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Effect of antioxidants and packaging on quality of banana chips

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ABSTRACT

Natural antioxidants like sodium ascorbate and tocopherol acetate at 0.01% and dried curry leaf powder at 0.02% were incorporated into 'Nendran banana' chips and packed in laminated and LDPE pouches to evaluate and compare the effect of antioxidants and packaging materials on the rancidity problem of banana chips, to delay the onset of oxidation during storage and to enhance shelf-life of packed product.. All antioxidant treated chips had superior physical and chemical quality parameters compared to untreated chips, indicating the superiority and advantage of antioxidant treatment. Among the treated chips, chips produced after incorporating dried curry leaf powder in oil had better physical (integrity, 94.5 and crispness, 6.32), chemical (peroxide value, 3.88 and iodine value, 12.52) and sensory characters, which are retained in storage too. There was an increase in moisture content, free fatty acid value and peroxide value and decrease in iodine value of chips during storage upto 3 months at ambient conditions. Quality degradation was slower in chips stored laminated pouches compared to in LDPE packaging.

Key words: Banana chips, antioxidants, curry leaf powder, packaging, shelf-life, quality.

INTRODUCTION

Nendran variety occupy 48,747 ha area under cultivation in Kerala (2011-12) and is consumed as raw fruit, cooked as vegetable or fried to make chips. Banana chips fried in coconut oil is a product of high demand due to its characteristic flavour and taste and production and marketing of banana chips is a wide spread cottage scale industry in Kerala. One of the major problems faced by the processors in storage of banana chips is rancidity; which imparts an off flavour to the product resulting in poor acceptability. Oxidative rancidity in oils occurs when heat, metals or other catalysts cause unsaturated oil molecules to convert to free radicals, which are easily oxidized to yield hydroperoxides and organic compounds, such as aldehydes, ketones, or acids resulting in undesirable odours and flavours, characteristic of rancid fats. Oxidation of oils modifies their organoleptic properties and affects the shelf life and nutritional value of the product.

Addition of antioxidants is effective in retarding the oxidation of lipid containing foods. Even though synthetic antioxidants like Butylated Hydroxy Anisole (BHA), Butylated Hydroxy Toluene (BHT) & Tertiary Butyl Hydro Quinone (TBHQ) are commonly used in food, toxicological effects have been reported and these are banned in some countries. Therefore, the need for natural and safe antioxidants has increased and a recent area of interest in antioxidant research is concerned with finding effective replacements for the conventional synthetic antioxidants from among various natural extracts of plant species having antioxidant properties. Another factor affecting shelf-life of any product is storage condition. By suitably modifying the packaging materials for improving the storage condition, there may be chances of improving the shelf-life of banana chips. In this background, an investigation was carried out at Department of Processing Technology, College of Agriculture, Vellayani for two years to evaluate and compare the effect of antioxidants and packaging materials on the rancidity problem of banana chips thereby enhancing shelf-life of product.

MATERIALS AND METHODS

Three antioxidants, 0.01% sodium ascorbate, 0.01% tocopherol acetate and 0.02% dried curry leaf powder (dried at 60°C for 6 h), which had higher efficiency and acceptability as antioxidants (Adrika, 1) were incorporated into 250 g Nendran banana chips by directly adding in unrefined oil at smoke point of 165°C before addition of banana slices. The oil-slice ratio was maintained at 2:1 during chips preparation, adding 0.7% salt and 0.15% turmeric. The antioxidant tretaed banana chips samples were evaluated for physical, chemical and sensory parameters.

Physical parameters like yield, oil uptake (AOAC, 3) moisture content (Ranganna, 9), integrity, shrinkage ratio (Akinbode *et al.*, 2) of the banana chips were recorded. Colour of banana chips was recorded as yellowness index using the $L^*a^*b^*$ colour indices by capturing the images of the chips and converting to graphs.

$$\text{Yellowness index , YI} = \frac{142.86 \times b}{L}$$

Where, b = blueness to yellowness index at the time of observation
L = luminance or lightness index at the time of observation.

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Texture of the banana chips was measured using a food texture analyzer (TAHD-Stable Microsystems, UK) by snap test method. Crispness was obtained as the count of peaks in the graph and toughness (Newton seconds-Ns.) by the area of graph. Hardness (Newton-N) which indicates the force required by the probe to break the chips was obtained at the Y-axis corresponding to highest peak in the graph (Akinbode *et al*., 2). Chemical parameters, *viz*., peroxide value, free fatty acid value and iodine value of treated banana chips were recorded using standard procedures (Sadasivam and Manickam, 12) and sensory evaluation was carried out using nine points hedonic scale by a 10 member semi trained panel (ISI, 4). The treated and untreated chips were packed in two different packaging materials such as tri-layered laminated (LDPE/metalized polyester/ LDPE) and 100 gauge LDPE pouches and stored under ambient temperatures of 27-30°C. Moisture per cent, colour, texture, all chemical parameters and sensory evaluation were carried out at regular intervals to assess the storage stability of treated chips. Data obtained were analyzed using one way ANOVA and in organoleptic analysis, the different preferences as indicated by scores were evaluated by Kendalls' coefficient of concordance.

RESULTS AND DISCUSSION

Treated and untreated chips were evaluated for physical, chemical and sensory parameters at the time of preparation and during storage at regular intervals. Chips with low oil uptake, moisture percent and high integrity can be considered of good quality. Different antioxidants did not show variation in yield recovery, oil content and moisture per cent initially (Table 1). But treated chips had lower yield, oil uptake and moisture per cent compared to untreated chips. The lower yield in treated chips is due to reduced oil uptake and moisture content. All chips, whether treated or untreated had similar shrinkage ratio. Fried foods shrink when the moisture is lost and the food cells collapse as a consequence of heating and evaporation during frying. Decrease in the product dimension occurs when heat-induced evaporation/ drying occurs (Krokida *et al*., 6). Lowest integrity value was recorded by the untreated chips (83.0%), which was on par with those treated with 0.01% sodium ascorbate (84.0%). Highest integrity (94.5) was recorded by chips treated with 0.02% curry leaf powder making it more acceptable.

Colour (yellowness index) of all antioxidant treated chips differed significantly from that of untreated chips which had highest colour (120.40). When the effect of antioxidants on hardness of chips was compared, the least hardness was recorded by chips prepared after adding 0.01% tocopherol acetate (5.45 N), untreated chips (5.64) and 0.01% sodium ascorbate (6.56 N). There was no significant difference in toughness among the chips. Crispness was same for all treated chips, but higher than untreated chips (4.32). Good quality should have higher crispness, hence curry leaf treated chips, which recorded highest crispness (6.32), can be considered as one with highly acceptable texture.

Free fatty acid value (FFA), peroxide value (POV) and iodine value (IV) are the rancidity factors of deep fried products. All antioxidants were on par

Table 1. Physical and chemical quality parameters of chips.

Parameter	Treatment				
	S (0.01%)	T (0.01%)	C (0.02%)	Control	$CD_{0.05}$
Yield (%)	66.00	66.10	64.00	70.00	2.30
Oil uptake (%)	31.60	31.10	30.25	40.34	3.13
Moisture (%)	0.22	0.27	0.27	0.93	3.18
Shrinkage ratio (%)	21.00	23.00	23.00	23.15	NS
Integrity (%)	84.00	88.50	94.50	83.00	3.54
Yellowness index	110.89	129.44	109.63	120.40	3.75
Hardness (N)	6.56	5.45	8.99	5.64	2.60
Toughness (Ns)	1.95	2.68	2.88	1.18	2.17
Crispness	5.75	5.41	6.32	4.32	1.29
Free fatty acid value	1.38	1.30	1.37	2.14	0.14
Peroxide value	5.31	6.22	3.88	6.88	NS
Iodine value	11.49	12.19	12.52	10.01	1.22

S = Sodium ascorbate T = Tocopherol acetate C = Curry leaf powder in producing chips of similar free fatty acid value, peroxide value and iodine value (Table 1). But all antioxidant treated chips had significantly lower free fatty acid value and higher iodine value than the untreated chips, indicating the superiority of treated chips. Among the antioxidants, 0.02% curry leaf powder showed superior performance by recording low peroxide value (3.88) and the highest iodine value (12.52). Moisture content of chips was evaluated at an interval of 15 days for a period of 90 days, whereas colour and texture were recorded at an interval of 30 days. When moisture content of chips was evaluated during storage, antioxidant treated chips showed significantly lower moisture in general compared to untreated chips in both the packages (Fig. 1). Chips treated with 0.02% curry leaf retained low moisture per cent throughout storage (0.28 at 15 days -0.46 at 90 days) when stored in laminated pouch. But in LDPE, chips treated with 0.01% sodium ascorbate had lowest moisture (0.3-0.56%) from 15-45 days and chips treated with 0.01% tocopherol acetate (0.8-0.98%) from 60-90 days. Chips stored in laminated pouch recorded comparatively lower moisture content at the end of storage. At the end of storage period, untreated chips recorded 2.18% moisture in laminated pouch and 2.40% in LDPE pouch, which is 134 and 158% increase, respectively.

Moisture content of chips packed in both packaging materials (Fig. 1), showed a gradual increase during storage and this agrees with the result of Molla *et al*. (7), who had recorded a gradual increase in moisture and weight during storage in LDPE pouches. Moisture of chips packed inside a pouch is dependent on the relative humidity of the surroundings. The chips absorb moisture from the storage atmosphere and gain weight gradually. The treated chips had a higher yellowness index compared to that of untreated chips, at the corresponding period (Fig. 2) when stored in laminated pouches. This retention of more yellowness may be due to the protection given by the laminated layers and the antioxidant applied. When stored in LDPE pouches, chips made after adding 0.01% tocopherol acetate had highest yellowness index of 114.98, which is closely followed by untreated chips (113.54).

Yellowness index did not show a gradual and definite change during storage and none of the treatments showed drastic reduction in colour. This may be due to the protection given by the antioxidants or due to selection of proper packaging materials preventing entry of exterior illumination. But gradual fading of typical golden yellow colour of banana chips to pale yellow and white colour during storage in polyethylene bags was reported by Ogazi (8).

Chips prepared after adding 0.02% curry leaf powder had the least hardness of 6.67 N at 30 days after storage (Fig. 3). in laminated pouches and at the final stage of 90 days, untreated chips had least hardness (5.43 N). Chips, whether treated or not, had similar toughness at 30 and 90 days (Fig. 4). At 60 days all treated chips showed least toughness. Crispness was same at 30 and 90 days of storage (Fig. 5). Though not significantly different, curry leaf powder treated chips had highest crispness (6.07) at final stage, indicating its superior quality. When treated chips were stored in laminated

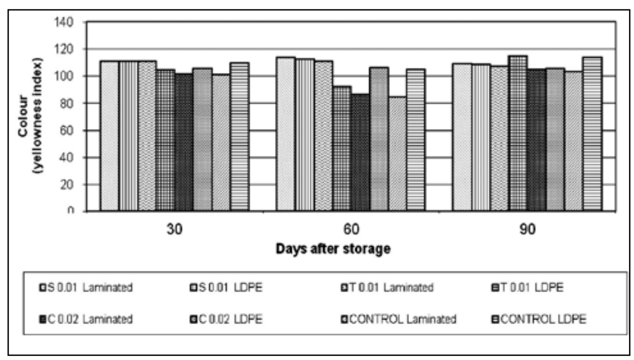


Fig. 2. Changes in colour (yellowness index) of stored chips.

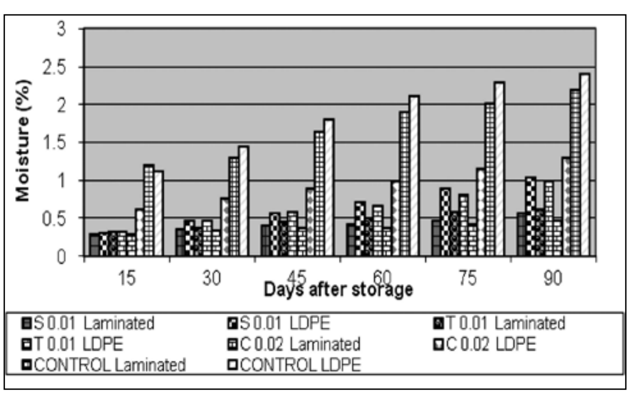


Fig. 1. Changes in moisture content of stored chips.

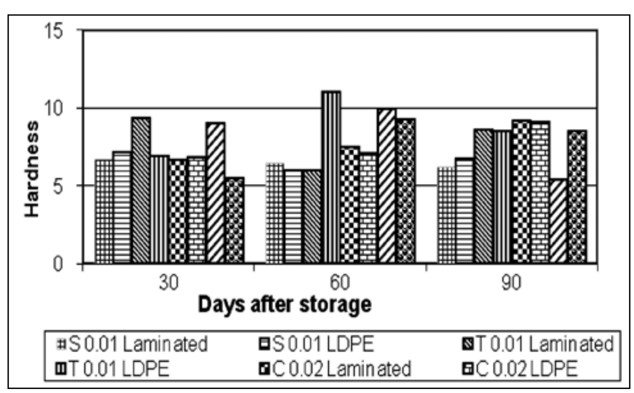


Fig. 3. Changes in hardness of stored chips.

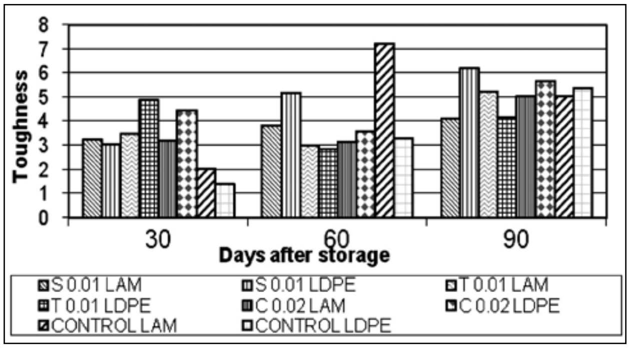


Fig. 4. Changes in toughness of stored banana chips.

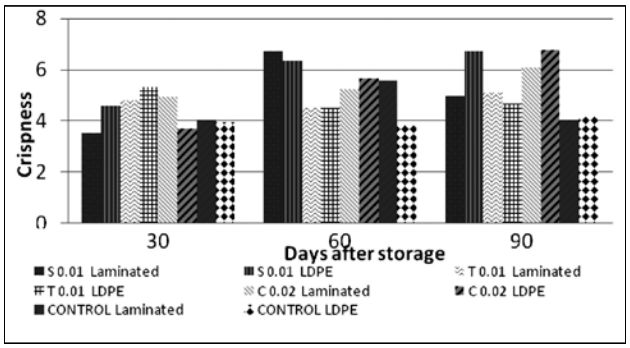


Fig. 5. Changes in crispness of stored banana chips.

pouches, their textural quality was not changed from untreated chips at all. But when stored in LDPE pouches, treated chips were similar in hardness during storage. Chips were significantly different in toughness during 30 and 60 days only. The untreated chips had least toughness (1.41 Ns) at 30 days and 0.01% tocopherol treated chips had least toughness (2.85 Ns) during 60 days. The condition was same in laminated pouch also. It is understood that antioxidant treated chips had similar toughness in both the packages. Chips had similar crispness at 30 and 60 days of storage. At final stage, 0.02% curry leaf powder treated chips had highest count value (6.75) indicating its high crispness, where as untreated chips had least (4.22) crispness. As crispness is one of the major factors affecting quality of banana chips, treated chips can be considered better in textural properties.

Good quality chips should have low free fatty acid (FFA) value, peroxide value (POV) and a high iodine value (IV). When the effect of antioxidants on the FFA value of chips stored in laminated pouches was compared (Fig. 6), all treated chips had significantly lower FFA value than that of chips made from untreated slices through out storage. This result is supported by Rehman (10), who stated that antioxidant treated potato chips had a lower free

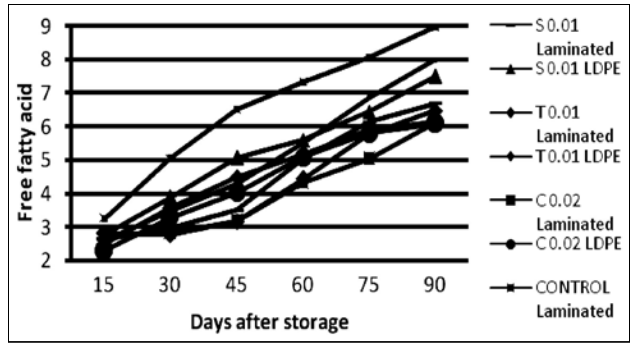


Fig. 6. Changes in free fatty acid content of stored chips.

fatty acid value than control during storage. Sodium ascorbate and curry leaf treated chips had lowest FFA value of 2.65 and 2.70 mg KOH/g respectively at 15 days after storage. Curry leaf powder retained the lowest FFA value of 6.11 mg KOH/g at 90 days as against 8.98 mg for untreated samples.

When the effect in LDPE pouches was compared, chips had similar FFA value till 60 days of storage. At 75 and 90 days all the treated chips had significantly similar and lower free fatty acid value compared to untreated chips. Among the treatments, curry leaf powder was better in maintaining least FFA with 5.80 at 75 days and 6.10 at 90 days of storage against 6.86 and 8.0 for untreated chips, indicating better storage stability. All the treated chips had significantly lower peroxide value (Fig. 7) than the untreated chips through out storage in laminated pouches indicating its superiority. Among the antioxidants tried, peroxide value of chips prepared after adding 0.02% curry leaf powder and 0.01% sodium ascorbate recorded the lowest peroxide value throughout storage. Untreated chips recorded a peroxide value of 9.22 meq. O_2/kg at 15 days, increasing to 13.63 meq. O_2/kg at 90 days after storage. In LDPE pouches, there was no significant difference between the treatments upto 30 days of storage. After 60 days, all the treatments had significantly lower peroxide value than untreated chips.

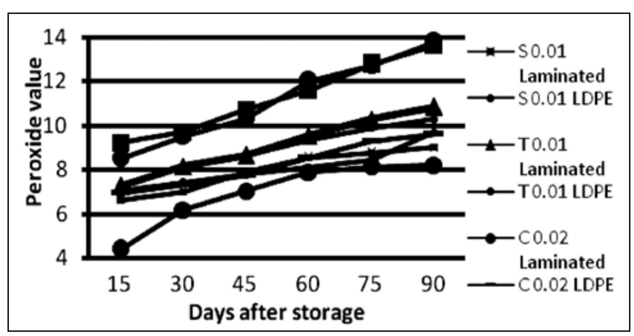
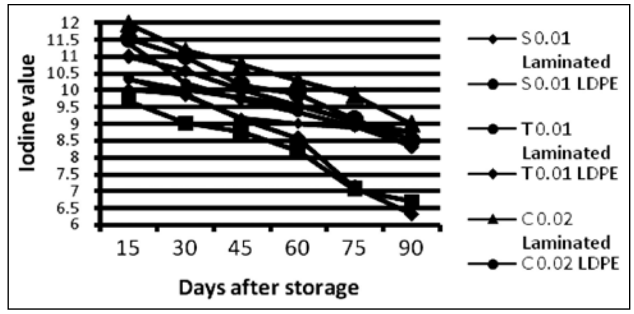


Fig. 7. Changes in peroxide values of stored chips.

All the treated chips stored in laminated pouches recorded significantly higher iodine value (Fig. 8) than the untreated chips, which is a favourable character. From 60 days of storage onwards, the treated chips had similar iodine value. However, chips treated with curry leaf powder maintained the highest iodine value through out storage period. But there was no significant difference between chips stored in LDPE pouch for iodine value except at 75 days. It is evident that LDPE was not at all effective in maintaining the superiority of treated chips. Even then untreated chips had lowest iodine value compared to treated chips throughout storage. In general, chemical quality parameters like free fatty acid value and peroxide value increased and iodine value decreased during storage of banana chips. The free fatty acid and peroxide values were less and iodine value was high in laminated pouches compared to chips packed in LDPE pouches. Islam and Shams-ud-din (5) and Roopa *et al*. (11) also reported that LDPE is a not a suitable packing material to store cassava and banana chips, respectively.

When sensory analysis was conducted, none of the treatments recorded high score through out storage (Table 2). But chips prepared after direct addition of 0.02% curry leaf powder in oil, had highest score for appearance (18.18), flavour (19.30) and taste (18.05) at the end of storage in laminated pouches. When stored in LDPE pouches, these chips had maximum score for taste (20.52) and appearance (16.60) during 90 days of storage. These results indicate that the treatment, which was having high physical and chemical quality parameters had high acceptability among judging panel. Untreated chips had acceptable sensory score for one month of storage and they had lowest score for appearance (14.40) and taste (10.32) in laminated pouches, whereas they had least score for flavour (7.52) and taste (6.70) in LDPE pouches at the end of storage.



S = Sodium ascorbate, T = Tocopherol acetate, C = curry leaf powder

Fig. 8. Changes in iodine value of stored banana chips.

Table 2. Sensory quality of treated chips under two packages during storage at 27-30°C.

	Treatment		Laminated pouch						LDPE pouch					
			Days after storage											
			15	30	45	60	75	90	15	30	45	60	75	90
Appearance	S 0.01	19.5	15.35	16.35	15.70	15.19	16.38	15.43	14.45	17.85	16.25	11.65	18.30	13.60
	T 0.01	19.2	15.07	18.05	18.63	12.12	15.15	18.07	14.73	12.57	9.93	17.02	15.32	13.50
	C 0.02	19.8	18.08	16.30	16.15	18.52	18.55	18.18	16.15	12.07	17.38	16.93	16.70	16.60
	Control	19.7	15.45	12.77	12.55	12.54	16.52	14.40	15.40	12.55	14.18	14.77	15.18	16.55
	Sig.		0.002	0.000	0.014	0.002	0.006	0.022	0.009	0.000	0.000	0.000	0.002	0.004
Flavour	S 0.01	19.2	18.25	16.45	15.12	15.50	15.08	10.38	19.08	14.13	15.65	12.57	14.52	19.05
	T 0.01	19.1	15.73	18.27	14.42	18.77	16.95	11.30	16.95	16.92	11.77	13.88	12.65	10.27
	C 0.02	19.8	16.00	12.68	10.32	11.95	19.90	19.30	16.90	16.60	18.70	15.35	11.38	17.83
	Control	19.5	14.80	11.85	12.35	12.25	15.45	12.00	15.45	12.93	12.27	13.20	8.55	7.52
	Assym. Sig.		0.000	0.006	0.001	0.001	0.000	0.010	0.000	0.003	0.002	0.000	0.000	0.000
Taste	S 0.01	19.3	17.13	18.05	16.42	11.27	16.52	17.70	16.38	18.00	20.58	15.45	13.57	14.68
	T 0.01	19.4	15.93	17.00	14.25	11.20	14.48	16.05	15.15	18.40	14.70	15.27	14.20	13.05
	C 0.02	19.8	18.57	18.88	18.68	19.38	11.90	18.05	16.15	12.10	15.32	15.50	10.95	20.52
	Control	19.6	17.38	11.77	11.98	16.52	14.32	10.32	7.45	12.02	17.27	15.07	9.63	6.70
	Assym. Sig.		0.000	0.000	0.000	0.002	0.001	0.000	0.000	0.000	0.001	0.000	0.003	0.012

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