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Effect of packaging on the storage of oat flour fortified fruit rolls

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Abstract
Apple, peach, pear and persimmon fruit pulp with skin along with the oat flour were used to prepare fruit rolls. The prepared fruit rolls were dried in dehydrator (60±2ºC) to 20 percent moisture contents with dehydration ratio of 14:1, 13:1, 11: 1 and 15: 1, respectively for apple-oat, peach-oat, pear-oat and persimmon-oat. Fruit-oat rolls (90:10) was found best among different treatments, on basis of sensory evaluation and among fruit rolls peach-oat rolls (6.67) found best on the basis of overall acceptability followed by apple-oat rolls (6.63). The fruit rolls prepared with oats showed maximum retention of ascorbic acid, total phenols, free radical scavenging activity, crude fibers, proteins and fats during storage in laminated pouches. There is greater scope and need to develop the functional mixed fruit rolls from fruit pulp containing skin and oats as they being rich in nutritional value a part from having good blended taste. It could be one of the alternatives to meet the growing demand of functional foods.

Keywords: Dehydration ratio, free radical scavenging activity, fruit rolls, storage, sensory evaluation

Introduction
Apple, persimmon, peach and pear are the most important fruits grown in the temperate regions of the world. The presence of various phenolic compounds in the fruits provides protection against different diseases (Heinonen *et al*., 1998; Scalbert and Williamson, 2000) [24, 42]. 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, 23]. 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) [27, 37, 13]. 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) [26]. 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. At the same time, commercially available fruit leather/bar is based on the dehydration of single fruit pulp without the addition/blending with the pulp of other fruits or with some cereals.

Temperate fruits like apple, pear, peach and persimmon are rich source of sugars, acids, vitamins and polyphenols but are deficient in protein. Fortification is an important way to improve the nutritional status of these fruits and thus, functional food products could be prepared by fortifying fruit pulp with oat flour. Oat is known as a rich source of endogenous antioxidant like tocopherols (Bratt *et al*. 2003) [10], carbohydrates (66g), fibre (11g) and β-glucon (Gray *et al*. 2002) [22]. Antioxidants help to maintain the stability of processed oat products and can stabilize fats and oils against rancidity (Peterson 2001). Fruit peel is the major source of phytochemicals which possess antioxidant properties. Therefore, pulp extracted alongwith skin will be much rich source of antioxidants as compared to pure pulp. According to Chinnici *et al*., 2004 [14], the apple peel is richer than pulp in all phenolics. Apple skin is reported to contain high amount of phytochemicals which are not present in the pulp (Rupasinghe *et al*., 2008) [38] and have high antioxidant activity (Drogoudi *et al*., 2008; D'Abrosca *et al*., 2007) [19, 17].

Further, 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 leather like jackfruit leather (Che and Taufic 1995) [12], jackfruit bars (Manimegalai *et al*., 2001) [31], wild apricot fruit bar (Sharma *et al*, 2013) [44] have been reported.

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

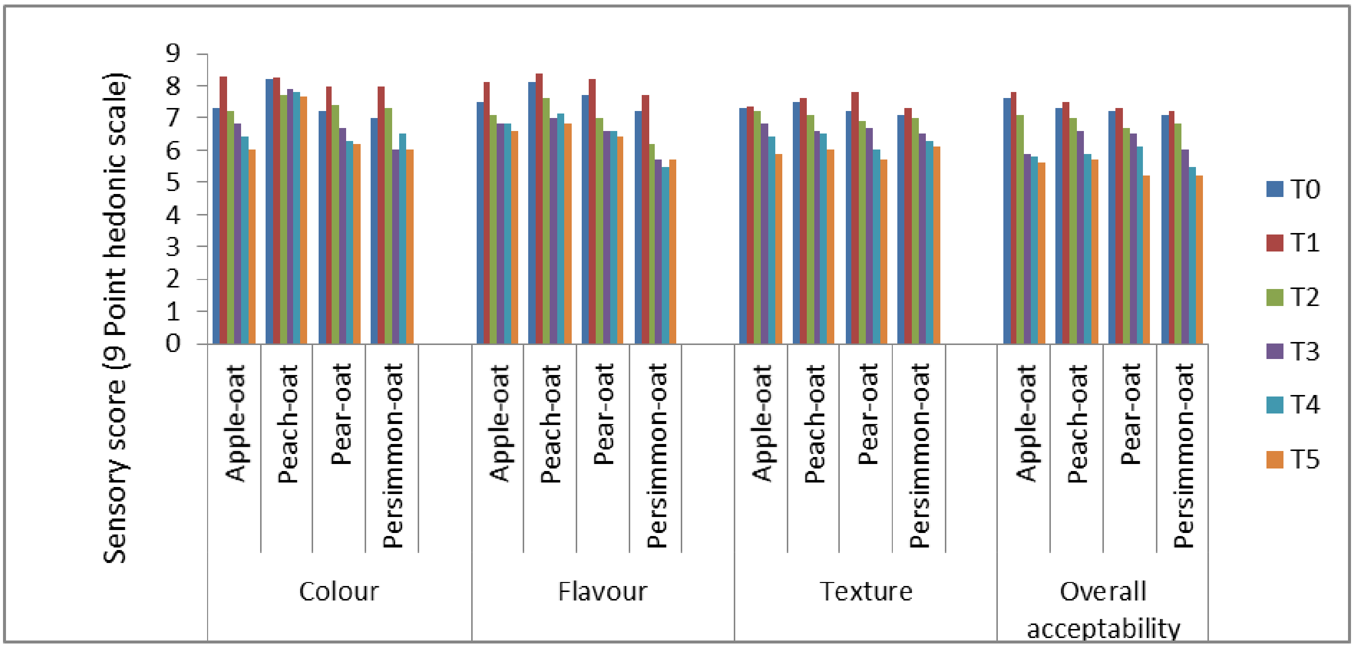
Materials and Methods

Ripe fruits of Apple *cv.* 'Golden Delicious', Peach *cv.* 'Elberta Giant', Pear *cv.* 'Pathar Nakh', Persimmon *cv.* 'Jiro' were procured from local orchards and Oat obtained from the local market were used for preparation of fruit pulp-oat blended rolls. The pulp of the fruits viz., apple, peach, pear and persimmon was prepared by using hot method (Lal and Sharma, 1989) [27]. The pulp was prepared by cutting the fruits into two to four halves followed by separation of seeds/ stone manually and after this the skin was added by grinding in mixer. Further, Oat seeds were passed through grinding machine to prepare good quality flour and the ground flour was then passed through sieve to remove the bran. For preparation of fruit rolls fortified with oat flour the apple, pear and peach pulp with skin (25°B) and persimmon pulp with skin (30°B) were used as control T0 and again, further blended in five combinations viz T1 (90:10), T2 (80:20), T3 (70:30), T4 (60:40) and T5 (50:50) for mixing fruit and oat flour respectively.

Further, the TSS of 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±2°C and expressed in terms of percentage. Reducing sugars and total sugars in percent were estimated by Lane and Eynon method, (1923) [28]. 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) [35]. 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) [11] 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±2 °C) 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) [20], whereas the ratio between fresh weight of material before drying to that of dried weight represented the dehydration ratio of given samples (Ranganna, 1997) [35]. Dehydrated products were further evaluated for sensory qualities on basis of colour, taste, texture and overall acceptability on a 9- points hedonic scale method as given by Amerine *et al.*,1965 [2] and was carried out by a panel of 7 trained panelists. Data pertaining to the sensory evaluation of fortified fruit-oat rolls were analyzed by using randomized block design (RBD) as described by Mahony (1985) [30] and the data on chemical characteristics were analyzed statistically by completely randomized design (Cochran and Cox 1967) [16].

Results and Discussion

Among all fruit combinations, (T1) 90:10 ratio of fruit pulp : oat flour was adjusted best based on organoleptic acceptability (Fig-1) of the product which might be due to the better fruit pulp –oat flour blend of the product as compared to other recipes used in material and methods. Among the fruit-oat rolls, apple-oat (7.8) performed best followed by peach-oat (7.5), pear-oat (7.3) with lowest score for persimmon-oat (7.2) on basis of overall acceptability. The lower score obtained by the fruit-oat rolls prepared by using 50% fruit pulp and 50% oat flour (T5) was probably due to the improper combination of the product. On the contrary the products prepared by using fruit pulp and oat flour (80:20), (70:30), (60:40) (i.e. T2 to T4) were not liked too much due to improper mixing of fruit pulp and oat flour. Therefore, the recipe containing Pulp 90% and oat flour 10% was optimized for further studies.



T_0-T_5 as detailed in material and methods

Fig 1: Standardization of recipe for preparation of oat fortified fruit rolls

Observations regarding the dehydration of fruit-oat rolls revealed that it took around 16-22 hours to dry up to a moisture content of 11-15% in different fruit-oat roll combinations (Fig 2). Highest rate of drying during initial period of dehydration was observed in case of persimmon-oat rolls and lowest in case of peach-oat rolls. The dehydration ratio of different fruit rolls varied from 11 : 1 to 15 : 1. The dehydration ratio for apple-oat, peach-oat, pear-oat and persimmon-oat was recorded as 14 : 1, 13 :1, 11 : 1 and 15 : 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) [20] also stated that rate of moisture removal is slowest during falling rate period of drying in apple.

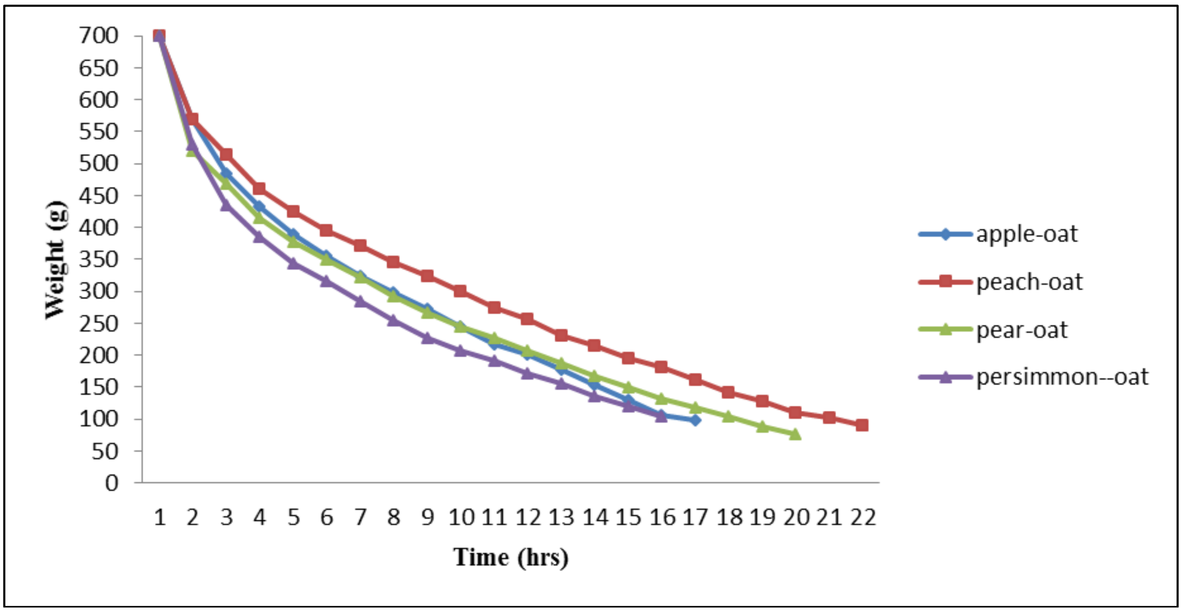


Fig 2: Drying curve for the effect of dehydration on fruit-oat rolls

Storage studies

Fruit rolls were packed in laminated and polyethylene pouches and stored under ambient storage conditions. The moisture content in fruit-oat rolls ranged from 11.25 to 15.16 per cent with maximum moisture content recorded in persimmon-oat (15.16%) and minimum in pear-oat (11.25 %) (Table 1). Further, fruit rolls packed in polyethylene pouches absorbed maximum moisture during storage and moisture content was almost constant in laminated pouches. Impervious nature of aluminium foil to air and water is the main reason for negligible changes in laminated pouches whereas, high moisture uptake in polyethylene pouches is the result of their permeability to air and moisture. 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) [25] observed a decrease in moisture content during storage of jackfruit bars.

Significant increase in reducing sugars of the products during the storage period of six months was recorded (Table 1). Products packed in laminated pouches experienced least changes in reducing sugars than those packed in polyethylene pouches when stored at ambient temperature which might be due to the inversion of non - reducing sugars into reducing sugars and the conversion of polysaccharides to monosaccharides. The trends are found in accordance to Sharma *et al.* (2000) [43] and Bhardwaj and Lal (1990) [6] in dried carrot and apple rings, respectively. Sagar and Khurdiya (1999) [39] also reported increase in sugars in dehydrated mango slices and osmo-dried apple rings respectively, during the storage.

Contrary to the reducing sugar levels the total sugar levels decreased from initial value of 59.60% to 57.46 and 57.72% in apple –oat rolls, 57.12% to 55.08 and 55.33% in peach –oat rolls, 59.12% to 57.00 and 57.26% in pear –oat rolls and 61.14% to 58.93 and 59.21% in persimmon –oat rolls in polyethylene pouch and aluminium laminated pouch respectively during storage of 6 months (Tables 1), which might be due to the participation of sugars in Maillard browning reactions. The net loss in total sugars of fruit rolls packed in aluminium laminated pouches was less as compared to polythene pouches indicates superiority of the former over the later in retention of nutritional quality of the stored products. The decrease in total sugars in apricot - soy toffees and papaya leather during storage was also observed by Thakur *et al.* (2007) [46] and Sandhu *et al.* (2008) [40] respectively. Similar findings have been reported during storage of sapota - papaya bar by Sreemathi *et al.* (2008) [45].

A significant decrease in ascorbic acid content was recorded during storage in fruit-oat blended rolls (Table 1). The loss of ascorbic acid during the storage could be attributed to its oxidation to dehydroascorbic acid followed by further degradation to 2,3 - diketogulonic acid and finally to furfural compounds which enter browning reactions.. Comparatively less reduction was recorded in fruit rolls packed in laminated pouches. Loss of ascorbic acid has earlier been reported in mango leather during of 3 months storage by Rao and Roy (1980b) [36]. Similar results have been reported by Sreemathi *et al.* (2008) [45] in sapota -papaya bar during 3 months of storage and Rai and Misra (2001) [34] in in Bael pulp powder.

Further, a slight decrease in total phenolics content of fruit rolls was recorded in all treatments during the storage (Table 1). It could be attributed to the loss of SO_2 during the storage which exhibits an inhibitory effect against the enzymes. Changes were minimal in case of products packed in laminated pouches as compared to polyethylene pouches which could be due to the prevention of air, oxygen and other gases in laminated pouches as oxygen can be responsible for the oxidation of phenols during storage. During the processing of foods, various transformations of phenolics occur to produce yellowish to brownish pigments (Clifford, 2000) [15].

Free radical scavenging or antioxidant activity of products was recorded to decrease during storage from initial value of 72.20% to 64.98 and 66.42% in apple –oat rolls, 61.73% to 55.56 and 56.79% in peach –oat rolls, 58.84% to 52.69 and 53.86% in pear –oat rolls and 82.66% to 74.39 and 76.05% in persimmon –oat rolls in polyethylene pouch and aluminium laminated pouch respectively during storage of 6 months (Tables 1). Like phenolic contents, it was also found to exhibit more decrease in polyethylene pouches as compared to laminated pouches. It has also been reported that foods undergo numerous processing changes before consumption which may alter their nutritional profile (Goyal and Khetarpaul, 1994; Negi *et al.*, 2001) [21, 32] including their antioxidants content (Sato *et al.*, 2006; Turkmen *et al.*, 2006) [41, 48].

Slight increase in non-enzymatic browning was observed in all types of products during storage (Table 1). 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) [31] in jack fruit bars. Similar trend of increase in non-enzymatic browning has been reported by Mahadeviah (1999) [29] and Aruna *et al.* (1998) [5] in papaya powder and Dabhade and Khedkar (1980) [18] in mango powder.

No significant decrease in the protein content was recorded during storage however; changes were more in polyethylene pouches as compared to laminated pouches (Table 1). This might be due to the denaturation of proteins during processing and storage. Similar results were reported by Thakur (1997) [47] in apricot-soya bars.

Sensory evaluation of fruit-oat rolls

Overall acceptability score varied from 7.2 to 7.8 in different fruit-oat rolls with maximum score in apple-oat (7.8) and minimum in persimmon-oat (7.2) (Fig-1). After six months of storage, the overall acceptability ranges between 5.80 to 6.30 after 6 months storage in polyethylene pouches and 6.00 to 6.70 in laminated pouches (Table 2). The highest score for overall acceptability were observed in case of peach-oat (6.30 and 6.70) followed by apple-oat (6.00 and 6.40) respectively in PE and laminated pouches. The sensory attributes like colour, taste, and texture noticed similar scores for peach-oat and apple-oat rolls. Further, the decrease in sensory score for colour, taste, and texture were less in products packed in laminated pouches as compared to polyethylene pouches. This trend might be due to impervious nature of the laminated pouches which provide a barrier to light and air.

Table 1: Effect of packaging on quality characteristics of fruit-oat rolls.

Parameter	SI (Months)	Fruit/Oat (F)								$CD^{0.05}$			
		Apple-oat		Peach-oat		Pear-oat		Persimmon-oat		F	P	SI	F*P*SI
		PP	LP	PP	LP	PP	LP	PP	LP				
Moisture content (%)	0	14.07	14.07	13.14	13.14	11.25	11.25	15.16	15.16	0.06	0.05	0.05	0.18
	3	16.67	14.02	15.44	13.09	13.95	11.20	17.23	15.12				
	6	17.42	13.99	16.24	13.07	14.51	11.18	18.14	15.09				
Reducing sugars (%)	0	31.79	31.79	30.92	30.92	31.31	31.31	32.66	32.66	0.07	0.05	0.06	NS
	3	32.74	32.42	31.84	31.53	32.24	31.93	33.63	33.31				
	6	33.69	33.37	32.77	32.46	33.18	32.87	34.61	34.29				
Total sugars (%)	0	59.60	59.60	57.12	57.12	59.12	59.12	61.14	61.14	0.03	0.02	0.02	0.08
	3	58.53	58.80	56.10	56.35	58.06	58.32	60.04	60.31				
	6	57.46	57.72	55.08	55.33	57.00	57.26	58.93	59.21				
Ascorbic acid (mg/100g)	0	9.32	9.32	10.86	10.86	16.93	16.93	17.19	17.19	0.07	0.06	0.08	NS
	3	9.13	9.18	10.64	10.70	16.59	16.65	16.85	16.93				
	6	8.95	8.99	10.43	10.48	16.25	16.38	16.50	16.59				
Total phenols (mg/100g)	0	767.62	767.62	697.35	697.35	276.46	276.46	1511.24	1511.24	12.45	14.10	15.23	16.10
	3	733.26	738.44	668.42	673.39	253.59	254.46	1453.10	1477.26				
	6	698.24	713.88	627.26	643.11	228.54	237.59	1397.56	1417.26				
FRS activity (%)	0	72.20	72.20	61.73	61.73	58.54	58.54	82.66	82.66	0.19	0.37	0.49	0.59
	3	68.59	69.31	58.64	59.26	55.61	56.20	78.53	79.35				
	6	64.98	66.42	55.56	56.79	52.69	53.86	74.39	76.05				
NEB (OD 440nm)	0	0.007	0.007	0.008	0.008	0.014	0.014	0.012	0.012	0.007	0.005	0.006	0.015
	3	0.106	0.026	0.115	0.020	0.160	0.046	0.156	0.042				
	6	0.302	0.031	0.313	0.035	0.355	0.062	0.344	0.056				
Proteins	0	10.45	10.45	11.23	11.23	10.40	10.40	10.68	10.68	0.12	0.09	0.11	NS
	3	9.03	9.50	10.32	10.66	8.93	8.93	9.46	9.87				
	6	7.86	8.27	8.98	9.27	7.90	7.90	8.94	9.14				

LP-Laminated pouches, PP- Polyethylene pouches, F- Fruit oat roll, P -Packaging SI – Storage intervals
FRS- Free radical scavenging, NEB- Non-enzymatic browning

Table 2: Effect of packaging on Sensory characteristics of fruit-oat rolls

Sensory attribute	Storage Period (S) (Months)	Fruit/Oat (F)								CD @5%			
		Apple-oat		Peach-oat		Pear-oat		Persimmon-oat		F	P	S	F*P*S
		PP	LP	PP	LP	PP	LP	PP	LP				
Colour	0	8.30	8.30	8.25	8.25	7.20	7.20	7.00	7.00	**0.02**	**0.01**	**0.07**	**NS**
	3	7.20	7.50	7.40	7.80	6.80	6.90	6.60	6.80				
	6	6.40	6.80	6.60	7.00	6.40	6.80	6.10	6.60				
Taste	0	7.50	7.50	8.10	8.10	7.70	7.70	7.20	7.20	0.01	0.03	0.08	NS
	3	6.00	6.30	6.80	7.20	6.40	6.80	6.80	6.70				
	6	5.30	5.70	6.00	6.50	5.70	6.00	6.00	6.40				
Texture	0	7.30	7.30	7.50	7.50	7.20	7.20	7.10	7.10	**0.02**	**0.01**	**0.02**	**NS**
	3	7.00	7.10	7.00	7.30	6.40	6.80	6.60	6.80				
	6	6.20	6.60	6.20	6.60	5.70	6.00	5.80	6.20				
Overall acceptability	0	7.60	7.60	7.30	7.30	7.20	7.20	7.10	7.10	0.02	0.02	0.05	NS
	3	6.70	7.10	6.90	7.00	6.60	6.90	6.50	6.80				
	6	6.00	6.40	6.30	6.60	5.90	6.20	5.80	6.00				

LP-Laminated pouches, PP- Polyethylene pouches, F- Fruit oat roll, P -Packaging S – Storage intervals,

Conclusion
The present investigation concludes that apple, pear and peach pulp with skin (25ºB) and persimmon pulp with skin (30ºB) mixed with oat 90:10 ratio of pulp:oat was found best and optimized for preparation of oat fortified fruit rolls. Fruit rolls could be stored for six months with better nutritional 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.

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