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Effect of Curry Leaf Application and Packaging in Enhancing Shelf Life of Banana Chips

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ABSTRACT: *The potency of curry leaf powder and effect of packaging in enhancing the quality and shelf life of Nendran banana chips were explored. Banana chips prepared with and without dried curry leaf powder were stored in low density polyethylene (LDPE) pouches, tri-layered laminated pouches and under modified atmospheric packaging (MAP) in laminated pouches for three months. Curry leaf powder application and MAP were found effective in retaining quality parameters. Chips prepared with 0.02% dried curry leaf powder and packed under MAP in laminated pouches showed low moisture (6.90%), FFA value (5.24 mg KOH/g), peroxide value (7.87 meq. O_2/kg), highest iodine value (10.27), yellowness index (109.86) and crispness (5.12) at the end of 90 days of storage. Higher mean rank value for sensory quality parameters and highest antioxidant activity (12.61 ± 1.31%) were also recorded by this treatment.*

The study revealed that incorporation of 0.02% oven dried curry leaf powder to frying oil at smoke point of 165^{0}C and storing under MAP system in laminated pouches ensures shelf life of three months to Nendran banana chips and also brings variability in banana chips industry.

Key words: *banana chips, antioxidants, curry leaf powder, MAP*

Banana chips is the most popular crispy snack of Kerala, having high demand due to its characteristic flavour and taste. It is prepared by deep fat frying of peeled and sliced mature unripe fruits of cv. Nendran (AAB) in suitable edible oil or fat, or combinations thereof [4]. But chips prepared in coconut oil is most preferred in Kerala. One of the major problems faced by small scale chips makers in storage of banana chips is rancidity, a condition produced by oxidation of unsaturated fats present in food, marked by unpleasant odour or flavour.

Antioxidants are often added to fat containing foods to delay the onset or slow the development of rancidity due to oxidation. Synthetic antioxidants such as butylated hydroxy anisole (BHA), butylated hydroxy toluene (BHT) and propyl gallate (PG) are widely used as food additives, but their application has been reassessed because of possible toxic or carcinogenic components formed during their degradation [12]. A large range of low and high molecular weight plant polyphenols presenting antioxidant properties has been studied and proposed for protection against lipid oxidation [14]. Antioxidant protein compounds isolated from curry leaf was effective in scavenging free radicals at 150 fold lesser concentration compared to BHA and tocopherol (400 µM) [8] and aqueous extract of *Murraya koenigii* leaves (10µg/ml) was effective in inhibiting 90% of lipid peroxidation [19].

Shelf life of plantain chips is greatly reduced when exposed to light, moisture and air, hence must be packed in moisture proof bags to prevent absorption and loss of crispness [18]. Several food packaging strategies are also currently employed to prevent harmful oxidative reactions within food systems. Packaging plays an important role in influencing shelf life of crispy chips under humid tropical conditions of Kerala. Hence in the present study, effect of curry leaf powder application and packaging in enhancing the shelf life of banana chips was explored.

MATERIALS AND METHODS

Fully mature unripe banana bunches of cultivar Nendran (AAB) were harvested between 85 – 95 days

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after inflorescence emergence from Instructional Farm, College of Agriculture, Vellayani. Good sized fingers were selected, separated, washed to remove adhering dirt and dust, subsequently peels were removed and sliced using an adjustable hand slicer into uniform slices of two mm thickness. Chips were prepared in unrefined coconut oil at 165^{0}C with an oil- slice ratio of 2:1 by adding 0.02% oven dried curry leaf powder and 0.7% salt + 0.15% turmeric as 20% aqueous solution at the end of frying [17].

100g each of curry leaf treated and untreated chips were packed in 100 gauge LDPE (Low density Polyethylene) covers (market sample) and laminated pouches (LDPE/ metalised polyester/ LDPE) & sealed using heat sealing machine (Quick seal ™ of Sevana (India) Ltd. Vacuum packaging of banana chips in laminated pouches was also adopted with a laboratory model vacuum packaging machine [Sevana's sevol vacuum packaging machine QS 400 MG (MC)]. These were then stored for three months under ambient room temperature condition.

The stored chips were evaluated for its physical quality parameters viz., moisture content, colour and texture, chemical quality parameters like FFA value, peroxide value, iodine value and total antioxidant activity and sensory quality parameters by organoleptic scoring at the time of storage and at periodic intervals for a period of three months.

Moisture content of chips was recorded at fortnightly intervals whereas colour & texture was recorded at monthly intervals. Moisture content was estimated using moisture analyser, which dries the sample using a halogen lamp and records the moisture content based on the principle of thermo gravimetric analysis. Colour was recorded using spectrophotometer as *L*a*b** colour indices, adopted by the Commission Internationale d'Eclairage yellowness index was computed as 142.86 x [b ÷ L]. Texture of the prepared banana chips was measured as crispness using a food texture analyzer (TAHD-Stable Microsystems, UK) snap test method.

Chemical quality parameters like free fatty acid (FFA) value, peroxide value and iodine value which represent the rancidity factors of deep fried products were recorded at fortnightly intervals for 3 months of storage. Free fatty acid value was determined by titrating the ground chips dissolved in neutral solvent (diethyl ether and ethanol in the ratio 1:1) against potassium hydroxide, using phenolphthalein as indicator and expressed as mg KOH/ g chips. Peroxide value was determined by titration of powdered chips against 0.1 N thiosulphate in presence of potassium iodide using starch as indicator and expressed as milliequivalent peroxide / kg chips. A known quantity of powdered chips were treated with Hanus iodine solution and iodine value was determined by titration of treated chips against sodium thiosulphate and expressed as gram of iodine absorbed per 100 g chips [15].

Total antioxidant activity of stored banana chips was determined using 2, 2-Diphenyl-1-picrylhydrazyl (DPPH) radical scavenging assay. 2.0 ml sample was added to 2.0 ml 0.1mM DPPH solution, shaken the mixture and left for 30 minutes at room temperature. The absorbance was read at 517nm. Scavenging effect was expressed as % inhibition of DPPH, [16].

$$\%\text{ inhibition of DPPH} = \frac{[A_{blank} - A_{sample}] \times 100}{A_{blank}}$$

where,

A_{blank} - Absorbance of DPPH solution without sample, read against ethanol blank

A_{sample} – Absorbance of the test sample

Sensory evaluation was done using organoleptic scoring by a 30 member semi trained panel comprising of research scholars of College of Agriculture, Vellayani. The panel were asked to score the appearance, colour, flavour, texture, taste and overall acceptability of the sample using a nine-point hedonic scale [10]. The best treatment which retains superior physical, chemical and sensory quality parameters was selected as the best method of banana chips preparation for enhanced shelf life and quality.

Statistical analysis: The treatment combinations were grouped according to the packaging method used for curry leaves treated & untreated chips and analyzed using one way ANOVA and significance was tested using CD. In organoleptic analysis, the different preferences as indicated by scores were evaluated by Kruskall – Wallis test to get the mean rank values for all the treatments.

RESULTS AND DISCUSSIONS

Physical quality changes during storage

Physical quality parameters of treated and untreated chips viz., moisture, colour and texture were measured at regular intervals for three months, after storing in three different packages/ packaging systems viz., LDPE pouch, laminated pouch and MAP in laminated pouch.

Snack foods may uptake water vapour from the surrounding environment since water vapour concentration gradient act as a driving force for the water vapour transport phenomenon through the packaging material [9]. When the effect of packaging material and antioxidant treatment were considered, treated chips stored under MAP in laminated pouches had least moisture content (6.90) at 90 days of storage. Highest moisture content (9.43%) was recorded by untreated samples packed in LDPE pouches. This is in accordance with the findings of Abong [2] who had reported a similar result in potato chips. Moisture content of chips whether treated or not increased during storage (Table 1). Curry leaf applied chips showed lesser moisture content compared to untreated ones.

Table 1
Moisture content of chips during storage in different packaging materials

Treatments	*Moisture Content (%)*						
	Days after storage						
	Initial	*15*	*30*	*45*	*60*	*75*	*90*
	LDPE						
Curry leaf	5.50	6.00	6.63	7.23	7.77	8.17	8.50
powder Control	5.66	7.17	7.67	8.13	8.73	9.13	9.43
	Laminated pouch						
Curry leaf	5.67	6.00	6.33	6.50	6.87	7.06	7.33
powder Control	5.76	7.27	7.70	8.07	8.33	8.70	8.90
	MAP						
Curry leaf	5.77	6.00	6.20	6.43	6.60	6.70	6.90
powder Control	5.66	7.13	7.40	7.70	7.93	8.33	8.57
CD (P=0.05)	0.28	0.30	0.32	0.32	0.27	0.31	0.31

Colour is the major quality criterion for determining the commercial quality with respect to consumer preferences and cost of the chips [5]. Colour, as yellowness index, of banana chips stored under different packaging systems are shown in Table. 2. Till 30 days of storage there was no difference in colour between chips in different packages. At 60 days and 90 days of storage curry leaf treated chips stored under MAP had highest yellowness index (109.98) compared to all other treatments. This high yellow colour is due to the protection given by the lamination of packaging cover and the antioxidant applied. Untreated samples packed in LDPE pouches recorded the least yellowness index (98.43). Colour was gradually reduced during storage. Gradual fading of the typical golden yellow colour of banana chips and turning to pale yellow and white colour during storage was reported by Ogazi [13] who had stated that processing and storage condition affect the colour of chips.

Texture is not a single attribute. It is a collective term that encompasses the structural and mechanical properties of a food and their sensory perception in

Table 2
Colour of chips during storage in different packaging materials

Treatments	*Yellowness Index*			
	Days after storage			
	Initial	*30*	*60*	*90*
	LDPE			
Curry leaf powder	109.30	107.42	102.54	101.16
Control	112.64	104.92	100.10	98.43
	Laminated pouch			
Curry leaf powder	114.04	108.36	104.76	100.57
Control	108.91	108.64	98.96	99.60
	MAP			
Curry leaf powder	109.53	108.78	109.98	109.86
Control	111.56	107.25	103.89	100.96
CD (P=0.05)	NS	NS	4.24	4.11

the finger or mouth. Instrumental texture analysis are preferred to sensory evaluations for research because instruments reduce variations so, are more precise [1] hence adopted in the present study. Texture, measured as crispness of banana chips during storage under different packaging systems are shown in Table 3.

Table 3
Texture of chips during storage in different packaging materials

Treatments	*TEXTURE Crispness [Count]*			
	Days after storage			
	Initial	*30*	*60*	*90*
	LDPE			
Curry leaf powder	3.83	3.49	3.16	2.37
Control	3.67	3.56	2.51	3.19
	Laminated Pouch			
Curry leaf powder	3.89	3.75	2.51	3.40
Control	3.58	3.63	3.16	2.96
	MAP			
Curry leaf powder	4.61	4.54	5.32	5.12
Control	4.15	3.55	3.54	3.61
CD (P=0.05)	NS	NS	1.12	0.73

Crispness is the most important factor for snacky chips. Highest crispness (5.12) was recorded by curry leaf powder treated chips packaged under MAP in laminated pouches on 90 days of storage. Crispness of all chips till 30 days of storage were similar irrespective of antioxidant treatment and packaging materials. At 60 and 90 days of storage, curry leaf treated chips in MAP system had highest crispness (5.32 and 5.12 respectively). All other treatments had lower and similar crispness.

Howarth [9] reported that packages having high water vapour barrier can maintain crispness of the fried and dried products. Vacuum packaging removes oxygen from the system and had low or no water vapour permeability thereby improving crispness of the stored banana chips.

Chemical quality changes during storage

A low FFA value, peroxide value and high iodine value are the requirements of any good quality chips. Oxidation and hydrolysis are the reactions occuring during frying and storage [11]. Till 15 days of storage the chips had same FFA value with in similar packages. Towards the later stages antioxidant treated chips showed a superior performance with low FFA value compared to untreated chips. At the end of storage, treated chips stored in MAP had least FFA value (5.24) whereas untreated chips stored in LDPE had highest FFA (11.22) value. Increase in free fatty acid value was due to hydrolysis of oils [6].

Peroxide value increased during storage irrespective of packaging materials tried. Curry leaf powder treated chips had a lower peroxide value compared to untreated chips throughout storage period. At 90 days of storage curry leaf powder treated chips in MAP had least peroxide value whereas untreated chips in LDPE had highest peroxide value.

Iodine value showed a decreasing trend during storage irrespective of antioxidant treatment and packaging materials. Curry leaf powder treated chips exhibited a high iodine value compared to untreated chips in all the packaging materials tried. Curry leaf powder treated chips in MAP had higher (10.27) iodine value and untreated chips in LDPE and laminated pouches had lowest (6.51) iodine value at 90 days of storage.

In general, curry leaf powder treated chips had a high FFA value, peroxide value and a low iodine value compared to untreated chips indicating its superiority. Curry leaf powder is an excellent antioxidant. Total antioxidant activity was higher in curry leaf powder treated chips during all periods of storage irrespective of packaging materials tried. Total antioxidant activity showed a decreasing trend during storage. Curry leaf powder treated chips stored under MAP and in laminated pouches had highest total antioxidant activity (12.61 and 12.52 respectively) a 90 days of storage. Superiority of curry leaf treated chips is due to the effect of antioxidant activity.

Among the three packaging systems tried, banana chips prepared by directly adding 0.02% oven dried curry leaf powder into the frying oil and packaged under MAP in laminated pouches recorded lowest free fatty acid values 5.24 mg KOH/g (Table 4), peroxide value 7.87 meq. O_2/kg (Table 5.) and highest iodine value (10.27) (Table 6.) and total antioxidant activity (12.61 ± 1.23%) (Table 7).

Table 4
Free fatty acid value of chips during storage in different packaging materials

Treatments	*Free Fatty Acid Value (mg KOH/g)*						
	Days after storage						
	Initial	*15*	*30*	*45*	*60*	*75*	*90*
				LDPE			
Curry leaf	1.12	1.68	3.93	5.60	7.11	9.16	10.66
powder Control	0.94	1.50	2.98	5.05	7.85	10.28	11.22
				Laminated pouch			
Curry leaf	1.12	2.05	2.98	4.10	5.24	5.98	6.92
powder Control	0.75	1.87	2.80	3.74	5.43	7.11	8.78
				MAP			
Curry leaf	0.56	1.31	2.24	2.98	3.74	4.48	5.24
powder Control	0.75	1.50	2.43	3.93	5.05	6.36	7.48
CD (P=0.05)	0.55	0.58	0.56	0.52	0.74	0.61	0.72

Table 5
Peroxide value of chips during storage in different packaging materials

Treatments	*Peroxide Value (meq. O_2/kg)*						
	Days after storage						
	Initial	*15*	*30*	*45*	*60*	*75*	*90*
				LDPE			
Curry leaf	3.93	4.53	6.00	7.47	8.20	9.20	10.00
powder Control	6.27	6.87	7.40	8.33	9.40	11.47	12.80
				Laminated pouch			
Curry leaf	4.00	4.53	5.20	6.00	7.07	7.53	8.27
powder Control	6.47	6.87	7.67	8.60	9.53	10.73	11.60
				MAP			
Curry leaf	3.93	4.53	5.60	6.33	6.87	7.40	7.87
powder Control	6.47	6.87	7.40	7.80	8.33	8.80	9.33
CD (P=0.05)	0.37	0.30	0.40	0.35	0.35	0.29	0.27

Table 6
Iodine value of chips during storage in different packaging materials

Treatments	*Iodine Value*						
	Days after storage						
	Initial	*15*	*30*	*45*	*60*	*75*	*90*
				LDPE			
Curry leaf	12.56	11.63	11.15	10.06	9.35	8.63	7.96
powder Control	10.96	9.94	9.56	8.75	8.25	7.57	6.51
				Laminated pouch			
Curry leaf	12.60	11.63	11.21	10.78	10.15	9.56	9.26
powder Control	10.70	10.06	9.68	9.17	8.25	7.27	6.51
				MAP			
Curry leaf	12.94	12.65	12.30	11.63	11.18	10.74	10.27
powder Control	10.65	10.16	9.76	9.52	9.14	8.63	8.29
CD (P=0.05)	0.34	0.29	0.29	0.20	0.25	0.24	0.35

Table 7
Total antioxidant activity of chips during storage in different packaging materials

Total Antioxidant Activity (%)				
Treatments	*Days after storage*			
	Initial	*30*	*60*	*90*
		LDPE		
Curry leaf powder	17.36 ± 1.77	15.26 ± 1.50	12.16 ± 1.25	9.89 ± 0.99
Control	6.89 ± 0.71	5.87 ± 0.57	4.92 ± 0.51	3.89 ± 0.39
		Laminated pouch		
Curry leaf powder	15.16 ± 1.55	14.35 ± 1.40	13.62 ± 1.40	12.52 ± 1.26
Control	7.50 ± 0.76	6.66 ± 0.65	5.38 ± 0.55	4.36 ± 0.44
		MAP in laminated pouch		
Curry leaf powder	14.71 ± 1.50	13.90 ± 1.35	13.23 ± 1.36	12.61 ± 1.23
Control	7.32 ± 0.75	6.02 ± 0.58	5.43 ± 0.56	4.80 ± 0.48
CD (P=0.05)	2.09	1.80	1.69	1.47

In general, free fatty acid value and peroxide value of curry leaf treated and untreated chips were increased and iodine value and total antioxidant activity decreased during storage irrespective of the packaging systems used. But, the rate of change was lower in chips stored under MAP in laminated pouches compared to those packed in laminated and LDPE pouches.

Sensory quality changes during storage

Any treatment which is having superior physical and chemical quality parameters should retain sensory quality characters too. Packaging does not only ensures that food contains and maintains the amount and form of the required ingredient and nutrients but also improves sensory quality and colour stability [7]. Proper packaging and storage of chips in appropriate conditions are therefore important necessities if acceptability of the product in the market is to be maintained [3]. Treated as well as untreated chips could maintain all sensory quality attributes when it is stored under MAP in laminated pouches for 90 days. Superior sensory quality attributes viz., appearance (75.60), colour (73.85), flavour (77.40), taste (81.95), texture (72.55) and overall acceptability (79.50) were recorded by curry leaf powder treated banana chips stored under MAP in laminated pouches (Table 8.).

The study indicated that application of curry leaf powder didn't affect the acceptability of chips negatively instead its application improved the sensory quality and acceptability.

Table 8
Mean ranks of chips during storage in different packaging materials

Attributes	*LDPE Days after storage*				*Laminated pouch Days after storage*				*MAP Days after storage*			
Appearance	Initial	30	60	90	Initial	30	60	90	Initial	30	60	90
Curry leaf powder	48.80	32.75	18.90	16.90	46.10	49.10	58.45	65.40	54.40	54.65	74.15	75.60
Control	39.25	28.85	19.80	15.75	43.40	49.10	39.10	33.85	46.10	54.65	53.40	60.00
Colour												
Curry leaf powder	43.50	37.30	26.70	35.25	45.30	50.20	62.95	68.70	46.70	52.40	69.20	73.85
Control	49.90	32.90	12.90	11.45	40.40	41.00	28.45	13.95	46.70	39.60	54.15	44.00
Flavour												
Curry leaf powder	69.50	48.00	34.80	27.00	55.15	63.60	59.30	61.90	62.15	70.40	74.05	77.40
Control	35.80	30.90	13.40	10.25	39.75	46.60	36.30	33.35	39.75	64.70	54.55	48.25
Taste												
Curry leaf powder	61.15	50.70	29.30	20.40	53.95	62.60	56.50	62.55	61.15	68.65	71.90	81.95
Control	37.75	21.60	13.20	13.20	37.05	40.90	30.00	20.60	43.70	39.80	46.90	46.50
Texture												
Curry leaf powder	47.60	32.70	35.60	20.05	41.80	57.60	58.40	66.15	51.20	60.80	69.90	72.55
Control	44.70	17.60	8.90	13.65	41.80	42.00	36.90	37.80	38.90	55.70	62.80	57.00
Overall acceptability												
Curry leaf powder	64.00	37.50	28.20	20.10	46.00	56.80	62.85	64.90	64.00	72.60	76.75	79.50
Control	41.50	16.50	9.30	10.30	41.50	45.00	30.30	27.70	41.50	52.85	59.70	50.55
CV value						22.89						

Based on superior physical, chemical and sensory quality parameters, it was concluded that preparing banana chips by adding 0.02% oven dried curry leaf powder to frying oil and storing under MAP in laminated pouches could ensure a shelf life of three months.

CONCLUSION

Curry leaf powder treated and untreated chips were stored in low density polyethylene pouches, tri-layered (LDPE/ Metalised polyester/ LDPE) laminated pouches and under modified atmospheric packaging (MAP) in laminated pouches for three months to evaluate the effect of antioxidant treatment and packaging in improving shelf stability. All the quality parameters showed decreasing trend during storage. Curry leaf powder treatment was effective in improving quality of banana chips. MAP by filling nitrogen was a better option for retaining quality during storage. Lamination was better than LDPE. Curry leaf treated chips packed under MAP in laminated pouches showed low moisture (6.90%), FFA value (5.24 mg KOH/g), peroxide value (7.87 meq. O_2/ kg), highest iodine value (10.27), yellowness index (109.86), crispness (5.12) and higher mean rank value for sensory parameters throughout storage period. Highest antioxidant activity (12.61 ± 1.31 %) was also recorded by this treatment. The study revealed that storing under modified atmospheric packaging condition in laminated pouches can ensure a shelf life of three months to Nendran banana chips.

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