		0.88	0.003		0.01	0.008		0.04	0.013		0.06
S	0.117		0.51	0.001		0.01	0.005		0.02	0.008		0.03
F × S	0.287		**NS**	0.004		0.02	0.012		0.05	0.019		0.08

NOTE: **Factor 1**: Composite flour **(F)Factor 2:** Storage condition **(S)**

F_1: 100% Wheat flour + 0% Sweet potato flour
F_2: 90% Wheat flour + 10% Sweet potato flour
F_3: 80% Wheat flour + 20% Sweet potato flour
F_4: 70% Wheat flour + 30% Sweet potato flour
F_5: 60% Wheat flour + 40% Sweet potato flour
F_6: 50% Wheat flour + 50% Sweet potato flour

S_1: Refrigerated
S_2: Ambient
NS – Non Significant

Table 9: Effect of flour combinations on *b colour values of orange fleshed sweet potato flour enriched cake as influenced by storage conditions.**

Treatments	Days after storage											
	Initial			3			6			9		
	S		Mean	S		Mean	S		Mean	S		Mean
	S_1	S_2		S_1	S_2		S_1	S_2		S_1	S_2	
F_1	19.04	22.44	20.74	23.69	22.57	23.19	24.15	23.12	23.63	24.99	24.54	24.76
F_2	23.13	22.65	22.89	23.93	22.96	23.25	23.54	24.25	23.87	25.56	24.97	25.26
F_3	24.10	23.63	23.86	24.60	23.96	24.28	24.42	25.15	24.78	25.66	25.63	25.64
F_4	25.46	27.44	26.45	28.32	27.54	27.93	28.12	27.19	27.65	28.04	26.30	27.17
F_5	25.96	27.14	26.55	29.48	27.57	28.52	29.17	27.66	28.39	29.22	27.64	28.43
F_6	26.16	28.15	27.15	29.66	28.20	28.93	29.61	29.12	29.39	30.66	27.70	29.18
Mean	**23.97**	**25.24**		**26.61**	**25.47**		**26.49**	**26.08**		**27.36**	**26.13**	
	S.Em±		**C.D.@1%**	**S.Em±**		**C.D.@1%**	**S.Em±**		**C.D.@1%**	**S.Em±**		**C.D.@1%**
F	0.770		0.04	0.018		0.08	0.044		0.08	0.073		0.22
S	0.445		**NS**	0.011		0.05	0.025		0.07	0.059		0.11
F × S	1.089		**NS**	0.026		0.11	0.062		0.15	0.063		0.27

NOTE: **Factor 1**: Composite flour **(F)Factor 2:** Storage condition **(S)**

F_1: 100% Wheat flour + 0% Sweet potato flour
F_2: 90% Wheat flour + 10% Sweet potato flour
F_3: 80% Wheat flour + 20% Sweet potato flour
F_4: 70% Wheat flour + 30% Sweet potato flour
F_5: 60% Wheat flour + 40% Sweet potato flour
F_6: 50% Wheat flour + 50% Sweet potato flour

S_1: Refrigerated
S_2: Ambient
NS – Non Significant

Table 10: Effect of flour combinations on overall acceptability of orange fleshed sweet potato flour enriched cake as influenced by storage conditions.

Treatments	Days after storage											
	Initial			3			6			9		
	S		Mean	S		Mean	S		Mean	S		Mean
	S_1	S_2		S_1	S_2		S_1	S_2		S_1	S_2	
F_1	6.98	6.99	6.98	6.87	6.42	6.64	6.78	6.31	6.54	6.66	6.24	6.45
F_2	7.22	7.13	7.17	7.25	7.11	7.18	7.17	7.09	7.13	7.12	7.04	7.08
F_3	7.25	7.13	7.19	7.20	7.11	7.15	7.16	7.04	7.10	7.14	7.02	7.08
F_4	7.55	7.60	7.58	7.43	7.29	7.36	7.40	7.18	7.29	7.37	7.18	7.28
F_5	7.45	7.30	7.38	7.40	7.30	7.35	7.34	7.20	7.27	7.32	7.12	7.22
F_6	7.17	7.09	7.13	7.15	7.06	7.10	7.13	7.01	7.07	7.10	6.99	7.04
Mean	**7.27**	**7.20**		**7.21**	**7.04**		**7.16**	**6.97**		**7.11**	**6.93**	
	S.Em±		**C.D.@1%**	**S.Em±**		**C.D.@1%**	**S.Em±**		**C.D.@1%**	**S.Em±**		**C.D.@1%**
F	0.025		0.11	0.011		0.05	0.005		0.02	0.006		0.03
S	0.015		0.06	0.006		0.03	0.003		0.01	0.004		0.02
F × S	0.036		**NS**	0.016		0.07	0.007		0.03	0.009		0.04

NOTE: **Factor 1**: Composite flour **(F)Factor 2:** Storage condition **(S)**

F_1: 100% Wheat flour + 0% Sweet potato flour
F_2: 90% Wheat flour + 10% Sweet potato flour
F_3: 80% Wheat flour + 20% Sweet potato flour
F_4: 70% Wheat flour + 30% Sweet potato flour
F_5: 60% Wheat flour + 40% Sweet potato flour
F_6: 50% Wheat flour + 50% Sweet potato flour

S_1: Refrigerated
S_2: Ambient
NS – Non Significant

CONCLUSIONS

The treated cakes showed better storage stability as compared to control samples. Better maintenance of moisture content, diameter, thickness, volume, density, colour values and overall acceptability was observed in refrigerated stored cakes (S_1) compared to ambient condition (S_2) up to final days of storage. Organoleptically acceptable of orange fleshed sweet potato flour enriched cakes can be prepared by the combination of 30 per cent SPF flour, 70 per cent wheat flour (F_4) at initial and final days of storage at (S_1) refrigerated condition.

FUTURE WORK

Standardization of protocol for preparation of special snacks like extruded products, baked products, confectionaries and fortified foods from coloured sweet potato can be studied. Coloured sweet potato has better health benefits so they can be used for pharmaceutical industries and for development of advanced health benefiting products.

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