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Antioxidant rich mixed fruit rolls and their storage stability

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Abstract
Mixed fruit rolls were developed from the fruit pulp extracted with peel of apple, peach, pear and persimmon. The prepared rolls were dried in conventional dehydrator (60±2ºC) to 20 per cent moisture with dehydration ratio ranging from 11:1 to 14:1 having rapid dehydration during initial period of drying, 50 per cent of moisture was lost during 6-7 h of drying. Among the mixed fruit rolls of various treatments, the best proportion of blend was 45:55 in apple-peach, 55:45 in apple-persimmon, apple-pear and pear-persimmon, and 70:30 in peach-pear and peach-persimmon. All the developed rolls were rich in polyphenols having high antioxidants potential with maximum content in persimmon followed by apple. During storage, slight increase was recorded in moisture, reducing sugars and non-enzymatic browning (NEB) whereas, total soluble solids, titratable acidity, total sugars, polyphenols, ascorbic acid, proteins, fats and free radical scavenging activity (FRSA) decreased with the storage period. Sensory quality during 6 month storage decreased slightly, comparatively less in laminated pouches stored under refrigerated conditions as compared to polythene pouches stored under ambient storage. Further, the sensory score for overall acceptability on Hedonic scale was highest (6.93) for apple-peach followed by 6.91for peach-pear and 6.90 peach-persimmon fruit rolls.

Keywords: Fruit rolls, dehydration, antioxidant, FRSA, NEB, sensory attributes

Introduction
Temperate fruits like Apple, persimmon, peach and pear are the important source of various phenolic compounds which provide protection against different diseases (Heinonen *et al*., 1998; Scalbert and Williamson, 2000) [20, 31]. Polyphenols deserve special mention due to their free radical scavenging activities and in-vivo biological activities (Bors *et al*., 1990; Rimm *et al*., 1996; Chen *et al*., 1996) [7, 28, 12]. Among all fruits studied in this study, the pear especially, sand pear fruits, are reported to contain high level of polyphenols as compared to apple (Kumar and Ghuman 2007) [22]. Apple and apple juice are reported to decrease possibility of prostate cancer, risk of chronic diseases like cardiovascular & cancer (Boyer and Liu, 2004 and Hamazu *et al*., 2005) [8, 19]. In true sense, the fruit pulp-based commercially dried products available to the consumers are not rich in the polyphenolics because while extracting the fruit pulp the skin of the fruits is discarded as waste. At the same time, commercially available fruit leather/bar is based on the dehydration of single fruit pulp without the addition/blending with other fruit pulp.
Fruit peel is the major source of phytochemicals which possess good antioxidant properties. The pulp extracted alongwith skin will be much rich source of antioxidants as the peel of apple is richer than pulp in all the quantified phenolics (Chinnici *et al.* 2004) [13]. According to Rupasinghe *et al*., (2008) [29], the apple skin is reported to contain high amount of phytochemicals, which are otherwise not present in the pulp and also have high antioxidant activity (Drogoudi *et al*., 2008, D'Abrosca *et al*., 2007) [17, 15]. These facts suggested that the apple peels may possess more bioactive compounds as compared to pulp. Generally, the fruit rolls are made by drying a very thin layer of fruit puree (in the form of leather) followed by rolling (Andress and Harisson 1999) [3]. Different types of functionally enriched fruit products have been prepared from fruits like jackfruit leather (Che and Taufic 1995) [11], jackfruit bars

(Manimegalai *et al*., 2001) [25] and wild apricot fruit bar (Sharma *et al*., 2013) [33]. A lot of work has been done by the researchers for the development of fruit leathers and bars but the literature on preparation of mixed fruit rolls by incorporating skin is lacking.

Therefore, antioxidant enriched fruits can be utilized for the development of a variety of functional foods with an adequate amount and quality of essential nutrients and functional components. The present investigation was thus carried out with the primary objective to develop the functionally enriched mixed fruit pulp rolls with skin from apple, pear, peach and persimmon.

Material and methods

Ripe fruits of Apple *cv.* 'Golden Delicious', Peach *cv.* 'Elberta Giant', Pear *cv.* 'Pathar Nakh', Persimmon *cv.* 'Jiro' were procured from local orchards and used for preparation of mixed fruit pulp blended rolls. The fruits were cut into two to four halves, seeds/stone were manually separated and the skin was then added by grinding in mixer. For preparation of mixed fruit rolls apple, pear and peach pulp with skin (25ºB) and persimmon pulp with skin (30ºB) were used as control T0 (50:50) with five combinations *viz* T1 (85:15), T2 (70:30), T3 (55:45), T4 (45:55), T5 (30:70) and T6 (15:85).

Physico-chemical analysis

The total soluble solids (TSS), titratable acidity, ascorbic acid and crude protein were estimated by following the method given in AOAC (1995) [4]. The moisture content was estimated by drying the weighed sample up to a constant weight in hot air oven at 70±2ºC and expressed in terms of percentage. Reducing sugars and total sugars in percent were estimated by Lane and Eynon method (Ranganna 1997) [27]. Non-enzymatic browning in fruit rolls involved measuring of optical density of alcoholic extracts of centrifuged samples (2000 rpm) at 440 nm, using 60 percent ethanol as blank (Ranganna 1997) [27]. Total phenols content was extracted in 80 percent ethanol and was estimated on the basis of their reaction with an oxidizing agent phosphomolybdate in Folin-Ciocalteau reagent under alkaline conditions (Bray and Thorpe, 1954) [10] and free radical scavenging activity was measured by method described by Brand *et al.* (1995) [9]. The rate of dehydration per unit time was calculated by placing a weighed quantity of pulp (700 g) on a stainless steel tray (30x20 cm) followed by drying in mechanical dehydrator (60±2ºC) to a moisture content of 12-14 percent (w/w). The loss in weight during drying was recorded at a periodic interval which was then calculated by plotting the percent moisture on dry weight basis against time in hours (Fellows, 1988) [18], whereas the ratio between fresh weight of material before drying to that of dried weight represented the dehydration ratio of given samples (Ranganna, 1997) [27]. Dehydrated products were further evaluated for sensory qualities on basis of colour, taste, texture and overall acceptability using 9- points hedonic scale method as given by Amerine *et al*. (1965) [2].

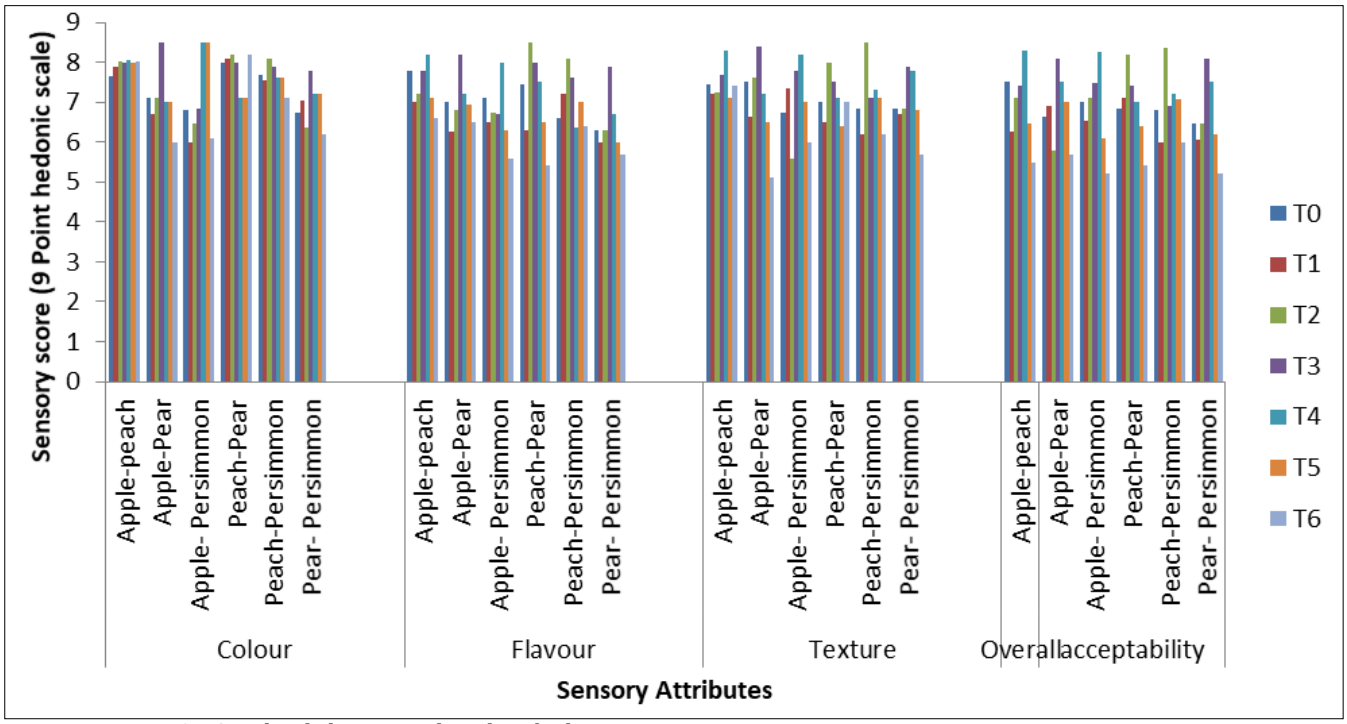
Statistical Analysis

Data pertaining to the sensory evaluation of fortified fruit-oat rolls were analyzed by using randomized block design (RBD) as described by Mahony (1985) [24] and the data on chemical characteristics were analyzed statistically by completely randomized design (Cochran and Cox 1967) [14].

Results and Discussion

Standardization of recipe for preparation of mixed fruit rolls

Among all fruit combinations in mixed fruit rolls treatment 'T4' (45:55) for apple-peach and apple-persimmon, treatment 'T3' (55:45) for apple-pear and pear-persimmon, treatment 'T2' (70:30) for peach-pear and peach-persimmon (T1) were adjusted best on the basis of organoleptic acceptability (Fig 1). The mixed fruit rolls were found of better quality due to the better fruit pulp blend of the product as compared to other recipes used in material and methods. Among the fruit rolls, sensory evaluation depicted that apple-peach (6.93) fruit rolls gave the best results for overall acceptability followed by peach-pear (6.91) and peach-persimmon (6.90) fruit rolls.



T0-T6 as detailed in materials and methods

Fig 1: Standardization of recipe for preparation of mixed fruit rolls.

Standardization of drying and dehydration ratio

The data presented in Fig 2, clearly reveals that the fruit rolls took around 19-26 hours to dry up to a moisture content of 11-14% for different combinations. Highest rate of drying during initial period of dehydration was observed in case of pear-persimmon fruit rolls and lowest was found in case of apple-peach fruit rolls. The dehydration ratio of different fruit rolls ranged from 11:1 to 14:1. The dehydration ratio for apple-peach, apple-pear, apple-persimmon, peach-pear, peach-persimmon and pear-persimmon was recorded as 13:1, 11:1, 14:1, 12:1, 13:1 and 12:1, respectively. Rapid dehydration rate in the initial stages may be attributed to the higher moisture content present in the different categories of fruits. Bhardwaj and Lal (1990) [6] observed that fastest rate of drying during the initial hours whereas, Fellows (1988) [18] also stated that rate of moisture removal is slowest during falling rate period of drying in apple.

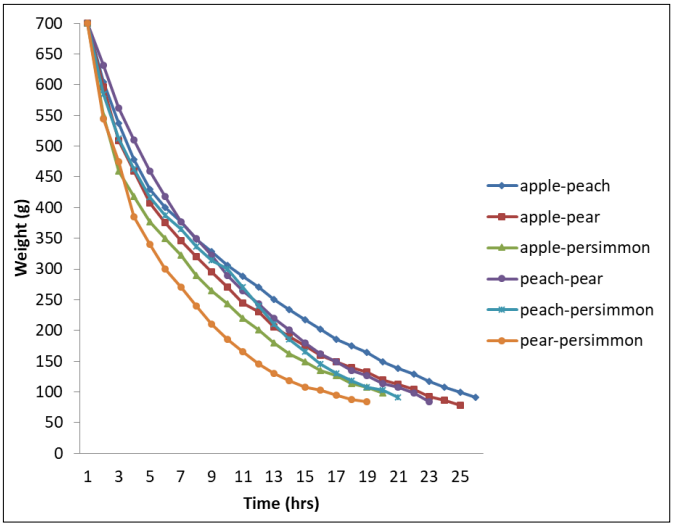


Fig 2: Drying curve for the effect of dehydration on mixed fruit rolls

Storage studies of mixed fruit rolls

Fruit rolls were packed in laminated and polyethylene pouches and stored under ambient storage conditions. The moisture content in fruit rolls ranged from 11.87 to 14.62 per cent with maximum moisture in apple persimmon rolls and minimum in apple pear (Table 1). After six months of storage, significant increase in moisture content from 13.01 to 14.10 percent was observed irrespective of fruit combination and packaging material. Similarly, Ambrose and Sreenarayanan (1998) [1] also found that the laminated pouches are better packaging material due to their barrier properties. Krishnaveni *et al.* (1999) [21] observed a decrease in moisture content during storage of jackfruit bars. The titratable acidity was found in the range of 1.68 to 2.55 percent in different mixed fruit rolls with maximum in peach-persimmon (2.55%) and minimum in apple-persimmon (1.68%), which after the six months of storage reduced to 2.46 and 1.62 per cent respectively. The total soluble solids varied from 72.24 to 73.80 ^{o}B with maximum TSS in apple-pear and minimum in peach-pear. Significant decrease in total soluble solids from 73.65 to 71.86^{o}B was observed during storage of six months, irrespective of package, storage temperature and fruit. The packaging material also shows significant results.

Further, significant increase in reducing sugars of the rolls during six months storage was observed (Table 2). The reducing sugars were increased to 33.33 from 32.23 per cent irrespective of fruit type and packing material. The packaging material shows significant effect as the rolls packed in PP shows high reducing sugars (33.19%) with 32.98% reducing sugars in laminated pouches. The trends are found in accordance to Sharma *et al.* (2000) [32] and Bhardwaj and Lal (1990) [6] in dried carrot and apple rings, respectively. Contrary to the reducing sugar levels, total sugars decreased from initial value of 60.48 to 58.70 percent. Maximum total sugars were recorded in apple-persimmon (61.50%) with minimum in peach-pear and apple-peach (58.36%). The decrease in sugars might be due to the participation of sugars in maillard browning reactions. The decrease in total sugars in apricot-soy toffees, sapota - papaya bar and papaya leather during storage was also observed by Thakur *et al.* (2007) [35], Sreemathi *et al.* (2008) [34] and Sandhu *et al.* (2008) [30] respectively. A significant decrease in ascorbic acid content (14.18 to 13.87 mg%) was recorded during 6 months storage of rolls (Table 2). Maximum ascorbic acid was recorded in pear-pesimmon (17.39 mg/100 g) with minimum in apple-peach (11.80 mg/100 g). Comparatively less reduction was recorded in fruit rolls packed in laminated pouches. Similar results have been reported by Sreemathi *et al.* (2008) [34] in sapota-papaya bar during 3 months of storage and Rai and Misra (2001) [26] in Bael pulp powder.

Data presented in Table 3 shows total phenol contents in the range of 504.9 to 1142.9 mg/100 g in fruit rolls with maximum phenol in apple-persimmon and minimum in apple-pear, which after the six months of storage reduced to 1104.2 and 444.2mg/100 g, respectively. The decrease could be attributed to the loss of SO_2 during the storage which exhibits an inhibitory effect against the enzymes. The phenols were found to decrease to 755.5 from 802.2 mg/100 g after six months storage irrespective of fruit type and packing material. Further, the free radical scavenging or antioxidant activity of products was recorded to decrease during storage from initial value of 80.06 to 73.58 percent irrespective of fruit type and packaging. Maximum free radical scavenging activity was recorded in apple-persimmon (88.30 per cent) and minimum in peach-pear (71.41 per cent). Among the packaging material, free radical scavenging activity of 76.06 and 76.86 per cent was observed in polyethylene pouches and laminated pouches after 6 months of storage irrespective of other factors.

Slight increase in non-enzymatic browning was observed in all fruit rolls during storage (Table 3). Minimal increase was recorded in products packed in laminated pouches while it was reasonable in polyethylene pouches which may be due to less retention of SO_2 in polyethylene pouches during storage. Products packed in laminates experienced minimum change in non-enzymatic browning which might be due to slow down of the browning reactions during storage. Similar trend of increase in non-enzymatic browning has been reported by Manimegalai *et al.* (2001) [25] in jack fruit bars. Similar trend of increase in non-enzymatic browning has been reported by Mahadeviah (1999) [23] and Aruna *et al.* (1998) [5] in papaya powder and Dabhade and Khedkar (1980) [16] in mango powder.

Table 1: Effect of packaging material and storage period on moisture, titratable acidity and TSS in mixed fruit rolls.

Fruit Combination (F) → Parameter ↓	Storage Period (S) (Months)	Packaging (P)												Mean (S)	CD @5%			
		Apple-peach		Apple-Pear		Apple-Persimmon		Peach-Pear		Peach-Persimmon		Pear-Persimmon			F	P	S	F*P*S
		PP	LP	PP	LP	PP	LP	PP	LP	PP	LP	PP	LP					
Moisture content (%)	0	13.14	13.14	11.87	11.87	14.62	14.62	12.24	12.24	13.43	13.43	12.73	12.73	13.01	0.08	0.07	0.05	0.18
	3	15.60	13.08	14.13	11.83	16.31	14.56	14.57	12.20	15.84	13.38	15.16	12.67	13.68				
	6	17.66	13.05	15.24	11.79	17.27	14.53	15.67	12.17	17.15	13.35	16.14	12.63	14.10				
	Mean	15.47	13.09	13.75	11.83	16.07	14.57	14.16	12.20	15.47	13.39	14.68	12.68					
	Mean (P)	14.90	12.96															
	Mean (F)	14.28		12.79		15.32		13.18		14.43		13.68						
Titratable acidity (%)	0	2.07	2.07	1.81	1.81	1.68	1.68	2.37	2.37	2.55	2.55	2.05	2.05	2.09	0.09	0.05	0.07	NS
	3	1.97	2.01	1.72	1.76	1.6	1.63	2.55	2.30	2.42	2.48	1.95	1.99	2.04				
	6	1.86	1.95	1.63	1.71	1.51	1.58	2.05	2.22	2.30	2.40	1.84	1.93	1.94				
	Mean	1.97	2.01	1.72	1.76	1.60	1.63	2.32	2.30	2.42	2.48	1.95	1.99					
	Mean (P)	1.99	2.03															
	Mean (F)	1.99		1.74		1.61		2.31		2.45		1.97						
TSS (%)	0	72.70	72.70	73.80	73.80	76.21	76.21	72.24	72.24	72.69	72.69	74.23	74.23	73.65	0.02	0.02	0.02	NS
	3	71.25	71.61	72.32	72.69	74.69	75.07	70.80	71.16	71.24	71.60	72.75	73.12	72.54				
	6	70.52	70.88	71.59	71.96	73.92	74.30	70.07	70.43	70.51	70.87	72.00	72.37	71.86				
	Mean	71.49	71.73	72.57	72.82	74.94	75.19	71.04	71.28	71.48	71.72	72.99	73.24					
	Mean (P)	72.41	72.66															
	Mean (F)	71.61		72.69		75.07		71.16		71.60		73.12						

LP-Laminated pouches, PP- Polyethylene pouches, S – Storage intervals, TSS- Total soluble solids

Table 2: Effect of packaging material and storage period on sugars and ascorbic acid in mixed fruit rolls.

Fruit Combination (F) → Parameter ↓	Storage Period (S) (Months)	Packaging (P)												Mean (S)	CD @5%			
		Apple-peach		Apple-Pear		Apple-Persimmon		Peach-Pear		Peach-Persimmon		Pear-Persimmon			F	P	S	F*P*S
		PP	LP	PP	LP	PP	LP	PP	LP	PP	LP	PP	LP					
Reducing sugars (%)	0	31.52	31.52	32.21	32.21	33.44	33.44	31.56	31.56	31.68	31.68	32.96	32.96	32.23	**0.04**	**0.03**	**0.02**	**0.09**
	3	32.46	32.15	33.17	32.85	34.44	34.10	32.50	32.19	32.63	32.31	33.94	33.61	32.73				
	6	33.41	33.09	34.14	33.82	35.44	35.11	33.45	33.13	33.58	33.26	34.93	34.60	33.33				
	Mean	32.46	32.25	33.17	32.96	34.44	34.22	32.50	32.29	32.63	32.42	33.94	33.72					
	Mean (P)	33.19	32.98															
	Mean (F)	32.36		33.07		34.33		32.40		32.52		33.83						
Total sugars (%)	0	59.35	59.34	60.69	60.69	62.54	62.54	59.34	59.34	59.49	59.49	61.50	61.50	60.48	0.12	0.09	0.11	NS
	3	58.27	58.54	59.60	59.87	61.41	61.69	58.27	58.54	58.42	58.69	60.39	60.67	59.80				
	6	57.21	57.47	58.50	58.78	60.28	60.56	57.21	57.47	57.35	57.62	59.28	59.56	58.70				
	Mean	58.27	58.45	59.60	59.78	61.41	61.60	58.27	58.45	58.42	58.60	60.39	60.58					
	Mean (P)	59.39	59.58															
	Mean (F)	58.36		59.65		61.50		58.36		58.51		60.48						
Ascorbic acid (mg/100g)	0	11.80	11.80	12.94	12.94	13.18	13.18	15.08	15.08	14.69	14.69	17.39	17.39	14.18	0.09	0.06	0.10	NS
	3	11.56	11.66	12.68	12.74	12.91	13.04	14.69	14.96	14.39	14.45	17.04	17.14	13.99				
	6	11.32	11.42	12.42	12.53	12.65	12.88	17.39	14.68	14.10	14.22	16.69	16.89	13.87				
	Mean	11.56	11.63	12.68	12.74	12.91	13.03	15.72	14.91	14.39	14.45	17.04	17.14					
	Mean (P)	14.05	13.98															
	Mean (F)	11.59		12.71		12.97		15.31		14.42		17.09						

LP-Laminated pouches, PP- Polyethylene pouches, S – Storage intervals

Table 3: Effect of packaging material and storage period on phenols, FRSA and NEB in mixed fruit rolls.

Fruit Combination (F) → Parameter ↓	Storage Period (S) (Month)	Packaging (P)												Mean (S)	CD @5%			
		Apple-peach		Apple-Pear		Apple-Persimmon		Peach-Pear		Peach-Persimmon		Pear-Persimmon			F	P	S	F*P*S
		PP	LP	PP	LP	PP	LP	PP	LP	PP	LP	PP	LP					
Total phenols (mg/100g)	0	732.9	732.9	504.9	504.9	1142.9	1142.9	616.3	616.3	987.3	987.3	828.9	828.9	802.2	2.80	4.21	5.20	7.04
	3	702.2	708.4	470.7	475.8	1110.2	1118.2	590.7	596.9	951.6	958.7	790.1	798.3	778.4				
	6	674.9	688.1	444.2	464.6	996.5	1104.2	574.2	580.9	921.8	937.5	766.5	772.8	755.5				
	Mean	703.3	709.8	473.3	481.8	1083.2	1121.8	593.7	598.0	953.6	961.2	795.2	800.0					
	Mean (P)	767.1	778.8															
	Mean (F)	706.6		477.5		1102.5		595.9		957.4		797.6						
Free radical scavenging activity (%)	0	72.51	72.51	79.24	79.24	88.30	88.30	71.41	71.41	86.52	86.52	82.37	82.37	80.06	0.19	0.37	0.49	0.59
	3	68.88	69.61	75.28	76.07	83.89	84.77	67.84	68.55	82.19	83.06	78.25	79.08	77.41				
	6	65.26	66.71	71.32	72.90	79.47	81.24	64.27	65.70	77.87	79.60	74.13	75.78	73.58				
	Mean	68.88	69.61	75.28	76.07	83.89	84.77	67.84	68.55	82.19	83.06	78.25	79.08					

	Mean (P)	76.06	76.86															
	Mean (F)	69.25		75.68		84.33		68.20		82.63		78.66						
Non-enzymatic browning (OD 440nm)	0	0.015	0.015	0.013	0.013	0.010	0.010	0.013	0.013	0.012	0.012	0.011	0.011	0.012	0.007	0.005	0.006	0.015
	3	0.162	0.046	0.157	0.040	0.140	0.032	0.164	0.044	0.155	0.034	0.143	0.025	0.083				
	6	0.364	0.066	0.341	0.058	0.321	0.051	0.363	0.066	0.330	0.053	0.337	0.046	0.135				
	Mean	0.180	0.042	0.170	0.037	0.157	0.031	0.180	0.041	0.166	0.033	0.164	0.027					
	Mean (P)	0.169	0.035															
	Mean (F)	0.111		0.104		0.094		0.111		0.099		0.096						

LP-Laminated pouches, PP- Polyethylene pouches, S – Storage intervals

Sensory evaluation of mixed fruit rolls

The sensory score for colour, taste, texture and overall acceptability presented in Table 4. On the basis of overall acceptability scores, maximum score was given for peach-persimmon rolls (8.35) with minimum for pear-persimmon and apple-pear fruit rolls (8.10). During 6 months of storage studies the average initial value (8.22) of overall acceptability decreased to 6.87, irrespective of other factors. Among the packaging material, the rolls packed in laminated pouches fetches better sensory scores for all the sensory characteristics.

Table 4: Effect of packaging material and storage period on Sensory characteristics of mixed fruit rolls.

Fruit Combination (F) → Parameter ↓	Storage Period (S) (Month)	Packaging (P)												Mean (S)	CD @5%			
		Apple-peach		Apple-Pear		Apple-Persimmon		Peach-Pear		Peach-Persimmon		Pear-Persimmon			F	P	S	F*P*S
		PP	LP	PP	LP	PP	LP	PP	LP	PP	LP	PP	LP					
Colour	0	8.05	8.05	8.50	8.50	8.50	8.50	8.20	8.20	8.10	8.10	7.80	7.80	**8.19**	0.08	0.05	0.07	0.18
	3	7.60	7.90	7.30	7.70	7.50	7.90	7.60	7.70	7.20	7.60	7.30	7.70	**7.68**				
	6	6.80	7.20	6.50	6.90	6.60	7.10	6.80	7.20	6.40	6.80	6.40	6.90	**6.88**				
	Mean	7.48	7.72	7.43	7.70	7.53	7.83	7.53	7.70	7.23	7.50	7.17	7.47					
	Mean (P)	7.40	7.65															
	Mean (F)	7.60		7.57		7.68		7.62		7.37		7.32						
Taste	0	8.20	8.20	8.20	8.20	8.00	8.00	8.50	8.50	8.10	8.10	7.90	7.90	8.15	0.07	0.05	0.07	NS
	3	7.10	7.50	7.20	7.70	7.30	7.70	7.30	7.70	7.60	7.90	7.70	7.60	7.61				
	6	6.30	6.70	6.40	6.80	6.50	6.90	6.50	7.00	6.80	7.20	6.80	7.20	6.84				
	Mean	7.20	7.47	7.27	7.57	7.27	7.53	7.43	7.73	7.50	7.73	7.47	7.57					
	Mean (P)	7.36	7.60															
	Mean (F)	7.33		7.42		7.40		7.58		7.62		7.52						
Texture	0	8.30	8.30	8.40	8.40	8.20	8.20	8.00	8.00	8.50	8.50	7.90	7.90	8.22	0.05	0.03	0.02	0.09
	3	7.10	7.40	7.30	7.80	7.40	7.70	7.60	8.10	7.60	8.00	7.10	7.50	7.67				
	6	6.30	6.70	6.50	7.00	6.60	7.00	6.90	7.20	6.70	7.10	6.40	6.80	6.87				
	Mean	7.23	7.47	7.40	7.73	7.40	7.63	7.50	7.77	7.60	7.87	7.13	7.40					
	Mean (P)	7.38	7.64															
	Mean (F)	7.35		7.57		7.52		7.63		7.73		7.27						
Overall acceptability	0	8.30	8.30	8.10	8.10	8.25	8.25	8.20	8.20	8.35	8.35	8.10	8.10	8.22	0.08	0.06	0.09	NS
	3	7.30	7.60	7.30	7.70	7.50	7.90	7.40	7.80	7.40	7.80	7.30	7.70	7.65				
	6	6.40	6.90	6.50	6.90	6.70	7.00	6.60	7.10	6.60	7.00	6.50	6.90	6.87				
	Mean	7.33	7.60	7.30	7.57	7.48	7.72	7.40	7.70	7.45	7.72	7.30	7.57					
	Mean (P)	7.38	7.65															
	Mean (F)	7.47		7.43		7.60		7.55		7.58		7.43						

LP-Laminated pouches, PP- Polyethylene pouches, S – Storage intervals

Conclusion

The present investigation concludes that the apple, pear and peach pulp with skin (25ºB) and persimmon pulp with skin (30ºB) mixed in different combinations 45:55 in apple-peach, 55:45 in apple-persimmon, apple-pear and pear-persimmon, and 70:30 in peach-pear and peach-persimmon were found best and optimized for preparation of mixed fruit rolls. Fruit rolls could be stored for six months with better nutritional and sensory quality after packing in laminated pouches. Thus, the developed technology can be commercially exploited at industry level for the production of quality fruit rolls to ensure better returns to the growers and prevention of environmental pollution due to the accumulation of skin of fruits as processing waste.

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