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Development and shelf life study of papaya fruit rollups

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Abstract
Papaya is a promising fruit crop in India which is economically available throughout the year.The present study was conducted to compare thepapaya fruit roll-upsprepared with cabinet dryer and Ezidri food dehydrator. Further study was carried out in order to evaluate the sensory and physico-chemical, microbial attributes at Intial, 6th, 8th and 10th week of storage period at the room temperature using LDPE packaging. The moisture content, TSS, thickness, pH, vitamin C, β-carotene, L* and b* color values ofpapaya fruit roll-ups decreased with increase of storage period at room temperature. The titrable acidity, a* color value and microbial counts were increased during 10 weeks storage. It was concluded that papaya fruit roll-ups dehydrated in Ezidri were superior in sensory, physico-chemical, vitamin C and β-carotene content in comparison with cabinet dried sample during storage.

Keywords: Papaya, Ezidri, Cabinet dryer, moisture, TSS, acidity, pH, microbial count, sensory evaluation

Introduction

Fresh fruits are known to be excellent sources of energy, vitamins, minerals and fibre along with high digestibility. The main causes of fruits deteriorationare wilting, shriveling and chilling injury due to in appropriate storage facilities and transportation. In India, due to high moisture content of fruits and low processing capacityabout 30–50% are lost annually. The fruits due to their relatively high metabolic activity after harvesting also make them highly perishable (Atungulu *et al.,* 2004) [7]. Thus, there is need for diversity in commercial utilizations. There are numerous ways of utilizing and processing fruits into juice, jams, concentrates, pulp, dehydrated products, jellies and fruit leather. *Carica papaya* originated in Central America as it is a climatic fruit. They are rich source of vitamins like riboflavin, folate, thiamine, niacin, C, A and minerals like calcium, iron, potassium and fiber. Papaya contains 64 mg/100g ascorbic acid of fresh fruit, which is higher than oranges with 37mg/100g (Santiago-Silva *et al.,* 2011) [19]. Raw papaya is used in commercial preparations as meat tenderizer, in chew-gums and as stabilizer and to clarify the beer (Krishna *et al.,* 2008) [12]. It has a greaterusage in fruit salad and deserts due to its sweet taste and attractive colour. The present investigation highlights the shelf stability of papaya fruit roll-ups in two dryersover 10 weeks storage period.

Methodology

The study was conducted at PGRC, Department of Foods and Nutrition, PJTS Agricultural University, Rajendranagar, Hyderabad. Fully matured, firm, ripe and healthy papaya fruits and other ingredients were collected from the local markets of Hyderabad. The fruits were cleaned, washed, peeled, sliced into long or cube like pieces / slices of suitable size and blanch them. Blanched fruits / slices were pulped and strained to remove seed or skinparticles. Papaya pulp (100%) was subjected to mild heat process along with 55^0 brix of sugar syrup to adjust the final Brix between $25\text{-}30^0$, citric acid (0.2%), KMS (0.2%) and pectin (0.2%). Finally, papaya pulp was spread uniformly over trays in cabinet dryer for 12 hrs at 60^0C and over fibre sheets in Ezidri for 14 hrs at 55^0C. The dried fruit layer was rolled and packed in LDPE to store at room temperature till further usage.

The physico-chemical analysis like moisture (AOAC, 2005) [5], TSS (AOAC, 2000) [3], thickness (AACC 2000) [1], colour (Hunter lab, 2013) [9], pH (Raghuramulu, 2003) [15], titratable acidity (IS 13844: 2003) [10], reducing sugars (Somogyi, 1952) [22], ascorbic acid (Sadasivam, 1987) [18], β-carotene (Ranganna, 2003) [17] and microbial counts (AOAC, 966.23.C) were carried out at intial, 6th, 8th and 10th week of storage period.

Sensory evaluation for fresh and stored fruit roll-ups from both dryer samples were evaluated by 15 semi-trained panelists on initial, 6th, 8th and 10th week of storage using 5 point hedonic scale (Meilgaard *et al.,* 1999) [13] and products were scored for appearance, colour, flavor, texture, taste, sweetness, shape of the rolland overall acceptability.

Physico-chemical analysis data was analyzed by two factorial CRD analyses at different weeks of storage (Snedecor and Cochran, 1980).

Results and discussion

The results of this research were discussed about physico-chemical, microbial and sensory evaluation during storage among the dryers was given in table 1 and 2.

Moisture: The moisture content of papaya roll-ups decreased significantly as storage period extended from initial week to 10^{th} week in control cabinet dryer from 15.59 to 14.13 % and in experimental Ezidri from 16.00 to 14.90 %. There was significant difference was found between two dryers at each week storage period ($p<0.001$) under ambient conditions which might be due to evaporation of moisture from rollups through packaging material. In Ezidri, movement of air and space was restricted compared to cabinet dryer. Hence, moisture loss of the product was significantly lower in Ezidri fruit rollups ($p<0.001$). The interaction between four storage periods and two dryers of papaya rollups did not show any significant difference. There was decreased moisture level in sapota-papaya (50:50) fruit barfrom 16.4 to 16.05% in 90 days storage period (Sreemathi *et al.,* 2008) [23] and in papaya leatherwas reduced from 19 to 16.9% during its 60 days storage period (Servesh *et al.,* 2015) [20].

TSS: The TSS as ^{0}brix of papaya rollups decreased significantly ($p<0.001$) with increase in storage period from initial to 10^{th} week storage of control rollups from 81.07^0 to 78.70^0 and Ezidri rollups from 80.60^0 to 78.33^0 which might be due to increase of acidity due to the decrease of moisture levels can be influenced by metabolic changes like convert ofcomplex sugars into simple sugars and utilization of sugars by microbes for their growth in fruit rollups. TSS of Ezidri sample was significantly lower ($p<0.001$) than control sample.The interaction between four storage periods and two dryers on TSS was found to be not significant for papaya rollups. Sreemathi *et al.* (2008) [23] reported that in papaya-sapota (50:50) fruit bar also TSS decreased from 80^0 to 78^0 brix during 90 days storage period and in papaya-banana leather, TSS decreased from 84.83^0 to 83.62^0brix during 6 months storage period (Piyush *et al.,* 2016) [14].

Thickness: Thickness of papaya rollups decreases from 2.27 to 2.00mm in cabinet rollups and 2.47 to 2.17 mm in Ezidri rollups. The thickness of the fruit rollups was decreased significantly ($p<0.001$) due to theloss of moisture content from rollups resulted reduction of thickness during storage. Evaporation of moisture would have been slow and took longer time in Ezidri since the product was enclosed between the small trays without much scope for quick evaporation inspite of air circulation. Hence, the thickness of Ezidri was significantly higher than control rollups during 10 weeks storage period ($p<0.001$). The interaction between four storage periods and two dryers on thickness of roll-ups was not significant. This could be of one reason for Ezidri sample to have slightly more thickness than cabinet sample.

Color: Color of papaya fruit roll-upswas estimated using Hunter lab colorimeter. L*, a* and b* values as they are nearer to human perception. It was observed that the intensity of L* value (darkness) was decreased significantly from 26.45 to 20.67 in control and 28.34 to 22.45 in Ezidri rollups with increase of a* value (redness) from 38.48 to 47.46 in control and 40.12 to 49.36 in Ezidri rollups due to the loss in b* value (yellow color) from 19.62 to 12.54 in control and 21.13 to 14.09 in Ezidri at each storage period of initial, 6^{th}, 8^{th} and 10^{th} week ($p<0.001$).

The mean L*, a* and b* color values was found significantly higher ($p<0.001$) in Ezidri rollups compared to control rollups. Ezidri papaya rollups were found to have higher color values, because the losses of original color of the products were minimal in Ezidri and it coincided with high rating for color by the sensory panel judges to the Ezidri rollups against cabinet dried rollups. Significant ($p<0.05$) difference was found between the interaction of both weeks and dryers in color a* value and L* and b* did not show any significant difference in storage period. The decreased L*, b* color and increased a* color values might be due to browning reactions that was accelerated by the oxidative and enzymatic caramelization of sugars. Identical observations were also reported by Jadhavar *et al.* (2014) [11] in papaya leather in its 90 days storage period.

pH: The mean pH value of the fruit rollups was slightly decreased from 4.67 to 4.46 in control and 4.74 to 4.54 in Ezidri roll-ups with significant difference ($p<0.001$) from both the dryers due to increase of acidity levels during 10 weeks storage. The pH of Ezidri was significantly ($p<0.001$) higher than control roll-ups in which the lower acidity levels was found during its 10 weeks storage period. There was no significant difference between the interaction effect of two dryers and four weeks storage of papaya roll-ups. Similar results of pH declined were reported in sapota-papaya fruit bar from 4.65 to 4.41 by Sreemathi *et al.* (2008) [23] during 90 days storage time and alsoin papaya leather from 3.80 to 3.58 by Ankit *et al.* (2015) [2] during 90 days storage.

Titrable acidity: The mean titrable acidity of papaya fruit roll-upsincreased from 0.41 to 0.70% in control and 0.36 to 0.59% in Ezidri roll-upswith significant difference ($p<0.001$) between the weeks. The titrable acidity of cabinet dried papaya roll-ups was significantly higher than Ezidri ($p<0.001$) at each storage period. There was not much difference in acidity levels of fruit roll-ups from both the dryers. The interaction between four storage periods and two dryers in titratable acidity of roll-ups did not show any significant difference. The elevated acidity levels might be due to hydrolysis of pectin, ascorbic acid degradation, formation of acid from sugars and conversion of SO_2 into sulphurous. Similar increase of acidity levels from 1.21 to 1.74% during 6 months storage was reported by Piyush *et al.* (2016) [14] in banana-papaya (50:50) fruit bar and also in Sapota-papaya fruit bar (50:50), acidity level increase from 0.405 to 0.423% during 90 days storage period by Sreemathi *et al.* (2008) [23].

Reducing sugar: The mean reducing sugar in papaya roll-upsincreased from 13.47 to 15.50% in control and 13.07 to 15.13% in Ezidri roll-ups with significant difference ($p<0.001$) between the 10 weeks of storage. The reducing sugar of papaya roll-ups from cabinet dryer was significantly higher than Ezidri rollups during 10 weeks storage ($p<0.01$). There was no significant difference between the interaction of two dryers and four weeks of papaya fruit roll-ups. More acid hydrolysis of sucrose was found higher in cabinet roll-upscompared to Ezidri roll-ups which results conversion of non- reducing sugars to reducing sugars. Similar findings of increase in reducing sugars from 7.50 to 8.98% in sapota-papaya (50:50) by Sreemathi *et al*. (2008) [23] in 90 days storage period and 16.6 to 22.4% in papaya leather by Attri *et al*. (2014) [6] during 6 months storage period.

Ascorbic acid: The mean ascorbic acid content of papaya fruit rollups decreased from 50.93 to 36.21 mg/100g in control rollups while, Ezidri roll-ups decreases from 57.24 to 45.00 mg/100g which was significantly differs ($p<0.001$) from each other between the weeks due to oxidation of vitamin C occurred during the storage period under the ambient conditions which leads to the formation of dehydroascorbic acid in the presence of acidic environment. The ascorbic acidof Ezidri papaya roll-ups was significantly higher than control rollups ($p<0.001$). The interaction of two dryers and four weeks of storage in papaya roll-ups was significantly differs ($p<0.01$). Similar decreased ascorbic acid content were observed by Ankit *et al*. (2015) [2] in papaya leather from 58.75 to 50.35 during 90 days storage time and in banana- papaya (50:50) leather, it was decreased from 31.16 to 20.41 by Piyush *et al.* (2016) [14] during 6 months storage. In papaya-apple (50:50) leather packed in LDPE, vitamin C has decreased from 22.24 to 17.60 mg/100g during 90 days storage (Ramesh *et al.,* 2015) [16].

β-carotene: The mean β-carotene content of papaya fruit rollups was decreased from 643.7 to 295.0 µg/100g in control and 746.0 to 397.7µg/100g with significant difference ($p<0.001$) between 10 weeks of storage. Degradation of β-carotene might be due to the biosynthesis of carotenoids cannot be occurred during processing and its degradation continued during storage. The β-carotene of papaya rollups from cabinet dryer was significantly ($p<0.001$) lower than Ezidri papaya roll-ups. The interaction between two dryers and four weeks storage period of papaya fruit roll-ups shows a significant difference ($p<0.001$).
Results of β-carotene reduction during storage were reported in sun dried chips of cassava stored for 4 weeks showed a reduction of β-carotene from 37.9 to 18.4% (Chavez *et al.,* 2007) [8]. In sapota-papaya (50:50) fruit bar, β-carotene content has decreased from 605.17 to 595.87 µg/100g during 90 days storage period (Sreemathi *et al.,* 2008) [23]. The β-carotene decreased in sweet potato from 5.9 to 4.2 µg/100g under sun drying (Vimala *et al.,* 2011) [24].

Table 1: Changes in physico-chemical constituents of papaya fruit roll-ups during storage.

Storage weeks	Samples	Moisture (g%)	TSS (^{0}brix)	Thickness (mm)	L*	a*	b*	pH	Titratable Acidity (%)	Reducing sugars (g)	Vitamin C (mg)	β-carotene (µg)
Initial	Ezidri	16.00 ± 0.07	80.6 ± 0.04	2.47 ± 0.02	28.34 ± 0.09	40.12 ± 0.06	21.13 ± 0.17	4.74 ± 0.01	0.36 ± 0.01	13.07 ± 0.08	57.24 ± 0.08	746.0 ± 1.0
	Control	15.59 ± 0.03	81.07 ± 0.06	2.27 ± 0.02	26.45 ± 0.13	38.48 ± 0.07	19.62 ± 0.07	4.67 ±0.004	0.41 ± 0.01	13.47 ± 0.11	50.93 ± 0.13	643.7 ± 1.0
	Mean	15.79^{d} ± 0.11	80.83^{d} ± 0.11	2.37^{c} ± 0.05	27.40^{d} ± 0.44	39.30^{a} ± 0.37	20.37^{d} ± 0.36	4.71^{d} ± 0.02	0.38^{a} ± 0.02	13.27^{a} ± 0.13	54.09^{d} ± 1.41	694.88^{d} ± 22.9
6th	Ezidri	15.60 ± 0.05	79.40 ± 0.06	2.30 ± 0.0	27.01 ± 0.30	44.14 ± 0.06	18.92 ± 0.11	4.61 ±0.002	0.47 ± 0.01	14.27 ± 0.04	50.08 ± 0.21	510.0 ± 0.5
	Control	15.11 ± 0.03	79.93 ± 0.06	2.10 ± 0.0	25.34 ± 0.08	43.10 ± 0.12	17.16 ± 0.08	4.56 ±0.002	0.51 ± 0.0	14.60 ± 0.07	42.45 ± 0.18	408.0 ± 0.5
	Mean	15.36^{c} ± 0.12	79.67^{c} ± 0.13	2.20^{b} ± 0.05	26.17^{c} ± 0.43	43.62^{b} ± 0.25	18.04^{c} ± 0.41	4.58^{c} ± 0.01	0.49^{b} ± 0.01	14.43^{b} ± 0.09	46.27^{c} ± 1.72	458.90^{c} ± 22.8
8th	Ezidri	15.18 ± 0.03	78.77 ± 0.02	2.23 ± 0.02	26.03 ± 0.04	46.48 ± 0.13	16.07 ± 0.29	4.58 ±0.004	0.53 ± 0.01	14.87 ± 0.15	48.11 ± 0.08	465.5 ± 1.7
	Control	14.75 ± 0.03	79.23 ± 0.02	2.03 ± 0.02	23.88 ± 0.08	44.98 ± 0.04	15.07 ± 0.14	4.51 ±0.002	0.66 ± 0.01	15.07 ± 0.04	40.12 ± 0.13	355.1 ± 1.7
	Mean	14.97^{b} ± 0.10	79.00^{b} ± 0.11	2.13^{a} ± 0.05	24.95^{b} ± 0.49	45.73^{c} ± 0.35	15.57^{b} ± 0.32	4.54^{b} ± 0.02	0.59^{c} ± 0.03	14.97^{c} ± 0.12	44.11^{b} ± 1.79	410.31^{b} ± 24.8
10th	Ezidri	14.90 ± 0.05	78.33 ± 0.06	2.17 ± 0.02	22.45 ± 0.14	49.36 ± 0.05	14.09 ± 0.15	4.54 ±0.002	0.59 ± 0.01	15.13 ± 0.04	44.99 ± 0.32	397.7 ± 1.0
	Control	14.13 ± 0.04	78.70 ± 0.07	2.00 ± 0.01	20.67 ± 0.10	47.46 ± 0.06	12.54 ± 0.05	4.46 ±0.004	0.70 ± 0.02	15.50 ± 0.04	36.21 ± 0.26	295.0 ± 0.7
	Mean	14.52^{a} ± 0.18	78.52^{a} ± 0.10	2.08^{a} ± 0.04	21.56^{a} ± 0.42	48.41^{d} ± 0.43	13.32^{a} ± 0.37	4.49^{a} ± 0.02	0.65^{d} ± 0.03	15.32^{d} ± 0.09	40.60^{a} ± 2.00	346.31^{a} ± 23.0
C.D value	0.15	0.17	0.06	0.47	0.27	0.51	0.01	0.05	0.27	0.64	3.64	0.15
Weeks Probability	0.0***	0.0***	0.0***	0.0***	0.0***	0.0***	0.0***	0.0***	0.0***	0.0***	0.0***	0.0***
Dryers Probability	0.0***	0.0***	0.0***	0.0***	0.0***	0.0***	0.0***	0.0***	0.0***	0.0***	0.0***	0.0***
Dryers× weeks	0.072^{NS}	0.782^{NS}	0.89^{NS}	0.731^{NS}	0.026*	0.445^{NS}	0.24^{NS}	0.17^{NS}	0.874^{NS}	0.007**	0.0***	0.0***

Note: Values are mean ± standard deviation of three determinations. Means with the same superscript in respective columns do not significantly differ at $p\leq 0.05$.

Microbial quality of the papaya fruit rollups during storage period

It was observed that there was no fungal growth of papaya rollups packed in LDPE up to final week storage. The growth of fungi was in negligible load with 0.33×10^{-1}cfu/g in both the dryers. In cabinet dryer papaya roll-ups bacterial growth was seen in 6th week with 0.33×10^{-7}cfu/g and it was increased to 1.0×10^{-7}cfu/g while, in Ezidri bacterial growth was found more than cabinet roll-ups with 0.67×10^{-7}cfu/g in 6th week and its count was increased to 1.67×10^{-7}cfu/g at the end of storage time. Addition of preservative (KMS) in roll-ups retards the growth of microbes for some extent and also LDPE does not have required bacterial barrier property but the papaya fruit rollups were in the safe limits hence it could be declared safe for consumption from the point of TBC and TFC. Similar results of microbial counts was reported by

Sreemathi *et al.* (2008) [23] in sapota-papaya (50:50) fruit bar, bacterial count was increased to 4×10^{-6}cfu/g and fungal count to 6×10^{-3}cfu/g.

Table 2: Microbial quality of papaya fruit roll-ups during storage.

Microbial load (cfu/g)	Cabinet dryer roll-ups				Ezidri roll-ups			
	1st week	6th week	8th week	10th week	1st week	6th week	8th week	10th week
Bacterial (10^{-7})	Nil	0.33	0.67	1.0	Nil	0.67	1.0	1.67
Fungal (10^{-1})	Nil	Nil	Nil	0.33	Nil	Nil	Nil	0.33

Sensory evaluation of papaya fruit roll-upsduring storage

Papaya fruit rollups were subjected to sensory evaluation by 15 taste panel judges on 5 point hedonic scale. The mean sensory scores of papaya roll-ups dehydrated in both Ezidri as well as cabinet dryer are given in table 3.

Table 3: Sensory evaluation of papaya fruit rollups during storage.

Sensory parameters	Cabinet dried fruit roll-ups				Ezidri fruit roll-ups			
	Initial wk	6th wk	8th wk	10th wk	Initial wk	6th wk	8th wk	10th wk
Appearance	4.33 ± 0.09	3.47 ± 0.09	2.93 ± 0.05	2.80 ± 0.07	4.93 ± 0.05	4.0 ± 0.07	3.67 ± 0.09	3.27 ± 0.08
Color	4.27 ± 0.08	3.73 ± 0.08	3.40 ± 0.09	2.93 ± 0.08	5.00 ± 0.00	4.20 ± 0.07	3.87 ± 0.06	3.47 ± 0.09
Flavor	4.47 ± 0.09	3.73 ± 0.08	3.07 ± 0.05	2.73 ± 0.08	4.93 ± 0.05	4.13 ± 0.06	3.67 ± 0.09	3.00 ± 0.00
Texture	4.27 ± 0.08	3.87 ± 0.09	2.53 ± 0.15	2.00 ± 0.0	4.87 ± 0.06	4.33 ± 0.09	3.93 ± 0.05	2.93 ± 0.18
Taste	4.20 ± 0.07	3.87 ± 0.06	3.00 ± 0.07	2.47 ± 0.09	4.80 ± 0.07	4.20 ± 0.07	3.80 ± 0.10	3.07 ± 0.08
Sweetness	4.40 ± 0.09	3.60 ± 0.09	2.80 ± 0.10	2.27 ± 0.08	4.60 ± 0.09	3.80 ± 0.10	3.33 ± 0.09	2.80 ± 0.07
Shape of the rollups	4.20 ± 0.07	3.33 ± 0.09	2.40 ± 0.09	2.20 ± 0.07	4.73 ± 0.08	4.20 ± 0.07	3.33 ± 0.09	2.93 ± 0.05
Overall acceptability	4.47 ± 0.09	3.87 ± 0.09	3.07 ± 0.05	2.67 ± 0.11	4.93 ± 0.05	4.07 ± 0.05	3.93 ± 0.05	3.13 ± 0.06

The sensory scores of control cabinet dried papaya roll-ups was decreased from initial to 10th week storage in the order of 4.33 to 2.80 for appearance, 4.27 to 2.93 for color, 4.47 to 2.73 for flavor, 4.27 to 2.00 for texture, 4.20 to 2.47 for taste, 4.40 to 2.27 for sweetness, 4.20 to 2.20 for shape of the roll and 4.47 to 2.67 for overall acceptability. In Ezidri rollups the sensory scores was decreases in the order of 4.93 to 3.27 for appearance, 5.00 to 3.47 for color, 4.93 to 3.00 for flavor, 4.87 to 2.93 for texture, 4.80 to 3.07 for taste, 4.60 to 2.80 for sweetness, 4.73 to 2.93 for shape of the roll and 4.93 to 3.13 for overall acceptability.

The highest rating for all sensory parameters was found in Ezidri rollups than control cabinet dryer throughout storage. The decreased sensory scores might be due to the loss of color, appearance, flavor, texture, taste perception by the panel judges which influenced the other sensory parameters during storage period. Similar observations of decreased sensory mean score were reported in Sapota-papaya fruit bar by Sreemathi *et al.* (2008) [23] during its 90 days storage period and also in papaya leather by Attri *et al.* (2014) [6]. Attri *et al.* (2014) [6] reported that papaya leather (60:40) on 9-point hedonic scale during 6 months storage showed decreased sensory scores for parameters like color from 8.0 to 7.5, flavor from 7.5to 7.0, taste from 7.9 to 7.0, texture from 7.9 to 6.7 and overall acceptability from 8.0 to 7.0.

Conclusion

Papaya fruit roll-ups are nutritionally enriched product. The moisture, TSS, pH, thickness, color (L, b) value, ascorbic acid, β-carotene content of the both samples was decreased while, acidity, reducing sugars, a* color value, microbial count was increased during storage period. Retention of β-carotene, ascorbic acid was higher in Ezidri sample than control. Microbial load was increased during storage but they were in the safe limits hence it could be declared safe for consumption from the point of TBC and TMC. Among two samples, Ezidri papaya fruit roll-upswas found superior in retention of nutrients, sensory acceptance and all other physico-chemical properities compared to cabinet dried roll-ups throughout storage period.

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