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Development and Shelflife Study of Papaya-Black Grape Blend Fruit Rollups

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The study aims to standardize papaya – black grape blend fruit rollups in proportions of 70:30, 60:40, 50:50 with experimental Ezidri food dehydrator and to compare them with 50:50 of control cabinet dryer rollups. Experimental Ezidri 50:50 ratio rollups were accepted by taste panel judges compared to other ratios and control sample. The results revealed that moisture content, TSS, thickness, pH, vitamin C, β – carotene, L*, a* and b* color values of fruit rollups decrease while, titrable acidity and microbial counts increase in storage period to 10 weeks at room temperature. It was concluded that Ezidri papaya – black grape sample showed superior qualities than control sample (cabinet) during storage.

Keywords: Ezidri; cabinet; papaya; black grape; moisture; TSS; acidity; pH; microbial count; sensory evaluation.

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1. INTRODUCTION

India is one of the largest producers of fruits in the world but the country faces lots of wastages during processing and harvesting time [1]. In the last few decades, consumer demands in the field of food production have changed considerably. Hence, in order to utilize the produce in glut season, it becomes necessary to adopt low cost processing techniques to preserve the produce as preserved pulps, jams, jellies, candies, fruit bars / leather and promote them in a commercial way like fruit rollups [2]. This helps to generate opportunities for self-employment through small scale processing units. The fruit leather / rollups have high calorific value while retaining their natural vitamins and minerals [3]. They were developed from fresh fruit pulps by simple dehydration technique to provide good nutritional supplementation.

Papaya (*Carica papaya L.*) is an important fruit crop of tropical world and has long been known as wonder fruit of the tropics. In India, papaya is widely cultivated in Andhra Pradesh, Gujarat, Maharashtra, Tamil Nadu, Kerala and plains of Uttar Pradesh [3]. They are rich source of vitamin C, vitamin A, riboflavin, folates, thiamine, niacin, calcium, iron, potassium and fiber [4].

Papaya contains 64 mg ascorbic acid / 100 g of fresh fruit, which is higher than oranges which has 37 mg / 100 g [5]. Papaya was used in commercial preparations such as meat tenderizer, chew – gums and as stabilizer to clarify the beer as it contains the enzyme papain [6]. Now-a-days, farmers have shown keen interest in cultivating papaya crop because of its higher fruit yield but, the main problem is its post-harvest handling and lower shelf life during marketing.

In India, grapes are an important commercial fruit crop. It is the second most important fruit crop after mango and they are exported to Europe and Middle East countries. Grapes are good source of antioxidants, polyphenols and antimicrobial agents against *Escherichia coli* O157:H7 [7]. The slight delay in the harvest affect the berry size, weight and juice content, but it increased the TSS to acid ratio and sugar units [8]. Grapes contains high percent of sugars that help in processing of different products like wine, raisins, juice, crush, jelly and canned grapes. Grape juice contains 80% water in which nutrient elements, sugar and natural acids are present in readily available forms, thus it acts as instant energy source [9]. Fresh grapes contain vitamin A of 80 IU / 100 g and vitamin C to 0.30 mg / 100 g [10].

The papaya flavor does not appeal to many consumers and hence combining with seasonal fruits like black grape will increase the acceptance of the product and also helps in promoting a unique commercial product. Thus, current study highlighted the shelf stability of papaya – black grape combination fruit rollups using Ezidri and cabinet dryers over a period of 10 weeks.

2. METHODOLGY

Fully matured, firm, ripe and healthy fruits of papaya, black grapes and other ingredients were collected from the local market of Hyderabad. The experiments were conducted at Post Graduate & Research Center, PJTS Agricultural University, Rajendranagar, Hyderabad.

The cleaned fruits were blanched separately, pulps prepared in electric juicer mixer, strained to remove seeds and skin particles. Papaya and grape fruit pulp were mixed in proportions of 70:30, 60:40 and 50:50 and dried in Ezidri food dehydrator and compared with 50:50 ratio of control sample developed using cabinet dryer. Pulp mixture was heated with continuous stirring for 5 min along with 0.2% w/w of citric acid, pectin, potassium metabisulphite and sugar syrup with 55°B and adjusted to final brix of 25-30° for the preparation of fruit rollups. The mixture then poured as two layers on trays and allows it for drying in cabinet dryer at 60°C for 12 h time period and at 55°C for 16 h in Ezidri food dehydrator. The best accepted combination fruit rollup was determined using sensory evaluation carried out by 15 semi trained panel members.

The best accepted combination and control samples were packed in LDPE, stored at room temperature and analysed for its physico-chemical analysis like moisture [11], TSS [12], thickness [13], colour [14], pH [15], titratable acidity [16], reducing sugars [17], ascorbic acid [18], β-carotene [19] and microbial counts [20] were determined initially. All the parameters were analysed on 6^{th}, 8^{th} and 10^{th} week along with sensory evaluation of rollups during storage period using the modified 5-point hedonic scale [21]. The results were analyzed by two factorial CRD analyses at different weeks of storage [22].

3. RESULTS AND DISCUSSION

The results of standardized papaya – black grape rollups showed that highest rating was

found for Ezidri 50:50 combination. The appearance of Ezidri papaya – black grape (50:50) rollup was attractive with shiny appearance as judged by 87% judges and 27% in case of control. The color of control rollups was felt as characteristic bright dark red color by 60% judges and 73% felt the same for 50:50 Ezidri rollups. Forty percent of judges felt that 50:50 Ezidri and control had strong flavor of black grape and papaya. The texture of 50:50 Ezidri rollup was felt to be typical soft and non-sticky by 47% against 33% for control.

The balanced taste of papaya and black grape was found by 67% for 50:50 Ezidri rollup against 40% in control rollups. Tartness of black grape was well pronounced in all proportion of fruit rollups. Shape of the papaya-black grape blend rollups was evaluated to be very good by 53% for 50:50 rollups and 47% in control. Increase in percentage of papaya pulp masked the taste of black grapes and decreased the shiny appearance of rollups after drying. Hence, Ezidri papaya+ black grape (50:50) rollups was selected for further analysis and compared with control sample.

The results of physico-chemical, microbial and sensory evaluation of papaya-black grape rollups during storage period among the dryers was given in Tables 1, 2 and Figs. 1a, 1b and 2.

Moisture: The moisture content of papaya blend rollups decreased gradually as storage period extended from 1st week to 10th week in the order of 16.51 to 15.17% for cabinet dryer and 16.87 to 15.38% from Ezidri sample. In Ezidri, movement of air and space was restricted in the equipment and hence moisture loss from the product was lower. It had significantly ($p<0.001$) higher moisture content than control rollups initially and the moisture levels decreased during storage period due to the evaporation through LDPE packaging material.

The correlation between four storage periods and two dryers of 4 formulations of papaya blend rollups did not show any significant difference but two dryers of papaya – black grape rollups were significantly ($p<0.001$) different. Similar decreased moisture levels were observed in sapota-papaya (50:50) fruit bar stored for 90 days where moisture has decreased from 16.4 to 16.05 g% during 90 days shelf life (Sreemathi et al. 2008). Papaya leather developed from cabinet dryer has shown a reduction of moisture from 19 to 16.9% in pet jar stored for 60 days [23].

TSS: The mean TSS (brix) of papaya-black grape blend rollups decreased significantly ($p<0.001$) from 82.53 to 80.57° Brix in control and 82.30 to 79.93° Brix in Ezidri rollups with advancement of storage period due to increase in acidity during storage as complex sugars converted to simple sugars. The prolonged storage period also might have reduced the pore space in the product due to reduction in moisture levels. This kind of observation was reported in papaya – sapota (50:50) fruit bar, where TSS has decreased from 80° to 78° Brix during 90 days storage period [24]. Reduction of TSS from 84.83° to 83.62° during 6 months storage period was reported in papaya – banana leather [3].

Thickness: The mean thickness of papaya – black grape blend fruit rollups decreased significantly ($p<0.001$) from 2.50 to 2.27 mm in control and 2.80 to 2.53 mm in Ezidri rollups during 10 weeks storage period due to the decrease of moisture levels. The thickness of Ezidri sample was significantly ($p<0.001$) higher than cabinet sample. There was no significant difference between the interaction of dryers and weeks.

Color: Color of papaya – black grape fruit rollups was estimated using Hunter lab colorimeter. L*, a* and b* values are nearer to human perception. It was observed that the intensity of brightness (L*) value decreased significantly ($p<0.001$) with increase of a* (redness) due to the loss of blue color (b*) with increased shelf life. The mean L* color values of control rollups was decreased from 17.19 to 13.43 and 20.96 to 15.32 in Ezidri rollups. The increase of a* color value from 38.23 to 47.60 in Ezidri was higher than cabinet dried rollups with 37.27 to 45.88 and the intensity of blue color was decreases with increase of b* color value from - 6.48 to - 2.50 in control and - 7.22 to - 4.73 in Ezidri rollups.

The interaction of dryers and weeks of L* ($p<0.001$) and b* color ($p<0.01$) values had statistically significant difference but a* color value did not show any significant difference. The decreased L* and increased a*, b* color values may be due to browning reactions (caramelisation of sugars) and accelerated oxidative process controlled enzymatically.

Identical observations to this were also reported in papaya leather where L* and b* color values was decreased from 19.65 to 17.31 and 3.68 to 2.98 respectively while a* color value increased from 6.80 to 8.48 in its 90 days storage period

[25]. The wide difference in the color values of this study in comparison with the present study can be attributed to the varietal differences of papaya.

pH: The mean pH value of papaya – black grape blend fruit rollups was significantly ($p<0.001$) decreased from 3.87 to 3.58 in control and 4.07 to 3.69 in Ezidri rollups during 10 weeks storage period. The increased acidity levels influenced the decreased pH levels. The mean pH value of Ezidri sample was significantly ($p<0.001$) higher as more acidity levels found in cabinet sample during 10 weeks storage and no significant difference between the interaction of dryers and weeks. Similar results of decline in pH upon storage for 90 days were reported in 50:50 sapota – papaya fruit bar from 4.65 to 4.41 [24]. In papaya leather, pH decreased from 3.80 to 3.58 [26] and in 50:50 papaya – guava leather, pH decreased from 3.43 to 3.2 [27].

Titrable acidity: The mean titrable acidity of papaya – black grape fruit rollups slightly increased from 0.62 to 1.02% in control and 0.59 to 0.98% in Ezidri rollups during 10 weeks storage which might be due to hydrolysis of pectin, ascorbic acid degradation, formation of acid from sugars and conversion of SO_2 to sulphurous. The cabinet dried papaya – black grape rollup had significantly ($p<0.001$) higher acidity level than Ezidri and it was found that there was no significant difference between the interaction of dryers and weeks of papaya-black grape rollups. Similar types of observations on variations in acidity also reported in 50:50 banana – papaya fruit bar [3] where acidity increased from 1.21 to 1.74% during 6 months storage and in sapota – papaya fruit bar (50:50), acidity level increased from 0.405 to 0.423% during 90 days storage period [24].

Reducing sugars: The mean reducing sugars of papaya – black grape fruit rollups was increased from 15.13 to 16.93% in control and 14.73 to 16.20% in Ezidri. Reducing sugars increased significantly due to more acid hydrolysis of sucrose at high temperature which resulted in inversion of non – reducing sugars to reducing sugars. The reducing sugar of cabinet dried papaya – black grape rollups was significantly ($p<0.001$) higher than Ezidri rollups due to higher concentration of TSS. There was no significant difference between the interaction of dryers and weeks in papaya – black grape blend rollups. Similar findings of increased reducing sugars was observed in 50:50 sapota – papaya fruit bar by 7.50 to 8.98% during 90 days storage period [24] and 16.6 to 22.4% in papaya leather during 6 months storage period [2].

Ascorbic acid: The mean ascorbic acid content of papaya – black grape fruit rollups decreased significantly ($p<0.001$) between the weeks from 33.48 to 20.58 mg in control and 37.33 to 26.68 mg in Ezidri rollups. Loss of vitamin C during storage may be due to the exposure to high atmospheric temperature even under controlled conditions and increased acidity in the products.

Papaya – black grape rollups from cabinet dryer had significantly ($p<0.001$) lower ascorbic acid content than Ezidri rollups and also a significant difference ($p<0.01$) was found between the interaction of dryers and weeks. Similar results of decreased vitamin C content were observed in papaya leather from 58.75 to 50.35 mg / 100 g during 90 days storage [26]. In papaya – apple (50:50) leather packed in LDPE, vitamin C has decreased from 22.24 to17.60 mg / 100 g during 90 days storage [28]. In banana – papaya (50:50) leather, vitamin C decreased from 31.16 to 20.41 mg / 100 g during 6 months storage [3].

β-carotene: The mean β-carotene (µg) content of papaya-black grape fruit rollups decreased from 284.6 to 155.10 µg in control and 341.6 to 146.1 µg in Ezidri rollups with significant difference ($p<0.001$) in 10 weeks storage period. Cabinet dried papaya-black grape rollups had lower β-carotene content than Ezidri with significant difference ($p<0.001$) between the dryers. The interaction of dryers and weeks of papaya-black grape rollups showed significant difference ($p<0.001$). The retention of β-carotene in Ezidri fruit rollups than cabinet dryer fruit rollups may be due to slow drying period which preserves the nutrients. The enzyme responsible for carotenoid biosynthesis was inactivated during processing resulting in stimulation of isomerization that causes oxidative degradation of carotenoids during storage. Results of β-carotene reduction during storage were reported in storage of sweet potato chips for 11 months to 10% [29].

Sun dried chips of cassava stored for 4 weeks showed a reduction of β-carotene from 37.9 to 18.4% [30]. In sapota-papaya (50:50) fruit bar, β-carotene content has decreased from 605.17 to 595.87 µg during 90 days storage period [24]. The β-carotene decreased in sweet potato from 5.9 µg to 4.2 µg under sun drying [31].

Table 1. Physico-chemical constituents of papaya – black grape blend fruit rollups during storage

Weeks		Moisture (%)	TSS (Brix)	Thickness (mm)	L*	a*	b*	pH	Titrable acidity (%)	Reducing sugar (%)	Ascorbic acid (mg / 100 g)	β-carotene (µg / 100 g)
Initial	Ezidri	16.87 ± 0.04	82.30 ± 0.06	2.80 ± 0.04	20.96 ± 0.12	38.23 ± 0.04	-7.22 ± 0.11	4.07 ± 0.02	0.59 ± 0.01	14.73 ± 0.11	37.33 ± 0.18	341.6 ± 1.10
	Cabinet	16.51 ± 0.07	82.53 ± 0.14	2.50 ± 0.00	17.19 ± 0.12	37.27 ± 0.08	-6.48 ± 0.05	3.87 ± 0.01	0.62 ± 0.01	15.13 ± 0.11	33.48 ± 0.12	284.6 ± 1.20
	Mean	16.69^{d} ± 0.09	82.42^{d} ± 0.12	2.65^{c} ± 0.07	19.08^{d} ± 0.85	37.75^{a} ± 0.22	-6.85^{d} ± 0.19	3.97^{d} ± 0.05	0.61^{a} ± 0.01	14.93^{a} ± 0.14	35.40^{d} ± 0.88	313.13^{d} ± 12.80
6th wk	Ezidri	16.25 ± 0.03	81.43 ± 0.02	2.70 ± 0.00	19.54 ± 0.11	44.03 ± 0.03	-6.61 ± 0.12	3.89 ± 0.00	0.77 ± 0.00	15.47 ± 0.11	32.51 ± 0.13	204.7 ± 0.90
	Cabinet	16.06 ± 0.05	81.63 ± 0.08	2.43 ± 0.02	15.37 ± 0.15	43.25 ± 0.22	-5.66 ± 0.12	3.72 ± 0.00	0.81 ± 0.01	16.33 ± 0.11	27.62 ± 0.21	155.1 ± 1.30
	Mean	16.16^{c} ± 0.06	81.53^{c} ± 0.08	2.57^{b} ± 0.06	17.46^{c} ± 0.94	43.64^{b} ± 0.24	-6.14^{c} ± 0.24	3.80^{c} ± 0.04	0.79^{b} ± 0.01	15.9^{b} ± 0.22	30.57^{c} ± 1.33	179.87^{c} ± 11.1
8th wk	Ezidri	15.89 ± 0.05	80.57 ± 0.04	2.67 ± 0.02	17.51 ± 0.13	45.35 ± 0.14	-5.61 ± 0.13	3.84 ± 0.01	0.81 ± 0.01	15.87 ± 0.04	29.51 ± 0.29	163.6 ± 0.90
	Cabinet	15.52 ± 0.10	80.97 ± 0.08	2.37 ± 0.02	14.54 ± 0.12	44.06 ± 0.14	-4.35 ± 0.10	3.65 ± 0.01	0.92 ± 0.01	16.67 ± 0.04	23.36 ± 0.21	124.5 ± 0.50
	Mean	15.70^{b} ± 0.11	80.77^{b} ± 0.11	2.52^{b} ± 0.07	16.03^{b} ± 0.68	44.70^{c} ± 0.32	-4.98^{b} ± 0.30	3.75^{b} ± 0.04	0.86^{c} ± 0.03	16.27^{c} ± 0.18	26.44^{b} ± 1.40	144.02^{b} ± 8.8
10th wk	Ezidri	15.38 ± 0.05	79.93 ± 0.06	2.53 ± 0.02	15.32 ± 0.11	47.60 ± 0.10	-4.73 ± 0.10	3.69 ± 0.01	0.98 ± 0.01	16.20 ± 0.07	26.68 ± 0.18	146.1 ± 0.50
	Cabinet	15.17 ± 0.02	80.57 ± 0.04	2.27 ± 0.02	13.43 ± 0.15	45.88 ± 0.08	-2.50 ± 0.18	3.58 ± 0.01	1.02 ± 0.02	16.93 ± 0.04	20.58 ± 0.08	104.4 ± 1.70
	Mean	15.27^{a} ± 0.06	80.25^{a} ± 0.15	2.40^{a} ± 0.06	14.38^{a} ± 0.44	46.74^{d} ± 0.39	-3.62^{a} ± 0.52	3.63^{a} ± 0.03	1.00^{d} ± 0.02	16.57^{d} ± 0.17	23.63^{a} ± 1.37	125.27^{a} ± 9.40
C.D. value		0.18	0.25	0.07	0.43	0.39	0.39	0.03	0.05	0.29	0.63	3.57
Week probability		0.00***	0.00***	0.00***	0.00***	0.00***	0.00***	0.00***	0.00***	0.00***	0.00***	0.00***
Dryer Probability		0.00***	0.00***	0.00***	0.00***	0.00***	0.00***	0.00***	0.00***	0.00***	0.00***	0.00***
Dryers × Weeks		0.595^{NS}	0.264^{NS}	0.917^{NS}	0.02***	0.099^{NS}	0.056**	0.102^{NS}	0.29^{NS}	0.364^{NS}	0.0034**	0.03***

Note: Values are Mean ± S.D of triplicates. Values with same superscript in respective columns indicates no significant difference

The percentage change in moisture, pH, titrable acidity, reducing sugars, ascorbic acid and β – carotene for Ezidri and cabinet dried samples are given in Figs. 1a and 1b respectively.

A decrease in moisture content was observed in all the samples during storage. The decrease in pH indicates that the acidity in the samples has increased and it ranged between 4.0 to 9.5% in the samples. The slight decrease in the pH resulted in an increase in titrable acidity by about 30.0% in the 6th week of storage and increased to 65.0% by the 10th week. The increase in titrable acidity was 48.0% for the 8th for the cabinet dried sample and it increased to only 37.0% in Ezidri sample. The decreased ascorbic acid and β – carotene contents were observed in all the samples during storage as reported by many researchers as reported above.

There was slight decrease of 1.0 to 3.0% in the TSS of both samples where as thickness decreased by 3.0 to 10.0 % in all samples due to moisture loss. In colour parameters, L* and a* did not show much percentage where as b* showed significant percentage change indicating that loss of blue colour during storage was more compared to loss of red colour. It was considerably higher in cabinet dried sample by the 10th week of storage increasing to 61.25% from 12.65% during 6th week in comparison to 0th week sample. The loss of blue colour in Ezidri sample ranged between 8.45 to 34.49% during storage.

Microbial quality of the papaya fruit rollups during storage period: There was no fungal growth in papaya – black grape fruit rollups packed in LDPE up to final week storage. In cabinet dried rollups, bacterial growth was seen from 8th week with 0.33×10^{-6} log of CFU/g and increased to 0.67×10^{-6} log of CFU/g where as in Ezidri rollups it was 0.67×10^{-6} log of CFU/g in 8th week and gradually increased to 1.0×10^{-6} log of CFU/g at final storage period. Samples had the microbial growth in permissible limits and hence safe for consumption from the point of TBC. The bacterial count increased to 4×10^{-6} log of CFU/g and fungal count to 6×10^{-3} log of CFU/g in 50:50 sapota – papaya fruit bar [24] which are more or less similar to the present study.

Sensory evaluation of papaya- black grape blend fruit rollups during storage: Papaya-black grape rollups were evaluated by 15 semi trained judges and its mean scores given in Fig. 1. Fruit rollups were evaluated for sensory parameters like appearance, color, flavor, texture, taste, sweetness, shape of the roll and overall acceptability by using 5-point hedonic scale.

The mean sensory scores of control cabinet dryer rollups significantly decreased from 1st to 10th week from 4.20 to 2.40 for appearance, 4.27 to 2.53 for color, 4.60 to 2.87 for flavor, 3.73 to 2.00 for texture, 4.20 to 2.00 for taste, 4.47 to 2.60 for sweetness, 4.07 to 2.00 for shape of roll and 4.20 to 2.40 for overall acceptability. The sensory scores of Ezidri rollups also decreased from 4.93 to 2.80 for appearance, 4.47 to 3.13 for color, 4.80 to 3.13 for flavor, 4.13 to 2.47 for texture, 4.67 to 2.13 for taste, 4.67 to 2.80 for sweetness, 4.07 to 2.87 for shape of the roll and 4.93 to 3.13 for overall acceptability during 10 weeks storage.

It was observed that Ezidri rollups had higher sensory scores than control rollups because high hot air currents over the fruit pulp in the cabinet chamber causes more flavor, taste, color losses and appearance changes than Ezidri. Hence, Ezidri rollups could be considered superior in quality parameters compared to cabinet dried rollups.

During 10 weeks storage period, significant decrease of sensory scores was observed for papaya – black grape rollups in both cabinet and Ezidri which might be due to chemical reactions like degradation of pigments by non-enzymatic reaction, moisture losses, LDPE packaging material, increase of reducing sugars and acidity in the product under ambient temperature during

Table 2. Changes in microbial quality of papaya-black grape blend fruit rollups during storage

	Cabinet rollups				Ezidri rollups			
Microbial load (Cfu/g)	**1st week**	**6th week**	**8th week**	**10th week**	**1st week**	**6th week**	**8th week**	**10th week**
Bacterial (10^{-6})	Nil	Nil	0.33	0.67	Nil	Nil	0.67	1.0
Fungal (10^{-1})	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil

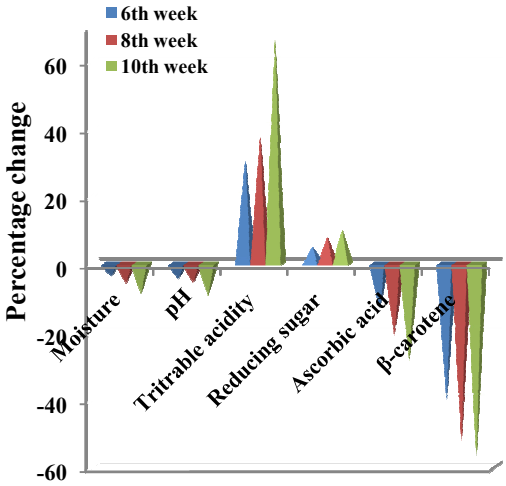

Fig. 1a. Percentage change in ezidri dried rollups

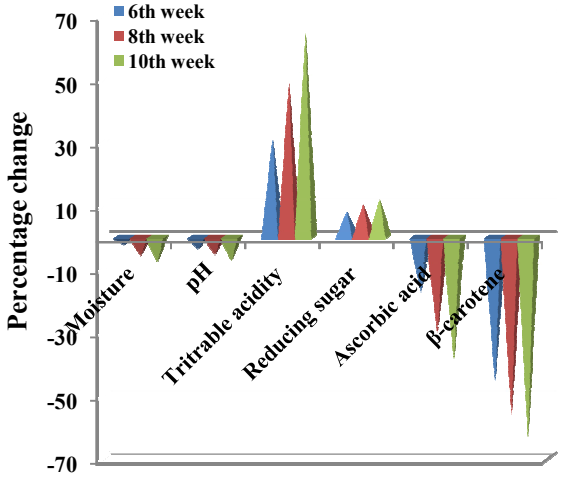

Fig. 1b. Percentage change in cabinet dried rollups

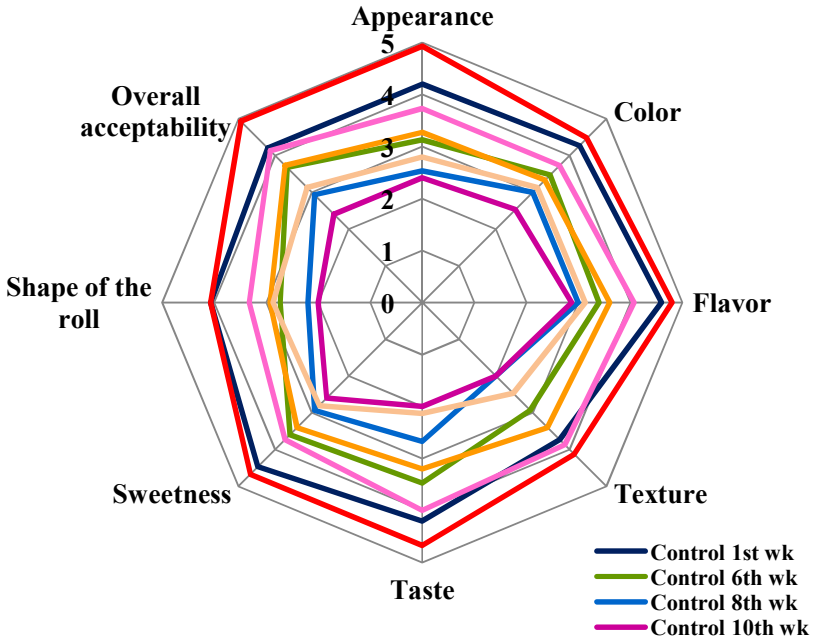

Fig. 2. Sensory scores of papaya-black grape blend fruit rollups during storage

storage period. Similar findings of decrease in sensory scores of sapota-papaya fruit bar (50:50) was reported by [24] and papaya-guava leather by [27].

4. CONCLUSION

Papaya – black grape fruit rollups are nutritionally enriched product. The moisture, TSS, pH, thickness, color (L) value, ascorbic acid, β-carotene content of the both samples was decreased while, acidity, reducing sugars, color (a and b) values, bacterial count was increased significantly during storage period. Retention of β-carotene, ascorbic acid was higher in Ezidri sample than cabinet fruit rollups. No fungal growth was observed throughout storage time but with negligible loads of bacterial load

was found with safe limits during storage hence it was declared as safe for consumption. Among two samples, Ezidri papaya – black grape fruit rollups was found best on the basis of sensory parameters throughout storage period.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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