

*Research Article*

## **Effect of packaging systems on shelf-life stability of Thai-style fried rice crackers**

**Sripak Namsai, Thanee Keokamnerd, Kornpaka Arkanit and Pranee Warasawas\***

Department of Food Technology, Faculty of Engineering and Agro-Industry,  
Maejo University, Chiang Mai, Thailand.

\*Author to whom correspondence should be addressed, email: [pranee.w@mju.ac.th](mailto:pranee.w@mju.ac.th)

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**Abstract:** The purpose of this research was to study the effect of packaging conditions on shelf-life stability of Thai-style fried rice crackers, known as “*nang led*”, or, “*kawtan*” in the north of the country. Two types of packaging materials; white co-extrusion oriented polypropylene and linear low density polyethylene (OPP/LLDPE) plastic bag and laminated multilayer metalized (MET) plastic bag were employed. Four conditions; none, oxygen absorber, desiccant and the combination of oxygen absorber and desiccant were used. Eight packaging systems were compared to the traditional packaging using transparent OPP. After four months the results indicated that peroxide value, conjugated dienes and conjugated trienes were increased and corresponded with the value of TBARS and carbonyl compounds. This also indicated and crackers packed in transparent OPP were rancid, while the crackers in other packaging conditions had a lower level of rancidity. The physical properties in terms of water activity and moisture contents were slightly changed and related to the crispiness of the crackers. The crackers packed in a metallic bag with oxygen absorber and desiccant had the best crispiness. The criteria used for measuring rancidity correlated well with quantitative descriptive analysis (QDA) performed by ten trained panelists during storage. The oxidative rancidity measurement and sensory evaluation showed that the sample packed in traditional packaging had strong rancid flavour, while the crackers in the other eight packaging systems were still acceptable to the panelists. The best packaging condition resulting from this study is the metallic bag with oxygen absorber and desiccant, because it showed the highest crispiness and the lowest chemical change, especially the increase of carbonyl compounds.

**Keywords:** packaging; Thai-style fried rice crackers; oxidation; oxygen absorber; desiccant

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## Introduction

Thailand has a world-wide reputation as a major rice producer and exporter. It is thus not strange that many uses are made of rice in the country, including fried rice crackers made from glutinous rice. This is a well-known snack food, usually called *nang led* in the central region, or *kawtan* in the north. It has a patty-shape of whole grain crackers with a light brown colour.

Puffing of the rice crackers is accomplished by deep fat frying. The frying process causes quite a high level of oil absorption to the product. This residual oil eventually contributes to rancidity of the product (Rajkumar *et al.*, 2003). The other factor of concern to producers is the decrease in crispiness due to moisture absorption.

These problems led the researchers to examine the use of different packaging systems to decrease the rate of deterioration. This followed the work of Smith (2004), who studied the application of an oxygen absorber, desiccant and antimicrobials with flexible plastic packaging, such as aluminum foil bags and metallic plastic bags, for snack food.

The specific objectives of our study were to determine the chemical and physical properties of Thai-style fried rice crackers packed in two types of packaging materials. These were white co-extrusion oriented polypropylene and linear low density polyethylene (OPP/LLDPE) plastic bags and laminated multilayer metalized (MET) plastic bags. The two types of bag were employed with four conditions; none, oxygen absorber, desiccant and the combination of oxygen absorber and desiccant. Eight packaging systems were then compared to the traditional packaging system using transparent OPP plastic bag. The study was undertaken over a period of four months to measure storage quality in ambient temperature.

## Materials and Methods

### *Production of Thai-style fried rice crackers*

Glutinous rice (Sanpatong variety) was purchased from the Maejo Market in Chiang Mai, Thailand. The rice was steamed and mixed with other ingredients (Jintara variety watermelon, salt, white and black sesame, all purchased from Maejo Market, Chiang Mai). The mixture was then molded by an acrylic mold. After molding the crackers were oven dried at 65<sup>0</sup>C until the final moisture content was around 10% (5 - 7 hrs). 200 ppm TBHQ was added to refined palm olein oil (Dokmai trademark purchased from local market) and the crackers were then fried at 210<sup>0</sup>C for 30 seconds. The product was then cooled by leaving at room temperature for 10 -15 min. The crackers were enclosed in two types of packaging (supplied by Strong Pack, Samutpakarn, Thailand) at the four conditions as stated above. Oxygen absorber was purchased from Alpine Foods (Bangkok, Thailand) and desiccant was purchased from Power Dry (Bangkok, Thailand). The control system was composed of the crackers packed in transparent OPP (traditional packaging) and kept at ambient temperature.

**Table 1.** Barrier properties of plastic composition, water vapour transmission rate (WVTR) and oxygen transmission rate (OTR) used in the experiment.

<b>Plastic composition</b>	<b>WVTR plastic<sup>a</sup></b> (g/m <sup>2</sup> .24hr.atm: 23°C)	<b>OTR plastic<sup>a</sup></b> (cc/m <sup>2</sup> .24hr.atm:38°C,95% RH)
95µ OPP	< 5-7	< 2000-2500
40 µ OPP/white LLDPE	< 2	< 6
77µ OPP/white PE/VMPET/ CPP	< 1	< 1

<sup>a</sup> According to information from the plastic suppliers.

### ***Measurement of lipid oxidation***

The samples were ground in a blender before being extracted with chloroform/methanol (2:1). The extracted solution was then analysed for chemical properties. These were the amount of conjugated dienes (CD) and conjugated trienes (CT) by Brown and Snyders' method as stated in Pegg (2005). Extraction was modified by using isooctane/2-propanol (3:2) and 10 ml, then vortexing (1 min, three times), with isolation of supernatant by centrifugation at 1000 g for 10 min. Peroxide value (PV) and 2-thiobarbituric reactive substances (TBARS) by AOCS 's method (AOCS, 2006) and carbonyl compounds (CC) were analyzed by Meyer and Rebrovic 's method as stated in Pegg (2005). All chemicals and solvents used were analytical grade of BDH (Pooled, England) and absorbance measurements were undertaken by spectrophotometer (Per kin Elmer, Lambda 2S model, Germany)

### ***Measurement of physical properties***

The samples were ground using a blender and analyzed for water activity (Novarsina, MIK 3000 model). The crispiness of the product was measured for the least amount of compression force to break the product apart by using universal TA-XT plus testing equipment (Stable Microsystems, Surrey, UK), with a stainless steel ball probe of 0.5 cm diameter, load cell of 5 kilograms. The condition of compression force used was 30 mm return distance and 20 mm/sec return speed.

### ***Sensory evaluation***

The samples were analyzed by the Quantitative Descriptive Analysis (QDA) method under a general environment at the sensory laboratory using ten trained panelists. The analysis was performed every 15 days over 120 days. The measured qualities included the regularity of grain expansion, colour, crispiness, rancidity and flavour.

### ***Statistical analysis***

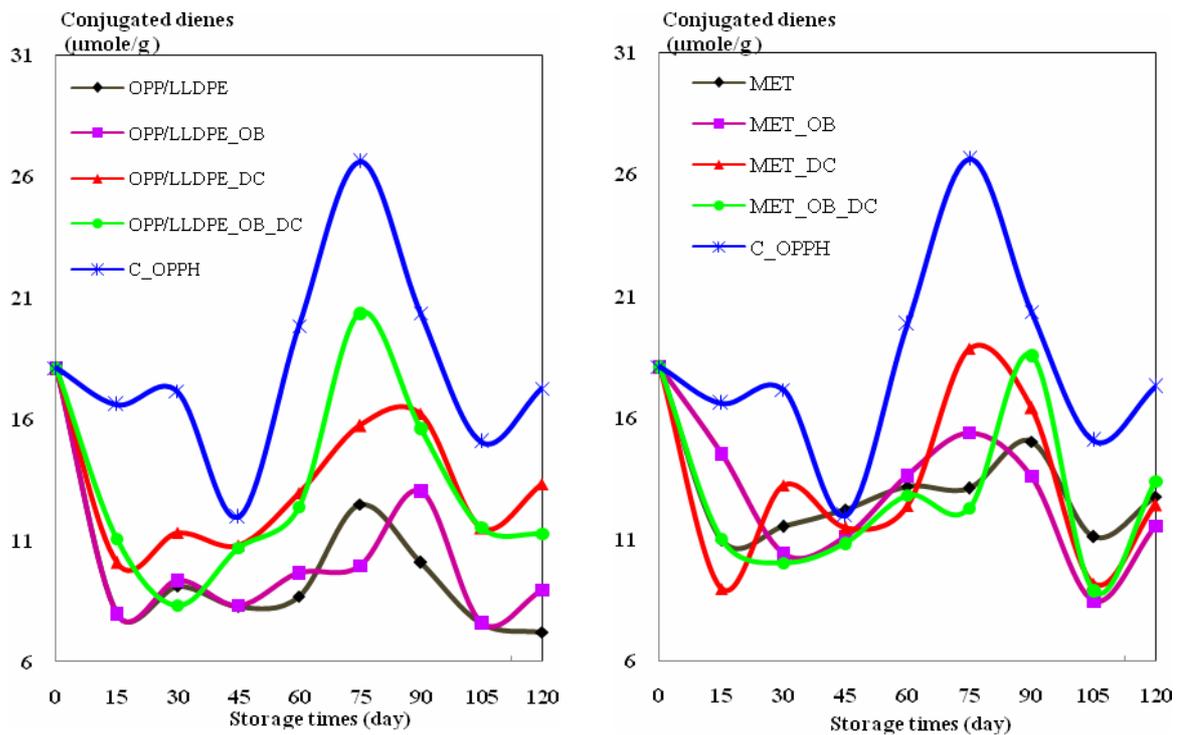
All measurements were undertaken in triplicate. The results were expressed as the mean values and standard error of means. All data were analyzed for indications of variance by using a 2×4 factorial in a completely randomized design with SPSS version 15. New Duncan's Multiple Range Test was used to compare differences among means.

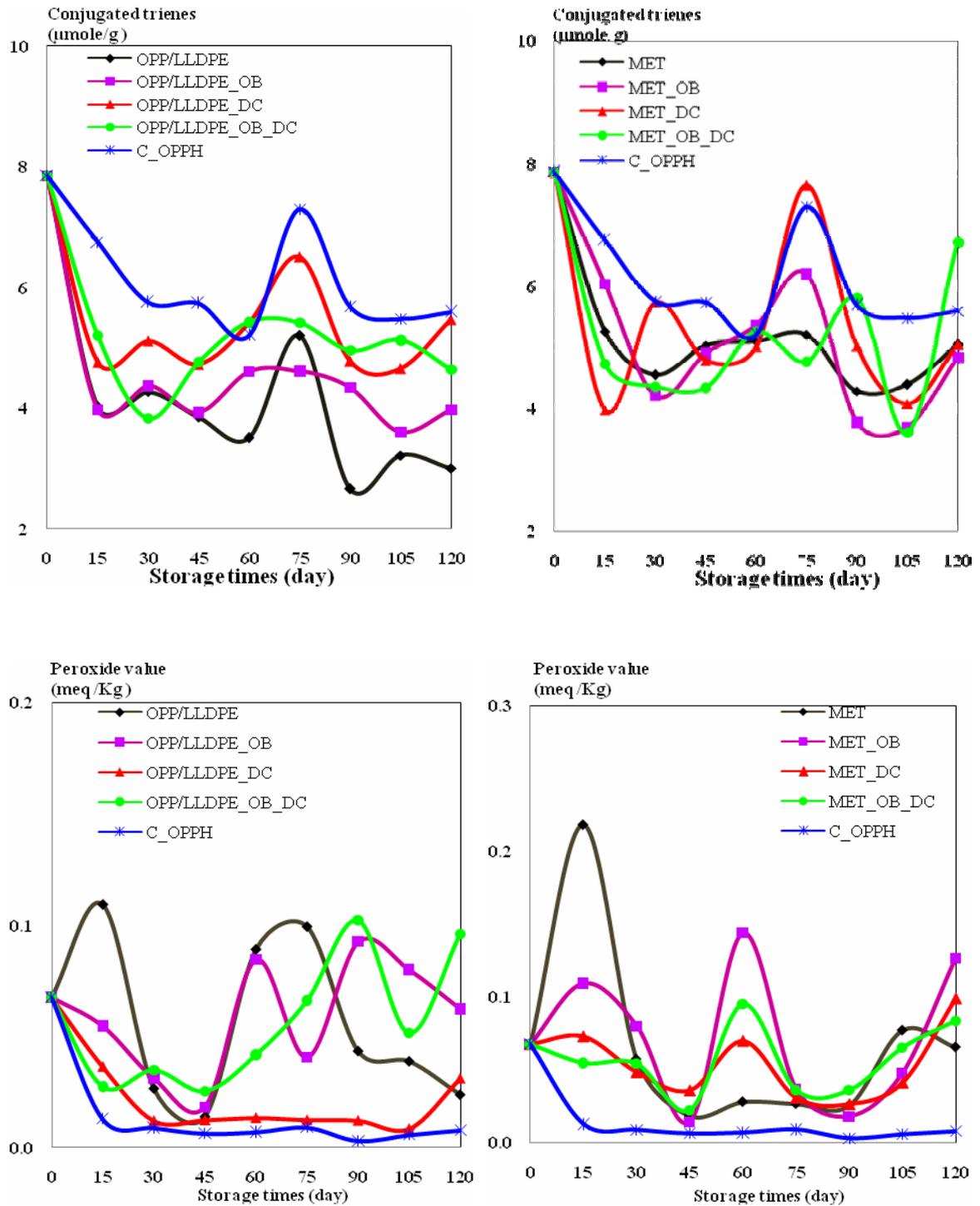
Significance was defined at a 95% level ( $P \leq 0.05$ ). Pearson correlation coefficients ( $r$ ) between chemical properties and storage times were calculated.

## Results and Discussion

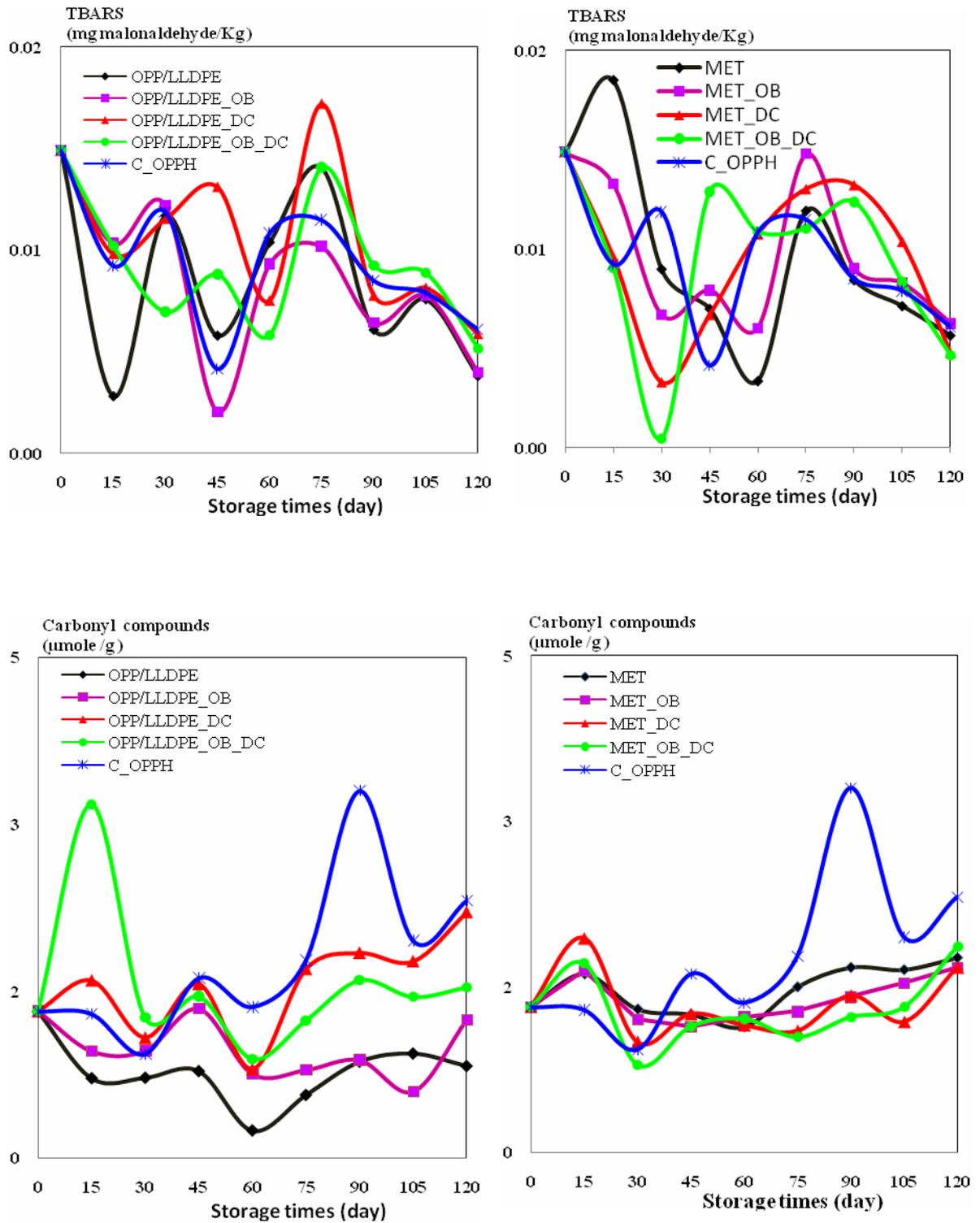
### *Effect of different packaging systems on lipid oxidation*

The appearance of conjugated dienes and trienes in oxidized lipids is due to shifting of bonds following free radical attack on hydrogen atoms of the methylene groups (Kiokias and Oreopoulou, 2006). In addition, another product of primary oxidation is hydroperoxide (Nawar, 1996). The results shown in Figure 1 present primary oxidative products of eight packaging systems compared with transparent OPP. They include the amount of conjugated dienes, conjugated trienes and the peroxide value of each packaging system. The amounts decrease at 120 days of storage because they decompose to produce secondary oxidative products. The crackers packed in MET containing oxygen absorber and desiccant has the longest induction period with respect to the amount of conjugated dienes ( $r = -0.72$ ,  $p \leq 0.01$ ), conjugated trienes, ( $r = -0.293$ ,  $p \leq 0.01$ ) and peroxide value ( $r = -0.099$ ,  $p \leq 0.01$ ) during 120 days of storage. The longest induction period shows the slowest rate of oxidation due to MET plastic having the lowest oxygen transmission rate and the absorber removing oxygen from inside the packaging.





**Fig. 1.** Effect of different packaging systems on the primary oxidative products at 120 days. Abbreviations: OPP/LLDPE = co extrusion oriented polypropylene and linear low density polyethylene plastic bag, MET = laminated multilayer metalized plastic bag, C\_OPPH = Transparent OPP of farmers' housewife groups, OB = oxygen absorber, DC = desiccant, and OB&DC = the combination of oxygen absorber and desiccant.



**Fig. 2.** Effect of different packaging systems on the secondary oxidative products at 120 days. Abbreviations: OPP/LLDPE = co extrusion oriented polypropylene and linear low density polyethylene plastic bag, MET = laminated multilayer metalized plastic bag, C\_OPPH = Transparent OPP of farmers' housewife groups, OB = oxygen absorber, DC = desiccant, and OB&DC = the combination of oxygen absorber and desiccant.

The secondary oxidation compounds are derived from hydroperoxide decomposition to short chain volatile compounds such as aldehydes and ketones, non-volatile compounds such as hydrocarbons of higher molecular weight (Fox and Stachowiak, 2007). The secondary oxidative products with respect to TBARS and CC, which are shown in Figure 2, demonstrate a tendency to be the lowest in crackers packed in metalized plastic incorporating the oxygen absorber and desiccant. This result corresponds with the primary oxidation products. In addition, TBARS and carbonyl compounds in this packaging system were quite lower than in the control. Pearson correlation coefficients between carbonyl compounds and storage times is positive with low correlation ( $r = 0.151$ ,  $p \leq 0.01$ ), while correlation coefficients between TBARS and storage times is negative with low correlation ( $r = -0.312$ ,  $p \leq 0.01$ ). The result corresponds with the report of Larsen *et al.* (2005). Their report showed the extruded oat product packed in OPP/PE plastic incorporating an oxygen absorber had no severe rancid odors or flavours, while rancid odors or flavours were present in the system of high oxygen transmission rate without oxygen absorber.

### *Effect of different packaging systems on physical properties*

**Table 2.** Means of different packaging systems on physical properties.

Packaging system	$a_w$	Compression force (N/mm)
OPP/LLDPE	0.47 <sup>c</sup>	2294.4 <sup>d</sup>
OPP/LLDPE_OB	0.49 <sup>e</sup>	2255.9 <sup>cd</sup>
OPP/LLDPE_DC	0.49 <sup>e</sup>	2252.1 <sup>cd</sup>
OPP/LLDPE_OB_DC	0.50 <sup>f</sup>	2161.8 <sup>bcd</sup>
MET	0.35 <sup>a</sup>	2029.8 <sup>bc</sup>
MET_OB	0.41 <sup>b</sup>	2200.6 <sup>cd</sup>
MET_DC	0.39 <sup>a</sup>	1921.3 <sup>ab</sup>
MET_OB_DC	0.41 <sup>b</sup>	2171.9 <sup>bcd</sup>
C_OPPh	0.48 <sup>d</sup>	Unbreakable

$a_w$ : <sup>a-f</sup>, Means within a column with different letters are significantly different ( $p \leq 0.05$ ).

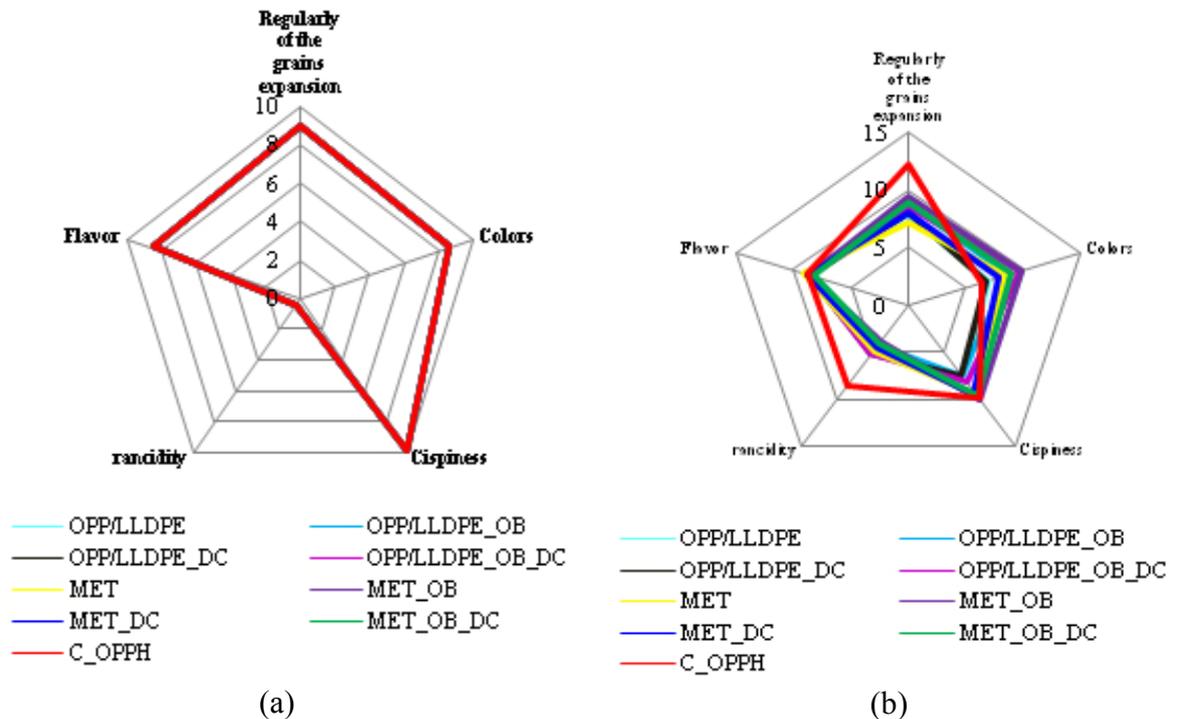
Compression force: <sup>a-d</sup>, Means within a column with different letters are significantly different ( $p \leq 0.05$ ).

Abbreviations: OPP/LLDPE = co extrusion oriented polypropylene and linear low density polyethylene plastic bag, MET = laminated multilayer metalize plastic bag, C\_OPPh = Transparent OPP of farmers' housewife groups, OB = oxygen absorber, DC = desiccant, and OB&DC = the combination of oxygen absorber and desiccant.

The physical properties of the product such as the crispiness and water activity ( $a_w$ ) were affected by the water vapour transmission rate (WVTR) of the packaging. In this way the desiccant gets rid of moisture in the headspace and transfers moisture from the environment. Table 2 shows the result of  $a_w$  and compression force.  $a_w$  are lowest in the crackers packed in MET and MET incorporating desiccant, followed by the crackers packed in MET incorporating an oxygen absorber and MET incorporating an oxygen absorber and desiccant. The compression forces demonstrate a tendency to correspond

with  $a_w$ . It is noticeable that the crackers packed in traditional packaging are unbreakable because they absorb moisture transmitted from outside to inside the packaging. The desiccant used in this experiment was diatomaceous earth. It requires a long time to reach saturation compared to other desiccants.

**Sensory Evaluation**



**Fig. 3** Effect of different packaging systems on sensory evaluation at (a) 0 days and (b) 120 days. Abbreviations: OPP/LLDPE = co extrusion oriented polypropylene and linear low density polyethylene plastic bag, MET = laminated multilayer metalize plastic bag, C\_OPPH = Transparent OPP of farmers’housewife groups,OB = oxygen absorber,and OB&DC = the combination of oxygen absorber and desiccant.

Sensory evaluation maintained a score of all attributes between day 0 and day 120. All showed a decrease over time, while rancidity increased. The main qualities that affect sensory evaluation are rancidity and crispiness, which were almost the same in all packaging systems at day 120, except for the traditional packaging. The rancidity levels of crackers in all eight packaging systems are in the range 3.69 - 4.66, which indicates slight rancidity, while the traditional OPP is 8.6, which means low rancidity. The crispiness scores of crackers in all packaging systems are in the range of 7.72 - 10.07, which means quite crispy. However, there was a contrast in the crispiness score and the texture analysis of crackers in traditional packaging. The score shows quite crispy and cannot be broken, but the texture analysis shows the toughness of unbreakable crackers. This information shows the accuracy of the objective test is better than subjective test.

## Conclusion

In this study, the eight packaging systems tested effectively benefit retarding deterioration during storage of Thai-style fried rice crackers. The co-extrusion metalized bag incorporating an oxygen absorber and desiccant was the best system. It extended the shelf life of crackers twice longer than the farmers' housewife groups system (C\_OPPH).

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