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The Effect of Using Stickers on the Fried Fish Crackers Package Towards the Physicochemical and Sensory Properties during Storage

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Abstract
Fish crackers are a traditional Malaysian snack food and are known as Keropok. It has a short shelf life and is easily rancid due to oxidation. This study was conducted to determine the effect of covering package material using paper-sticker on the physicochemical and sensory properties of fish crackers during storage. A storage study of deep-fat-fried keropok was carried out for three months at ambient temperature (27ºC) using Polypropylene (PP) packaging material covered with 0% paper-sticker (as control), 40% paper-sticker, and 80% paper-sticker. Oxygen transmission rate (OTR), moisture content, peroxide value (PV), thiobarbituric acid (TBA), and sensory attributes of the fish crackers were analyzed after 0, 1, 2, and 3 months. All parameters increased significantly with time ($P<0.05$) in all the samples under different percentages of paper-sticker covering the packing material. Polypropylene plastic bags covered with 0% paper sticker (as a control) recorded the highest oxygen transmission rates (OTR). However, covering of PP plastic bag with 80%paper-sticker reduced more than 60% oxygen transmission rate (OTR). After three months of storage time, the PV and TBA values were significantly lower ($P<0.05$) for samples packaged with PP covered with 80%paper-sticker compared to samples packaged with polypropylene (PP)

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covered with 0% and 40% paper-sticker. Sensory attribute scores had decreased during storage time. The scores of crispiness, overall acceptability and off- flavour were significantly higher (P<0.05) for samples packaged with 80% paper-sticker compared to PP film with 0% paper-sticker after one and two months of storage time. The best percentages of the paper-sticker covering packaging material is PP with 80% paper-sticker. Therefore, using paper-sticker with 80% was able to reduce OTR and showed a delay rancidity by decrease of PV and TBA values.

Keywords: fish crackers, paper sticker, Polypropylene (PP), sensory evaluation, physicochemical properties.

تأثير استخدام الملصقات على عبوات مقرمشات السمك المقلي على الخصائص الفيزيائية والكيميائية والحسية أثناء التخزين

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الملخص:

المقرمشات السمكية من الوجبات الخفيفة الماليزية التقليدية، وتُعرف باسم كيروبوك (Keropok). تتميز بفترة صلاحية قصيرة، وتفسد بسهولة بسبب الأكسدة. أجريت هذه الدراسة لتقييم تأثير تغطية مادة التغليف باستخدام ملصق ورقي على الخصائص الفيزيائية والكيميائية والحسية للمقرمشات السمكية أثناء التخزين. أجريت دراسة تخزين للكيروبوك المقلي في زيت عميق لمدة ثلاثة أشهر في درجة حرارة الغرفة (27 درجة مئوية) باستخدام مادة تغليف من البولي بروبيلين (PP) مغطاة بالملصق ورقي بنسبة 0٪ (كعينة مراقبة) و40٪ و80٪. تم تحليل معدل نفاذية الأكسجين (OTR) ومحتوى الرطوبة وقيمة البيروكسيد (PV) وحمض الثيوباربيتيوريك (TBA) والخصائص الحسية لمقرمشات السمكية بعد 0 و1 و2 و3 أشهر. زادت جميع المقاييس بشكل ملحوظ مع زيادة فترة التخزين (P <0.05) في جميع العينات المغطاة بنسب مختلفة من الملصقات الورقية.

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سجلت الأكياس البلاستيكية المصنوعة من البولي بروبيلين المغطاة بملصق ورقي بنسبة 0٪ (كمراقبة) أعلى معدلات نفاذية الأكسجين (OTR) ومع ذلك، فإن تغطية أكياس البلاستيك المصنوعة من مادة البولي بروبيلين بنسبة 80% ملصق الورقي قللت من معدل نفاذية الأكسجين (OTR) بأكثر من 60%. بعد ثلاثة أشهر من التخزين، كانت قيم PVو TBA أقل بشكل ملحوظ (P<0.05) للعينات المعبأة في البولي بروبيلين (PP) و المغطاة بنسبة 80% ملصق الورقي مقارنةً بالعينات المعبأة في PP والمغطاة بنسبة 0% و40% من الملصق الورقي. انخفضت درجات الخصائص الحسية أثناء فترة التخزين. كانت درجات القرمشة والقبول العام والنكهة غير المرغوبة أعلى بشكل ملحوظ (P<0.05)للعينات المعبأة بنسبة 80% من الملصق الورقي مقارنةً بالعينات المعبأة في PP بنسبة 0% ملصق الورقي بعد شهر وشهرين من التخزين. خلصت الدراسة إلى أن أفضل نسبة لتغطية مادة التغليف PP بالملصق الورقي هي 80%. بالتالي، كان استخدام الملصق الورقي بنسبة 80% قادراً على تقليل معدل نفاذية الأكسجين (OTR) وأظهر تأخيراً في التزنخ من خلال انخفاض قيم PV و TBA.

الكلمات المفتاحية: مقرمشات السمكية، ملصق ورقي، البولي بروبيلين(PP)، التقييم الحسي، الخصائص الفيزيائية والكيميائية.

Introduction:

Lipid oxidation is one of the primary reactions that cause food deterioration because it produces compounds that degrade the quality properties of products such as textural, color, nutritional value, and flavours that arise during manufacturing, storage, distribution, and final preparation of foods (Cheng, 2016). The oxidation is the main cause of rancidity in fish crackers, the presence of oxygen leads to destruction of fatty compounds in fish crackers into the compounds that cause rancidity. The rancid odour of fish crackers is caused by the degradation of fat into free fatty acids due to the oxidation process, thereby forming free fatty acids which have low volatile molecular weight, causing the oil to become rancid (Pangawikan et al. 2017). The oxidation rate immediately connects to the O_2 concentration in the environment (Ziaolhagh, 2013). Thus, snacks such as fish crackers with oil content that is, higher than 30%, not only require protection against moisture, but also oxygen and light to avoid lipid oxidation during storage. Air is found to be a pro-oxidant agent and appropriate packaging is necessary for

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longer shelf life of products (Koontz, 2016; Abong et al. 2011). Oxidation, which is i accelerated at the high temperature used in deep frying, creates rancid flavours and reduces the organoleptic characteristics of fried food. Hydro-peroxides are the major initial products of the lipid oxidation reaction. Though they are unsteady and decompose suddenly to form other compounds such as aldehydes, ketones, alcohols, acids and hydrocarbons (Shahidi and Zhong, 2015).
Fish crackers are known in Malaysia as Keropok. They are a widely consumed snack in Asian countries. They are made from tapioca flour, fish meat, salt, sugar and monosodium glutamate and is boiled or steamed in order to produce gelatinized dough. They are often formed in cylindrical shapes (Amin et al. 2023; Kaewmanee et al. 2015; Wan-Hamat et al. 2020). Afterwards, this dough is chilled, cut into slices and exposed to air or sun to reduce its moisture content to approximately 10 %-12% (Huda et al. 2010). Finally, the dried slices are “fried in deep, hot oil” (Kaewmanee et al. 2015). Fish cracker is a type of deep-fried food that adsorbs a lot of oil (Abong et al. 2011). Fried food products occupy a significant portion of today’s markets. These products include different materials such as roots, tubers, cereals, bananas, plantain, fish, and chicken which are mostly produced and supplied as composites with coatings, such items are produced by deep-fat frying (Frakolaki et al., 2023), which are achieved through dipping food items in edible oil for a few minutes at high temperature that ranges between 130 °C and 190 °C at atmospheric pressure. Deep-fat frying is a complex procedure involving diverse parameters, where heat and mass transfer occur instantaneously (Dangal et al.,2024, Oke, et al.,2017). Appropriate packaging is one of the most important methods to mitigate oxidation. The primary role of food packaging is to maintain product quality, prevent product loss and containment, aid in transportation, allow safe storage and is a form of product advertising (Steenis et al., 2017).
The main requirement of the packaging material is its ability to act as an oxygen barrier if the food item in question is sensitive to oxygen. Usually, less oxidation leads to longer shelf-life and better quality of food items (Dey and Neogi, 2019). Fish crackers are susceptible to deterioration due to environmental influences such as oxygen and water vapor. Crackers that are not given protective packaging can undergo to rancidity because of oxidation, which cause by oxygen. Tiwari et al. (2011) stated that rancidity is the

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common off-flavour developed in deep-fried snacks. One of the methods to prevent rancidity is by using proper packaging that can protect the fried fish crackers from oxygen and light.

The best packaging to prolong the shelf life of fish crackers, which is a cheap and very familiar to use as a packaging material for fish crackers, is polypropylene. This type of packaging is widely used for fish crackers packaging because it is easily formed, moderately resistant to water vapor, and has a transparent appearance, but unfortunately, this type of plastic is insufficiently resistant to oxygen making it less suitable for food products that are sensitive to oxygen, such as fish crackers (Pangawikan et al. 2017). This study was done as, a result of limited information available for the quality improvement of fried fish crackers as Malaysians traditional deep-fried snack, and to could possibly offer a cheap solution for cottage industries to reduce the rancidity of fried products in order to maintain the quality and extent the shelf life of their deep-fried fish crackers products during storage. Specifically, this study attempts to use a sticker so, as to achieve the following objectives: To determine the effect of covering by using different percentages of paper-stickers and storage period on the physicochemical and sensory properties of fried fish crackers.

Materials and Methods:

Sample Collection and Preparation:

Raw fish crackers were bought from Terengganu local market. The fish crackers were fried in deep oil at 180ºC. Fried fish crackers were packaged in Polypropylene packaging material and sealed. The sticker was covered with 0 %, 40 % and 80 % of polypropylene packaging material. Approximately 150 g of fried fish crackers were packaged into polypropylene packaging. The packaged crackers were stored at room temperature 27°C. The fried fish crackers were analyzed for oxygen transmission rate (OTR), moisture, peroxide value (PV), and Thiobarbituric acid (TBA) immediately and thereafter at 2-week intervals during storage for 3 months. The flavour, aroma, and acceptability were determined initially and at 12-week intervals during the same period.

Measurement Of Oxygen Transmission Rate (OTR):

The Op Tech- O2 Model P, was used to measure Oxygen Transmission Rate (OTR) of PP plastic film covered with 0 %, 40

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% and 80 % paper-sticker according to described by (Abdellatief and Welt, 2009).

Determination of Moisture Content:

The moisture content was determined according to the Association of Official Analytical Chemists as standard (AOAC, 2005). 5g of sample was placed in a dish and weighed accurately. After that, the dish with the sample was placed in the oven at 105ºC for 24 hours, and after drying, the dish was transferred with a covered lid to the desiccator to cool. The dish was weighted. The percentage of moisture content was calculated as follows:-

$$\textbf{Moisture}\ (\%) = \frac{\mathbf{W_1 - W_2}}{\boldsymbol{W_1}} \times \mathbf{100}$$

Where: W1= weight (g) of sample before drying
W2 = weight (g) of sample after drying

Fat Content Determination:

The lipid of fried fish crackers was extracted by the Soxhlet method as described by (AOAC, 2005). Soxhlet extractions were carried out in triplicate using 5 g of dried fried fish crackers were weighed with 200 ml of petroleum ether for 6 h. The extracted lipid was evaporated under vacuum at 45ºC using a Heidolph WB/VV 2000 rotary evaporator (Heidolph, Germany) and then placed in an oven at 45ºC for 1 h before being transferred into a desiccator before reweighing. The percentage of fat content was calculated as ***W***

$$\textbf{Crude Fat}\ \% = \frac{\mathbf{W_2 - W_1}}{\mathbf{S}} \times \mathbf{100}$$

Weight of empty flask (g) = W_1.
Weight of flask and extracted fat (g) = W_2 ,
Weight of sample = S,

Measurement of Lipid Oxidation:

Peroxide Value (PV):

The peroxide value (PV) was determined in the lipid extract according to the AOCS method (Cd 8-53,2003). Approximately 2g of extracted lipid was weighed into a 250 ml Erlenmeyer flask, and 30 ml of a mixture of acetic acid/chloroform (3:2 v/v) was added. The contents were stirred continuously until the extracted lipid was dissolved completely. One ml of saturated potassium iodide (KI)

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solution and distilled water (30 ml) were added. The contents were titrated against 0.002 N sodium thiosulphate, with 0.5 ml of 1.5% starch as an indicator. The PV was expressed as meq oxygen/kg fat and was calculated as follows:

$$\mathbf{PV} = (\mathbf{meq}\ O_2/\ \mathbf{Kg\ fat}) = \frac{(\mathbf{V}_s - \mathbf{V}_b) \times \mathbf{N} \times \mathbf{1000}}{\mathbf{W}}$$

Where: $\mathbf{V_s}$ = is the volume consumed during titration of the sample (ml). $\mathbf{V_b}$ = is the volume consumed in the evaluation of the blank (ml). **N** = is the normality of the sodium thiosulphate solution.
W = is the weight of extracted fat used (g);

Thiobarbituric Acid (TBA):
Lipid oxidation of all samples was determined by 2-thiobarbituric acid (TBA) value according to the method (Cd 19-90) described by (AOCS, 1997). Weigh 50-200mg of extracted fat (m) into a 25ml volumetric flask. Dissolve in small volume of 1-butanol, made up to volume with1-butanol, and mix. 5 ml of the sample solution was pipetted to 5ml of TBA reagent (the TBA reagent is prepared by weighing 200 mg of TBA and dissolving in 100 ml 1-butanol and mix, filtered, store at 4°C not more than 7 days), was added into a screw-cap test tube and heated in a water bath (95°C) for 120 min until pink color development. The test tube was then cooled, and the optical density was determined at 532 nm on a Spectrophotometer apparatus using a control solution (reagent blank) containing 5 ml each of 1-butanol and TBA reagent. The sample absorbance (As) was measured. Run a reagent blank, absorbance (Ag) not to exceed 0.1. The TBA value was expressed as mg malonaldehyde/kg sample and was calculated as follows:

$$\mathbf{TBA\ Value} = \frac{\mathbf{50} \times (\mathbf{As} - \mathbf{Ag})}{\mathbf{m}}$$

Sensory Evaluation:
Coded samples were presented to 10 semi-trained panelists, all familiar with fish crackers. Panel members scored for flavour, aroma, crispy and overall acceptability on a 7-point hedonic rating scale varying from 1 (extremely dislike) to 7 (extremely like).
Statistical Analysis:
All the experiments were arranged in a completely randomized block design. All experiments were carried out in triplicate. Data

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was subjected to analysis of variance (One Way ANOVA) by using Minitab (17) software. The difference among the mean values of the percentage of paper-sticker covering packaging material and storage period was determined by the Turkey Pairwise Comparisons test, and the significance is defined at $P<0.05$. Results of physicochemical and sensory analyses were reported as mean values ± standard deviation.

Results and Discussion:

Oxygen Transmissmion Rate (OTR):

Oxygen concentration is one of the most important storage factors affecting lipid oxidation. By reducing the O2 concentration, lipid oxidation can be reduced to a minimum level (Johnson and Decker, 2015). Consequently, many previous studies aimed to reduce O2 uptake considerably. Applying edible coating could be used as O2 barrier, limit and delay the lipid oxidation rate. It was shown that whey protein isolate-based edible coatings were good O2 barriers on the nut surface and could considerably delay O2 uptake of dry roasted peanuts (Maté et al. 1996). It was also observed that utilizing Laminated Aluminum Foil (LAF), as a packaging material provided high good barrier properties, and it was most effective for delaying the lipid oxidation among different packaging materials of banana chips (Ammawath et al. 2002: Khanvilkar et al. 2016). In the current study, paper-sticker has been used as a simple and inexpensive means to small enterprises to reduce the oxidation of fish crackers.
Table 1 below shows the oxygen transmission rates (OTR) of the different packaging materials used in this study. (PP) Plastic bags scored the highest oxygen transmission rates. However, covering 40 % of PP plastic bag with paper sticker reduced more than 30 % (OTR) in them, while covering 80 % of PP plastic bags with paper stickers reduced the oxygen transmission rates of (PP) plastic bags by more than 60 %. Therefore, using paper sticker was able to reduce (OTR) in PP plastic bags. Polypropylene plastic bags scored the highest (OTR). However, covering 40% of PP plastic bags with paper-sticker reduced more than 30% OTR. To calculate percentage decrease: First: work out the difference (decrease) between the two numbers that are comparing (in this case 453, 91 and 661, 46). Then: divide the decrease by the original number (in this case 661.46) and multiply the outcome by 100 = - 31.37%. The negative sign indicates a percentage decrease. A similar approach was followed to

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reduce 60% OTR by covering the PP plastic bags with 80% paper stickers.

Table 1. Oxygen Transmission Rates (OTR) of PP plastic bags covered with 0%,40% and 80% paper stickers

Packaging material	OTR (cc/[m^2- day)
PP plastic bags	661.46
PP plastic bags + 40% paper sticker	453.91
PP plastic bags + 80% paper sticker	246.36

PP= Polypropylene, OTR= oxygen transmission rates, cc= cubic centimeter, m^2=square meter

Moisture Content:

The summary of one-way ANOVA analysis conducted to examine the effect of covering paper-sticker on moisture content levels of fish crackers stored in PP plastic bags are shown in Table 2 below. There was no significant difference for moisture content among the fish crackers stored in PP plastic bags with and without paper stickers at zero time of period storage. The moisture content of fish crackers stored in PP plastic bags with paper-stickers 40% and 80% was significantly lower ($P<0.05$) than those fish crackers stored in PP plastic with paper-stickers (0%) after one month of storage. In contrast, after two and three months of storage time, no significant difference of placing paper-sticker with varying percentages was observed for moisture content of fish crackers. This shows that the effectiveness of the paper-sticker in reducing moisture content absorption decreased with increased storage time of two and three months, suggesting that the integrity of paper-sticker, have been compromised after the first month of storage time. For control samples of fish crackers, moisture content was significantly higher ($P<0.05$) after one month of storage and was followed by a slight increase up to the end of storage, suggest that moisture from the surround migrated into the package and was absorbed by fish crackers. However, no difference was found in moisture content between the samples after two months. While moisture content in control fish crackers after three months of storage time was significantly higher ($P<0.05$) compared to the samples at zero and after one and two months of storage time. Fish crackers stored in PP plastic bags covered with both 40% and 80% paper-sticker, were significantly higher ($P<0.05$) after one month of storage time. Subsequently, further increase in storage time to three months did not produce any significant change in moisture content. The moisture content in fish crackers samples packed in PP plastic films

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with 0% paper-sticker ranged from 2.49% to 7.57%. However, the moisture content of fish crackers samples packed in PP plastic films with paper-sticker ranged from 2.51% to 7.04% and from 2.08% to 6.90% for 40% coverage and 80% coverage, respectively. The increase in the moisture content during storage may be due to water vapor transmission (WVT) characteristic of the packaging film (Purohit and Rajyalakshmi 2011; Jagadeesh et al. 2007). In comparison with the control, moisture contents were lowered by applying paper-stickers on the packaging material during the period of storage, as shown in Table 2. Similar results also reported by (Abong et al. 2011) on potato chips, and (Ammawath et al. 2002) on banana chips, when they found that packaging material such as aluminum foil pack was the most effective in controlling the increase in moisture content compared to transparent packaging polypropylene (PP), which allowed the highest moisture build up in the stored crisps. These differences might be due to the differences in moisture vapor permeability of the packaging films (Ammawath et al. 2002). Moisture content is an important shelf-life determinant, the higher level of moisture, the higher rate of microbial spoilage of food products and the faster the breakdown of oils in stored products, thereby, resulted in poorer quality (Parnsahkorn & Langkapin 2013). Therefore, a great care must be given to the type of packaging material which in turn affects the WVT rate. In current study a simple solution, paper-sticker, is used to slow down WVT rate for the PP plastic package.

Table 2. Moisture and Fat content of fish crackers packaged in PP plastic film and covered with different paper-sticker at different storage time.

	Storage Time (Month)			
Treatments	**0**	**1**	**2**	**3**
	Moisture Content			
0% sticker as control	$2.49{\pm}0.01^{f}$	$5.91{\pm}0.31^{d}$	$6.63{\pm}0.25^{bcd}$	$7.57{\pm}0.48^{a}$
40 % sticker	2.51 ± 0.10^{f}	4.63 ± 0.41^{e}	6.26 ± 0.28^{bcd}	7.04 ± 0.09^{ab}
80 % sticker	2.08 ± 0.42^{f}	4.12 ± 0.07^{e}	6.14 ± 0.33^{cd}	$6.90{\pm}0.22^{abc}$
	Fat Content			
0% sticker as control	31.86 ± 0.15^{abc}	31.68 ± 0.10^{abc}	33.55 ± 1.88^{a}	33.11 ± 1.28^{ab}
40 % sticker	30.98 ± 0.10^{bcd}	26.33 ± 0.40^{e}	29.28 ± 0.51^{d}	25.98 ± 0.20^{e}
80 % sticker	31.44 ± 0.51^{abcd}	29.84 ± 0.04^{cd}	33.21 ± 0.84^{a}	30.20 ± 0.28^{cd}

(a-e) different letters show significant difference at ($P< 0.05$).

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Fat Content:

The effect of both the storage time and covering packaging material by applying the paper-sticker on the fat content of fish crackers as shown in (Table 2). At the beginning of storage time, the fat content did not differ significantly between samples stored in PP plastic bags without sticker and those that were covered by paper-sticker at different percentages. However, after one month of storage time, the fat content was significantly higher (P<0.05) for samples in PP plastic film alone and those that were covered by 40% paper-sticker. In contrast, no significant difference for fat content was observed between fish crackers samples stored in PP plastic bags without sticker and those that were covered by 80% paper-sticker. After two months of storage time, the fat content did not show any significant change between keropok crackers samples that stored in PP plastic bags alone and the samples that covered by 80% paper- sticker. However, the fat content was significantly higher (P<0.05) for samples packaged in PP plastic without sticker and the samples covered with 40% paper- sticker. After three months of storage time, the fat content was significantly higher (P<0.05) for samples packaged in PP plastic bags alone compared to those that were covered by paper-sticker at different percentages. For the effect of the time, the fat content, did not show any significant change from after one month of storage until they reached three months of storage time. Fat content for samples covered by 40% paper-sticker was significantly lower(P<0.05) after one month of storage time, however after two months of storage, the fat content was significantly higher (P<0.05) compared to after one month of storage time, in contrast, after three months of storage, the fat content was significantly lower (P<0.05) compared to after two months of storage. For samples packaged in PP plastic bags covered with 80% paper- sticker, the fat content did not differ significantly after one month of storage time, however, after two months of storage time, the fat content was significantly higher (P<0.05) compared to after one month of storage, in contrast, after three months of storage the fat content was significantly lower (P<0.05) compared to after two months of storage.

Peroxide Value (PV):

The peroxide value (PV) content of the fish crackers at zero storage time did not differ significantly, as shown in 3. This was expected since the crackers were fresh and the effect of the packaging

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material was negligible. However, after one month of storage, there was a significant difference ($P<0.05$) in PV values between the fish crackers stored in the polypropylene (PP) plastic film with 0% and those that were stored in the PP plastic film covered with paper-stickers at different percentages (40% and 80%). Unlike, there was no significant difference for PV between the different percentages of paper- sticker (40% and 80%) after one month of storage time. After 1, 2, and 3 months of storage, the fish crackers stored in bags without paper stickers had a higher value of PV ($p< 0.05$) compared to those covered with a paper sticker (40% and 80%). These results could be due to the reaction of lipid oxidation in the presence of light and oxygen (Manikantan et al.2014). While the values of PV in the fish crackers stored in bags with 80% paper- sticker, were significantly lower ($P<0.05$) than those stored either in the bags with 40% paper-sticker or without paper stickers during storage time.
Consequently, when the light and oxygen permeability of PP plastic were lowered by applying paper- stickers on them (Table 3), the PV levels were significantly ($P<0.05$) reduced. Similar observations were reported by Manikantan et. al. 2014 that banana chips stored in films having lower light and oxygen permeability resulted in lower PV. Crackers are susceptible to lipid oxidation because the surface area in contact with the air is high, and metal ions in the product can catalyze the formation of carbonyl compounds and hydroperoxides at the aging stage from the fat in the cracker (Noomhorm et al.1997). Similar results were also observed by (Maté et al.1996) on peanut surface, they showed that WPI-based edible coatings were good O_2 barriers and could delay considerably O_2 uptake. The delay in O_2 uptake in coated peanuts is a good indication that could delay the formation of hydroperoxide. This is in accordance with the current study, when crackers packaged in PP plastic films only, which had higher OTR (Table 3) and possibly light permeability produced the highest PV in all the samples. Thus, results showed that application of paper- sticker, was significantly able to reduce the oxidation of fish crackers. In addition, results showed that the level of PV values in sticker packaged was considered acceptable.

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Table 3. Peroxide values and thiobarbituric acid values of fish crackers packaged in PP plastic bags and covered with different percentage of paper sticker at different storage time

Treatments	Storage time (Month)			
	0	1	2	3
	Peroxide Value			
0 % sticker as control	9.83 ± 0.36[e]	16.84 ± 0.67[d]	20.15 ± 0.25[d]	68.23 ± 1.19[a]
40 % sticker	9.18 ± 0.43[e]	12.4 ± 0.74[e]	17.86 ± 1.05[d]	46.65 ± 2.74[b]
80 % sticker	9.79 ± 0.50[e]	11.63 ± 0.48[e]	16.50 ± 0.91[d]	31.55 ± 2.47[c]
	Thiobarbituric Acid Value			
0 % sticker as control	0.05 ± 0.00[e]	0.10 ± 0.00[bcd]	0.15 ± 0.02[a]	0.16 ± 0.03[a]
40 % sticker	0.05 ± 0.00[e]	0.09 ± 0.00[cde]	0.14 ± 0.02[ab]	0.14 ± 0.04[ab]
80 % sticker	0.05 ± 0.00[e]	0.08 ± 0.01[de]	0.09 ± 0.02[cde]	0.10 ± 0.01[bcd]

(a-e) different letters show significant difference at (P< 0.05)

Thiobarbituric Acide (TBA):

The thiobarbituric acid (TBA) value of the fish crackers stored in bags covered with paper sticker 40% and 80% in comparison with those without paper sticker at 0 and after 1, 2 and 3 months are shown in table 3. Since the fish crackers were fresh, made their TBA values, insignificantly different at the beginning, between samples that packaged in PP plastic bags without paper-sticker and those covered in PP plastic bags with paper-sticker at varying percentages. After one month of storage time, the TBA values of fish crackers still insignificantly different among fish crackers stored in PP plastic bags without paper sticker, and those that were stored in PP plastic bags covered with (either 40% or 80%) paper- sticker. However, after two months of storage time, the difference in the levels of TBA values of the fish crackers became significant ($P<0.05$). The TBA values of fish crackers stored in PP bags covered with 80% paper-sticker were significantly lower ($P<0.05$) compared to TBA values of both the control and 40% paper-sticker along of period storage. Overall, TBA values seemed to increase steadily from the initial value and continued to increase during the entire time of storage. However, the TBA values after two months of storage time significantly ($P<0.05$) increased. However, the effect of storage

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time was not statistically significant between samples after two and three months of storage time. In contrast, the effect of storage time on the TBA values of fish crackers packaged in 80% paper-sticker became significantly higher after three months of storage when compared to the initial TBA. No significant difference was observed between samples covered with paper-sticker 80% after one, two and three months of storage.

For fish crackers samples packaged in PP plastic film covered with paper –sticker 80%, TBA value was significantly lower compared to samples without paper- sticker, this due to applying paper-sticker on PP plastic film, that reduced oxygen transmission rate (OTR) of PP plastic film (Table 3). The results were in agreement with those reported by Namsai et al. 2008 on rice crackers when they showed that applying plastic bag and laminated multilayer metalized (MET), resulted in slowest rate of oxidation, the slowest rate of oxidation due to MET plastic, having the lowest oxygen transmission rate and the absorber removing oxygen from inside the packaging. The results were in agreement with those reported by Ibadullah et al. 2019 on fried fish crackers when they showed that applying two types of packaging with four different layers; (A) polyethylene terephthalate-polyethylene-aluminium linear low density polyethylene (PET-PE-ALU-LLDPE), and (B) oriented polypropylene-polyethylene-metallized polyethylene terephthalate-linear low density polyethylene (OPP-PE-MPET-LLDPE), resulted in packaging B with 0.8 moisture vapor transmission rate (MVTR) and 0.8 oxygen transmission rate (OTR), higher than packaging A with 0.05 MVTR and 0.05 OTR showed higher resistance of fried fish crackers towards lipid oxidation. The effects of packaging materials are demonstrated and would give insights into prolonging the shelf life of fried fish crackers. Similar results were also reported by Ammawath et al.2002 on banana chips, when they showed that samples of banana chips packaged with laminated aluminum foil (LAF) gave the lowest rancidity, due to good barrier properties for LAF in controlling oxygen permeability. In the present study, PP with paper-sticker can be useful to small enterprises as an inexpensive means of reducing the rancidity and prolonging the shelf life. Similar findings were also reported by Gunaratne et al. 2015 on sweet and savory rice crackers with a shelf life of 6 months were packed separately Sweet and Savory rice crackers were packed in four different ways using triple laminated packing material {Polyethylene terephthalate (PET)+ Metalized Polyethylene

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terephthalate (METPET)+Linear low-density polyethylene (LLDPE)}. One type was packed by incorporating a silica gel packet as a desiccant (DE), another type by incorporating an oxygen absorber (OA), other type by incorporating both an oxygen absorber and desiccant (OA+DE), and a final type without incorporating any of them (Control). These packets were stored at high temperature (47ºC) and room temperature (28ºC) with saturated conditions to conduct accelerated shelf-life testing. Results revealed that the packets containing both desiccant and oxygen absorber (OA+DE) have the lowest malonaldehyde concentration and it has the lowest probability of oxidative rancidity and it gained the longest shelf life of 9.2 - 11 months.

Sensory Evaluation:

Table 4 explains the effect of covering PP plastic bags containing on fish crackers using paper-sticker on their sensory attributes. At the beginning of storage time, the crispiness scores of fish crackers between 0%, 40% and 80% paper-sticker, did not differ significantly, since the fish crackers were fresh. After one and two months of storage time, the crispiness were significantly higher ($P<0.05$) for samples covered with paper-sticker 80% compared to those without paper-sticker. There were no significant difference for crispiness scores between fish crackers packaged in PP plastic bags and covered with 40% paper-sticker and without paper sticker. After three months of storage time, no significant difference for crispiness scores between fish crackers packaged in PP plastic bags and covered with 80% paper-sticker and PP plastic without paper-sticker. However, the scores of crispiness were significantly higher ($p<0.05$) for samples packaged in PP bags with 40% paper-sticker compared to PP bags without paper-sticker for the effect of the time, Overall, the crispiness scores for fish crackers among all the treatments decreased significantly ($P<0.05$) throughout the storage up to three months. On the other hand, for off-flavour attribute, initially, since the fish crackers were fresh, there was no significant difference for off-flavour scores among fish crackers packaged in PP bags with 0% paper-sticker, 40% paper-sticker and 80% paper-sticker. After one month of storage time, no significant difference for off-flavour scores were observed among the treatments, namely, 0%, 40% and 80% paper-sticker. After, two and three months of storage time, the off-flavour scores were significantly higher ($P<0.05$) for samples packaged in PP bags with 80% paper-sticker

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compared to samples packed in PP bags without paper-sticker paper-sticker. For the effect of the time, the scores of off-flavour for fish crackers that stored in PP bags covered with 40% paper-sticker and without paper-sticker were significantly lower ($P<0.05$) after one and two months of storage time. However, there was no significant effect of time storage on off-flavour scores after two and three months of storage time.

For overall acceptability, as previous attributes, crispiness and off-flavour, at the beginning, did not show any significant change, among all the treatments namely, 0% paper-sticker, 40% paper-sticker and 80% paper-sticker as shown in table 4. Similar results was observed after one month of storage time. No significant difference for overall acceptability scores among all the treatments. However, after two months of storage, the overall acceptability scores were significantly higher ($P<0.05$) for samples packaged in PP bags with 80% paper-sticker compared to samples packaged in PP bags without paper-sticker. No significant effect for overall acceptability scores between samples packaged in PP bags without paper-sticker and with 40% paper– sticker. In contrast, after three months of storage time, no significant difference for overall acceptability scores was exhibited among all treatments, possibility indicate that the effectiveness of paper-sticker reduced with time. For the effect of the time, samples packaged in PP bags without paper-sticker, exhibited significant decrease ($P<0.05$) for overall acceptability scores after one, two and three months of storage time. For samples packaged in PP bags with 40% and 80% paper-sticker, no significant difference for overall acceptability scores after one month of storage, but there was significant decrease($P<0.05$) in overall acceptability scores occurred after two and three months of storage.

The main off-flavour that affect sensory evaluation of fish is rancidity. In the case of off-flavour attribute, after three months of storage time, samples packaged in PP bags with 80% paper-sticker recorded significantly high score ($P<0.05$) 4.30 while, samples without paper-sticker gave the lowest score ($P<0.05$). The low acceptance for off-flavour of fish crackers packaged in PP plastic bags without paper-sticker during storage might be due to reaction of lipid oxidation in the presence of the oxygen (Manikantan et al. 2014), therefore, when the oxygen transmission were reduced by using paper-sticker, the scores of rancidity increased significantly ($P<0.05$). The results were in agreement with those reported by

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Namsai et al. 2008 on rice crackers, when they showed that, Laminated Multilayer metalized (MET) plastic bag with oxygen absorber had lower level of rancidity compared to traditional packaging using Oriented polypropylene (OPP). Similar results also reported by (Gunaratne et al.2015) on sweet and savory rice crackers were packed separately under four categories as with desiccant, with oxygen absorber, with both desiccant and oxygen absorber and without any of them. . Results revealed that sensory parameters gradually deteriorate with time. the highest rank of taste, odor, color, appearance, crispiness and overall acceptability was obtained by savory rice crackers packets containing both oxygen absorber and desiccant when compared to other packing methods.

Table 4 Change in sensory attributes of fish crackers packaged in PP bag covered and withdifferent percentage of paper sticker at different storage time.

Storage time	Attributes		Treatments	
		0% Sticker as control	40% Sticker	80% Sticker
0	Crispiness	5.80 ± 0.63^{ab}	6.20 ± 0.79^{a}	6.10 ± 0.74^{a}
1		4.50 ± 0.71^{de}	4.90 ± 0.74^{cd}	5.20 ± 1.03^{bc}
2		3.40 ± 0.52^{f}	3.90 ± 0.88^{ef}	4.20 ± 0.63^{e}
3		1.80 ± 0.63^{h}	2.60 ± 0.70^{g}	2.40 ± 0.84^{gh}
0	Off-Flavour	5.50 ± 0.97^{a}	5.50 ± 0.97^{a}	5.50 ± 0.97^{a}
1		3.80 ± 1.39^{b}	4.40 ± 1.17^{b}	4.40 ± 0.84^{b}
2		2.00 ± 0.94^{d}	2.70 ± 1.06^{cd}	3.60 ± 0.84^{bc}
3		2.70 ± 1.25^{cd}	3.50 ± 1.35^{bc}	4.30 ± 1.35^{b}
0	Overall Acceptability	5.90 ± 0.88^{a}	5.90 ± 0.88^{a}	5.90 ± 0.88^{a}
1		4.90 ± 1.45^{b}	5.20 ± 1.14^{ab}	5.20 ± 1.14^{ab}
2		3.20 ± 0.42^{de}	3.70 ± 0.48^{cd}	4.40 ± 0.53^{bc}
3		2.10 ± 0.57^{f}	2.80 ± 1.14^{ef}	2.70 ± 0.95^{ef}

* Different letters show significant difference at (P <0.05)

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Conclusion:

The polypropylene plastic bags recorded the highest (OTR) without paper-sticker. However, covering 80% of PP plastic bag with paper-sticker reduced more than 60% (OTR). The effect of covering the polypropylene bags with different percentage of paper sticker was observed on the physicochemical properties of fried fish after three months of storage period. The fried fish stored in polypropylene plastic covered by 80% paper-sticker, showed significantly lower for PV and TBA values compared to fried fish crackers stored in PP plastic bag without paper-sticker. The different storage period also has effect on the moisture content, PV, and TBA values of fried fish crackers increased significantly with time ($P<0.05$) in all treatments namely, 0%, 40% and 80% paper-sticker.

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