

Research Article

Development of active modified atmosphere packaging systems for traditional Thai fried banana snacks

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Abstract

Although traditional Thai fried banana snack ('*Klui Break Taek*' in Thai) is one of the favourite and high value snacks, practically it has a short shelf life (i.e. 14 days) under ambient atmospheric conditions because of rancidity and low crispness. In the present work, active modified atmosphere packaging systems (Active MAP) were developed and these were combined with an oxygen scavenging sachet (Wonderkeep[®]) and metallized film bag (PET/mPET/LLDPE). These packages principally have capabilities to minimize permeations of, and accumulations of, oxygen and water vapour in package headspaces because these can lead to oxidative rancidity through lipid oxidation and soften textures through water vapour absorption, respectively. Qualities and shelf life of the snacks kept in Active MAP were statistically compared to those kept in the traditional clear Polypropylene (PP) bags and ambient package headspace. Experiments were operated in three replicates under 30°C for 90 days. Whilst oxygen concentrations in Active MAP were nearly 0% (v/v) throughout the storage, proving the capabilities of oxygen scavengers and metallized films, those in PP bags were comparable to ambient conditions. The snacks kept in Active MAP appeared to have higher qualities, compared to those kept in the traditional packaging system. In particular, oxidative rancidity, measured using Peroxide Value (PV), Active MAP technically retarded increases of PV throughout the storage period (i.e. < 20 meq·kg⁻¹) (p<0.05), meanwhile PV of the products kept in the traditional systems were higher than 30 meq·kg⁻¹ measured on day 90. These analyzed results for PV were favourably supported by sensory and consumer studies. However, other quality attributes including moisture content, water activity, texture and colour in both systems were not significantly different. This could be attributed to high variations in particular thickness and colour of individual pieces, as well as high resistance to water vapour permeations of both polymeric films, contributing to low changes of water vapour related attributes. Because of its effectiveness and general suitability, the Active MAP developed has potential to be implemented for extending shelf life of fried banana snacks, as well as for up-scaling and other traditional snacks such as prawn crackers.

Keywords: shelf life, active packaging, MAP, peroxide value, spoilage, Thailand.

Introduction

Traditional Thai fried banana snack (*'Klui Break Taek'* in Thai; a thin and flat shape) is one of the favourite and high value snacks. However, practically it has a short shelf life i.e. 14 days because of rancidity and low crispness which are considered key undesirable product attributes to consumers. Although such problems are commonly known to fried banana processors and retailers (data collected through in-depth interviews conducted in December 2009), there are limited scientific reports published, particularly utilization of packaging technology to extend shelf life of this product. At present, the fried banana snack is typically packaged in clear Polypropylene (PP) film bags which mostly are heat-sealed. Although PP film has a moderate resistant property to oxygen permeation [1], the film is considered as having limits to be used for long period storage because of continuous oxygen transport i.e. from surrounding environment into the package headspace. Oxygen is accordingly accumulated and dynamically interacts with the fried banana. The interaction is considered one of key deterioration modes of fried snacks because it principally can lead to oxidative rancidity and subsequently off-smell [2]. In the present work, applications of packaging technology, namely active modified atmosphere (Active MAP) with an oxygen scavenger was utilized to limit oxygen transport and accumulation in the package headspace. Active MAP systems have been employed to extend shelf life of a range of food products including fried snacks [3, 4, 5], however, their application with traditional Thai fried banana have not been reported. This research accordingly contributes to the global knowledge on design of packaging systems to essentially improve marketability of indigenous food products. Effectiveness of the Active MAP system on qualities and shelf life of the traditional Thai fried banana accordingly was tested and compared to that of the typical packaging systems.

Materials and Methods

Materials

Fried banana snack was purchased from a wholesale processor, at Warin Charoensri Market, Warinchamrap District, Ubon Ratchathani Province, Thailand. The product was freshly fried on scheduled basis and it was transported within 2-3 hours to the laboratory, Faculty of Agriculture, Ubon Ratchathani University. Plastic packages of sizes 6" × 9" were employed (note an actual bag size after sealing was about 6" × 8"). These were categorized into two groups including (1) clear PP bag (ubiquitously available in local markets) and (2) metalized laminated film bag (PET/mPET/LLDPE; Thai Flexible Pack Co. Ltd.). An oxygen scavenging sachet (called oxygen scavengers for further reference) known as Wonder Keep[®] RP-100 (Jenjaras Chem Supply Co. Ltd., Thailand) was used. One scavenger was technically packaged in one bag (both plastic types) in addition to the fried banana snack. The system in which the bags were PP plastic polymer and had no scavengers was designated as 'Control'. A summary of experimental treatments is provided in Table 1.

Table 1. Experimental treatments.

Abbreviations	Packages		Packaging systems	
	PP	Metallized	Air	O ₂ Scavenger
PP-Air (Control)	√		√	
PP-O2Ab	√			√
Met-Air		√	√	
Met-O2Ab		√		√

Methods

In this work two key studies were conducted including, (1) proximate analysis and (2) active modified atmosphere packaging (Active MAP) tests. The former is referred to measurements of moisture, fat, fibre and ash contents [6]. To prepare MAP tests, fried banana snack (net weight ~100g) was randomly packaged into PP and metalized film bags. Individual film types were separated into two groups regarding atmospheric conditions achieved in package headspaces including (1) ambient and (2) modified atmosphere (i.e. reduced oxygen concentration). The latter was achieved through using oxygen scavengers which were placed into the bags prior heat-sealing. The bags were kept at ambient storage temperature (~35°C) for 90 days. One packaging system was comprised of 5 replicates (bags). One replicate was randomly chosen in order to measure quality attributes at each of storage day 15, 30, 45, 60 and 90. The quality attributes measured included product colour (L*, a*, b* - Minolta CR300), hardness (Universal Testing; LLOYD model. LR series, USA), package O₂ concentrations (MAP test 3050), oxidative rancidity, moisture content [6], water activity (a_w) Novasina TH 200 model, Switzerland) and yeast and mould [7]. It should be noted that only evaluations of yeast and mould were conducted every 30 days during the storage period. Measurements of quality attributes were made in 3 replicates. Sensory and consumer tests were conducted with 40 untrained panelists who were asked to rate their product liking on the 9-point hedonic scale. In the present work, three experimental replicates were conducted during November 2009 to April 2010.

A factorial experiment with 2 plastic film bags (i.e. PP and metalized films) and 2 packaging systems (i.e. ambient air and modified atmosphere headspaces) was utilized. Treatments were arranged in a completely randomized design. Data were analyzed using analysis of variance (ANOVA) and Duncans Multiple Range Test (p<0.05) for comparison of means using Statistical Package for the Social Sciences for Windows (SPSS).

Results and Discussion

Proximate composition

Key fundamental information on proximate composition and nutrition of traditional Thai fried banana snacks, which is not previously reported, is shown in

Table 2. Although the product is essentially an important source of carbohydrate (~27.14%), it has a relatively high fat content (~55.80%). The extent of such components appear to be comparable to those of traditional Thai fried sweet potato snack reported by Santaweek, *et al* [8] which are approximately 12.34% and 68.16%, respectively. With regard to the high fat content, it can be implied that the fried bananas have high likelihood of having off-smell because of oxidative rancidity, subsequently leading to the product's short shelf life and marketability. Whilst the fried banana snack contains a considerable amount of ash (~11.12%), which principally indicates minerals and other nutritional values of food and feeds [9], the snack has small amounts of fibre and protein. The fried banana snack has low moisture content (~4.45%). Based on such information, the snack, like other dried products [10], is likely to uptake water vapour from the surrounding environment because of water vapour concentration gradients, as a driving force of the water vapour transport phenomenon. Packaging systems having appropriate water vapour resistant properties, for example low density polyethylene (LDPE) and PP polymeric film [1], are accordingly required to minimize water vapour uptake of the snacks.

Table 2. Proximate composition of traditional Thai fried banana snack.

Proximate composition	Percentage
Fat	55.80 ± 0.39 ¹
Ash	11.12 ± 0.31
Carbohydrate	27.14 ± 0.08
Moisture Content	4.45 ± 0.04
Protein	0.41 ± 0.01
Fiber	1.08 ± 0.08

¹ Average ± Standard Deviation (The data were calculated by 9 replicates).

Effects of active modified atmosphere packaging (Active MAP) on quality and shelf life of traditional Thai fried banana snacks

Oxygen scavengers have significant influence ($p < 0.05$) on oxygen concentration package headspaces of, in particular, metallized film packages (Table 3) where the concentrations were maintained lower than the ambient level throughout the storage period. Experimental findings confirm the knowledge and applications of the oxygen scavengers on minimizing accumulations of oxygen in the package headspaces [3]. This research indicates that oxygen scavengers must be used with the metallized film packages in order to maintain oxygen scavenging capabilities of the scavenger. In practice, the metallized film is considered to have relatively high resistance to oxygen, particularly the metallized film has PET film as a component because of its low oxygen permeability, i.e. 0.22×10^{-11} ml (STP) $\text{cm cm}^{-2} \text{s}^{-1} \text{cm Hg}^{-1}$ (30°C) [1]. Given low (or presumably nil) oxygen permeation from the surrounding environment, oxygen in the headspaces dynamically and interactively disappeared through the oxygen scavenger.

Table 3. Oxygen concentrations in package headspaces (% v/v).

Storage days	Ambient condition	Experimental Treatments			
		PP-Air	PP-O2Ab	Met-Air	Met-O2Ab
0	~21	-	-	-	-
15	-	19.71 ^{a,1}	19.90 ^a	20.00 ^a	8.10 ^b
30	-	20.41 ^a	19.89 ^a	19.62 ^a	8.71 ^b
45	-	20.90 ^a	20.45 ^a	20.00 ^a	1.12 ^b
60	-	20.90 ^a	20.70 ^a	20.20 ^a	2.82 ^b
90	-	21.21 ^a	20.33 ^a	19.76 ^a	0.40 ^c

¹ The data are means of 9 replicates. Means within each storage day (row) followed by the same letter are not significantly different according to Duncans Multiple Range Test (DMRT) ($p < 0.05$).

Considering Met-Air treatment (Table 3), the oxygen concentrations in package headspaces are comparable to those in the ambient condition. It can be implied that interactions between oxygen and the product could proceed with the low rates. Furthermore, there is a high likelihood of oxidative rancidity occurring in the product because of the high oxygen availability in the headspace. Although the oxygen scavengers were packaged in the PP film bags (PP-O2Ab; Table 3), oxygen concentrations in the package headspaces apparently are similar to those in the ambient condition. PP film technically is moderate barrier to oxygen. Oxygen permeability of PP film is approximately 2.30×10^{-10} ml (STP) $\text{cm cm}^{-2} \text{s}^{-1} \text{cm Hg}^{-1}$ (30°C) which is nearly 100 times higher than that of PET film [1]. Oxygen permeation into the package headspace of PP film bags thus can occur with a high rate, subsequently leading to oxygen saturations of the scavenger within a short timeframe (i.e. ~15-30 days)

Peroxide values of fried banana snacks were found to continuously increase throughout the storage period (Table 4). The highest values at individual experimental day ($p < 0.05$) were found among the snacks packaged in the clear PP film bags. Whilst peroxide values of the fried banana packaged in other packaging systems did not show any clear difference, which could be contributed to by variance in raw materials or experimental errors, the values of the snacks packaged in the metalized bags containing oxygen scavengers appear to be comparatively lower (Figure 1). The findings suggest that incorporating oxygen scavengers reduces accumulation of oxygen in the package headspace which importantly lowers peroxide values of the products. It is interesting to note that peroxide values of the products packaged in Met-Air generally tend to be lower than those of the snacks packaged in PP-Air (Figure 1). The results point out that the metalized film essentially limits oxygen permeation into the package headspace.

Table 4. Peroxide value (PV) (meq/kg).

Storage days	Ambient condition	Experimental Treatments			
		PP-Air	PP-O2Ab	Met-Air	Met-O2Ab
0	2.05±0.65 ¹	-	-	-	-
15	-	5.01 ^{a,2}	4.38 ^a	3.92 ^a	2.72 ^a
30	-	12.20 ^a	9.13 ^{ab}	7.86 ^b	6.11 ^b
45	-	20.14 ^a	12.71 ^b	9.04 ^{bc}	6.71 ^c
60	-	29.47 ^a	15.50 ^b	13.77 ^{bc}	11.53 ^c
90	-	30.51 ^a	17.72 ^b	15.77 ^{bc}	12.46 ^c

¹ Average ± Standard Deviation (The data were calculated by 9 replicates).

² The data are means of 9 replicates. Means within each storage day (row) followed by the same letter are not significantly different according to Duncan Multiple Range Test (DMRT) ($p < 0.05$).

According to Pearson and Cox [11], the peroxide value is an indicator of oxidative rancidity which creates an off-smell in the product. An off-smell caused by rancid taste and smell becomes noticeable when the peroxide values are between 20 and 40 meq/kg [11]. In the present work, the rancid or off-smell of the fried banana packaged in PP-Air (Control) can be easily perceived on the 30th test date. It can be implied that such undesirable effect of the product becomes apparent after a 2-week storage period. The experimental findings are consistent with information gained from the retailers and processors interviewed. Although peroxide values of the products in other treatments were lower than 20 meq/kg, considered on 90th storage day (Table 4), rancid smell was noticeable, particularly those of PP-O2Ab and Met-Air. However, the smell detected was relatively lighter compared to that of the products packaged in the PP-Air. The fried banana snacks packaged in Met-O2Ab treatment apparently had no rancid smell. Such characteristics were confirmed by the consumer tests (data not shown where 40 untrained test panelists tested the products kept for more than 45 days). The research findings confirm applications of the oxygen scavengers and metalized film package on extending shelf life of the fried products through minimizing oxidative rancidity.

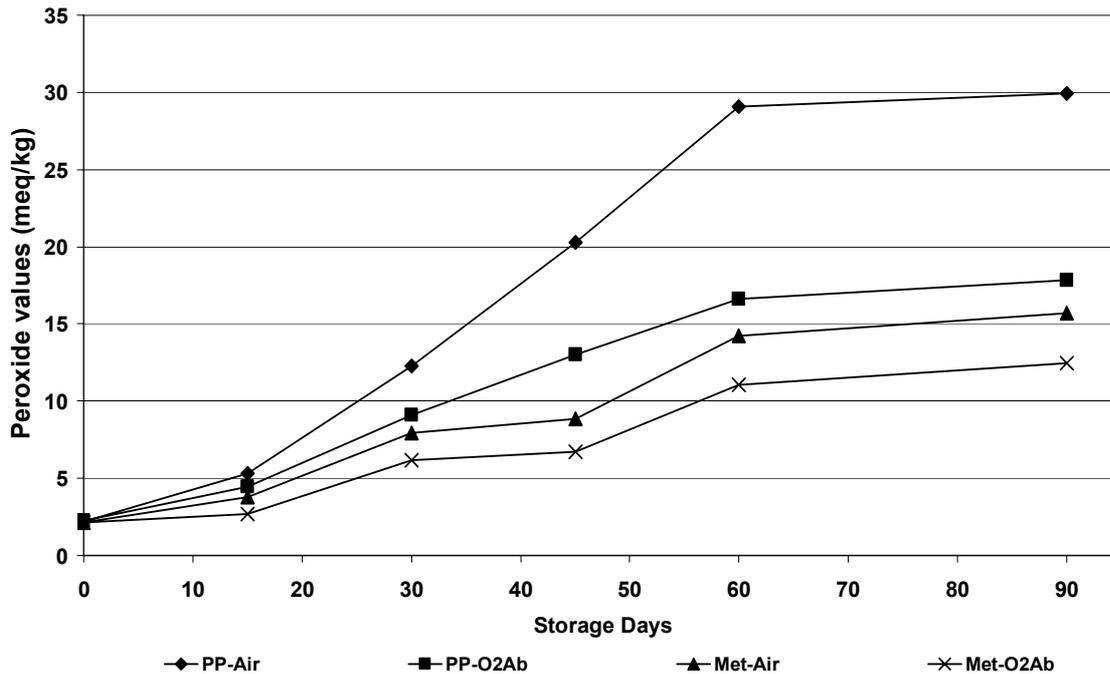


Figure 1. Trends of peroxide values of traditional Thai fried banana packaged in different packaging systems.

Influences of the packaging systems on colour, texture, moisture content, water activity (a_w ; approximately 0.30-0.40) and yeast and mold were not obvious (data not shown). In particular, there is a relatively low extent of yeast and mold found in all experimental treatments throughout storage period (i.e. < 30 colonies on agar plates considered at 10^{-3} dilutions). Values of the parameters noted above (except yeast and mold) slightly changed throughout the storage period. These could be contributed to variances in raw materials, for example high variations in product thickness were noticeable and these could in part be contributed to the processing technique where individual pieces were hand-sliced. It was found that the processors did not control ripeness of banana used and this could be an important factor contributing to high variations in the product colour, especially redness (data not shown).

With regard to moisture content and a_w , unobvious changes of these parameters were essentially because of the film packages used. Both PP and metalized films form a relatively high barrier to water vapour [1]. Therefore water vapour can permeate into the package headspace with the low rate leading to a low extent of water vapor accumulation. The minimal changes of moisture content and a_w of the fried banana were confirmed by its high crispness (measured through the hardness attribute) although the product was kept for 90 days i.e. hardness measured on day 0th and 90th were approximately 6.45 and 5.97 N, respectively. The results confirm the knowledge on packages having high water vapour barrier can maintain crispness of the fried and dried products [10].

Conclusions

Active modified atmosphere packaging (Active MAP) system developed, i.e. incorporation of oxygen scavenger and metalized film bag, has good capability to extend shelf life of the traditional

Thai fried banana product through essentially minimizing oxidative rancidity which is technically promoted by the high fat content of the product and oxygen in the surrounding environment. The research findings importantly point out that the clear PP film bag is considered improper to be utilized with the oxygen scavenger because of its low barrier to oxygen. Because of its practical applications and simplicities, the Active MAP system developed can be applied to other similar products such as traditional fried sweet potato chips and deep-fried sausages.

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