Photo-Oxidation Stability of Mayonnaise from Striped Catfish and Red Palm Mixture Oil

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Abstract. The purpose of this study was to determine the effects of light on the photo-oxidation stability of mayonnaise. The mayonnaise was made from a mixture of 20% striped catfish oil and 80% red palm oil. The treatments were condition storage, namely P1 (coated aluminium foil), P2 (uncoated aluminium foil), and P3 (exposed to a light intensity of 7500 lux) for two days and evaluated every 8 hours. Results showed that the light increased peroxide and TBA value, but decreased total carotene and tocopherol in the mayonnaise. The highest increase of peroxide and TBA value were shown in P3 with k values of 0.0067 meq O₂ kg⁻¹ h⁻¹ and 0.0061 mg MDA kg⁻¹ h⁻¹. The highest decrease of total carotene was shown in P3 with a k value of 0.0155 mg kg⁻¹ h⁻¹, but the highest decrease of total tocopherol was shown in P1 with a k value of 0.0161 mg kg⁻¹ h⁻¹. The light affected descriptively but not hedonically characteristics of colour, aroma, texture, and overall assessment of the mayonnaise. The best treatment was P1 with descriptive characteristics of yellowish-orange colour, red palm oil aroma, and very viscous. The hedonic characteristics of P1 were like by panelists on colour and texture but rather like on the aroma.

Keywords: mayonnaise, catfish oil, red palm oil, photo-oxidation

1. Introduction

Striped catfish (Pangasius hypophthalmus) is one of the fishery commodities that has a high economic value in Indonesia. Striped catfish meat has a nutritional content per 100 g consisting of 74.4 g water, 17.0 g protein, 6.6 g fat, 1.1 g carbohydrates, and 132 cal energy [1] as well as a distinctive, delicious, and savoury meat flavour. Striped catfish production in Riau Province increased by 2.3 tons, which is in 2014, the production was 1,602.9 tons to 1,605.2 tons in 2015 [2]. The production of striped catfish that has been done in the Kampar Regency not only covers the cultivation aspect but is also developed up to its processing. [3] states that the people in Kampar Regency generally process striped catfish by smoking.

Many processed products of striped catfish such as fillets, nuggets, smoked fish, and others produced by-products in the form of belly fat. Belly fat has not been maximum utilized and becomes a problem because it pollutes the environment. One of the efforts that can be made to solve the problem is by extracting oil from the belly fat of striped catfish and then processed into food products that have an economic value. [4] states that the entrails of striped catfish have the highest fat content ranging from 26.51-35.32%. Composition of unsaturated fatty acids of crude catfish oil was dominated by oleic,
linoleic, and linolenic acids, respectively at 40.14, 19.97, and 0.83%, while saturated fatty acids were dominated by palmitic, stearic, and myristate acids, respectively at 26.22, 5.06, and 2.85% [5]. The yield of striped catfish oil (SCO) is high, has many benefits for the body, and can be applied to food products such as mayonnaise.

Mayonnaise is a semi-dense food product with egg yolks as an emulsifier. Mayonnaise emulsion consists of two phases, namely the dispersed phase (oil) and dispersion phase (vinegar acid) as well as the absence of emulsifying agent (egg yolk). Mayonnaise can be used for bread, potatoes, or salad dressings. Mayonnaise can be made from various types of oils, one of which is SCO. [6] states that the content of fish oil is beneficial to maintain health and prevent some degenerative diseases, but the oil is susceptible to oxidation processes. Furthermore, fatty acids of fish oil may have been considered to treat other diseases, including obesity, type-2 diabetes, depression, non-alcoholic fatty liver disease, and inflammation [7]. Researches have shown that besides the reducing risk of cardiovascular disease, omega-3 fatty acids also improved heart rate, reduced the risk of heart attack, blood pressure, blood lipid levels, and hardening of the arteries [7].

The high content of polyunsaturated fatty acid (PUFA), especially of EPA and DHA, allows fish oil susceptible to oxidation reactions that can increase unwanted colours, smells, and flavours as well as a loss of nutritional value [8]. The application of fish oil into the food products consumed by smeared such as salad dressings and mayonnaise is certainly very susceptible to photo-oxidation damage. High oxidation levels cause fish oil needs to be added natural antioxidants, one of which is red palm oil (RPO) which is rich in antioxidants.

Red palm oil (RPO) is palm oil that is processed without the bleaching process so that the colour is still red because it has a high carotenoid content. The carotene content of RPO is as much as 500 mg/kg and is dominated by β-carotene. Also, RPO contains 900-1000 mg/kg of vitamin E, consisting of α-tocopherol, α-,γ- and δ-tocotrienol [9]. The results of previous research on the addition of RPO into SCO were able to improve the oxidation stability of the mixture oil especially at high light intensity (10000 and 15000 lux) during 14 days of storage. A mixture of 20% SCO and 80% RPO and a mixture of 50% SCO and 50% RPO showed a nearly identical rate of increase in the number of peroxides [10]. The addition of RPO into SCO allows for increased oxidation stability of the mixture oil as a functional food ingredient in the form of mayonnaise.

Oil damage can be caused by an oxidation reaction of unsaturated fatty acid by oxygen during processing and storage. But what has not been widely realized is the oxidation reactions induced by the absence of light or photo-oxidation. During photooxidation, UV energy is absorbed by oil or food systems containing oil, moved to a higher energy state, and produced singlet oxygen, which attacks unsaturated fatty acids to produce peroxy radicals and then hydroperoxides. The physical form of oil, temperature, and microcomponents in the oil (such as hydroperoxides, free fatty acids, and pigments) were influenced by the extent of oxidative deterioration [11]. The high light intensities can accelerate the rate of an oxidation reaction in oils cause decreased content of bioactive components and further oil damage [12].

The use of light intensity can trigger photo-oxidation reactions in oils, where the photo-oxidation mechanism involves an excitation sensitizer when capturing light energy and then released into its ground state activating oxygen O₂ into highly reactive O₂ singlet oxygen [13]. The use of light in this study was carried out with the consideration that mayonnaise products will be traded in packaging that gets light exposure, especially during storage and display at retailers. Seeing the advantages and potential of SCO and RPO as functional foods, it is necessary to conduct a study of the stability of the photo-oxidation mayonnaise from the mixture of SCO and RPO. In this study, mayonnaise was exposed to light to accelerate photo-oxidation reactions so that it could be calculated the rate of the mixture oil damage. This research aims to study the effects of light on the photo-oxidation stability of mayonnaise.
2. Materials and Methods

2.1 Materials
The raw materials for making mayonnaise were red palm oil (RPO), striped catfish oil (SCO), egg yolks, water, salt, sugar, and lemon. Red palm oil was obtained from the Sei Galuh palm oil factory at Perkebunan Nusantara V Incorp. and purified in Palm Oil Processing Laboratory, Kampar Polytechnic. Crude striped catfish oil was obtained from the striped catfish smoking industry in District XIII Koto Kampar, Kampar Regency, and purified in the Centre for Agro-based Industry, Bogor. Red palm oil has palmitic acid (35.8%), stearic (3.9%), oleic (40.3%), and linoleic (11.0%) with a ratio of saturated: unsaturated fatty acids 45:55. Red palm oil contains 556.93±0.24 ppm total carotene, 935.8475±22.5 ppm total tocopherol, and 4.36±0.03 ppm total chlorophyll. Striped catfish fish oil has the main composition of 26.22% palmitic, 5.06% stearate, 40.14% oleic, and 19.97% linoleic acid with a ratio of saturated fatty acids: unsaturated 35:65. Materials for analysis include acetic acid, chloroform, Na₂SO₃, KI, starch indicator, distilled water, 2-thiobarbituric acid (TBA reagent), butanol, hexane, toluene, bipyridine, FeCl₃·6H₂O, ethanol, methylene chloride, and aluminium foil.

The equipment used in this study was a controlled temperature light storage box, a UV-Vis spectrophotometer (UV mini-1240, Shimadzu), metrohm Rancimat (Model 743, Herisau, Switzerland Metrohm), a transparent 100 ml sealed serum bottle, parafilm, digital thermometer, lux meter, and other glassware.

2.2 Research Methodology

2.2.1 Mayonnaise-making process
The process of making mayonnaise refers to [14] with modification. Mayonnaise was made through several stages, namely weighing and measuring the volume of raw materials such as 56 ml RPO, 14 ml of SCO, 12 g egg yolk, 0.96 g salt, 0.96 g sugar, 9.84 ml water, and 5.6 ml lemon juice. Egg yolks are homogenized using mixers in containers, RPO and SCO were mixed little by little until thickened dough forms. Salt, sugar, water, a squeeze of lemons are inserted and homogenized using a mixer, and mayonnaise was silenced to form a perfect emulsion.

2.2.2 Mayonnaise photo-oxidation
Photo-oxidation was conducted by storing 30 ml of mayonnaise into a transparent bottle under different light exposure conditions. Different light exposure conditions include P1 (coated aluminium foil), P2 (uncoated aluminium foil), and P3 (exposed to a light intensity of 7500 lux in the light storage box) for two days and evaluated every 8 hours. The light intensity and temperature of the box are maintained in the range of 7500 lux and 30±2°C using lux meters and a digital thermometer.

2.2.3 Analysis
The analysis was carried out on the oils contained in mayonnaise and the mayonnaise. Analysis of oil in mayonnaise including peroxide number [15], TBA number [15], carotene total [16], and tocopherol total [17]. Analysis of mayonnaise included sensory evaluation descriptively and hedonically on colour, aroma, and overall assessment [18].

2.2.4 Sensory evaluation
Sensory evaluation descriptively and hedonically on colour, aroma, and overall assessment was conducted following [18]. The descriptive test was conducted by semi-trained panellists as many as 30 students from the Agricultural Technology Department, Faculty of Agriculture, Riau University. The hedonic test was conducted by 80 untrained panellists from the Faculty of Agriculture students of Riau University. Mayonnaise samples that have been stored under different light exposure conditions are presented as much as 5 g in the glass cup. Each sample was coded with three random numbers. An organoleptic test form is provided, in which are listed test figures to assess the description and hedonic colour, aroma texture, an overall assessment of the mayonnaise. The descriptive assessment of the mayonnaise colour from very yellow to very orange. The descriptive assessment of the mayonnaise aroma from very flavorful of SCO to very scented of RPO. The descriptive assessment of the texture of
mayonnaise from very dilute to very viscous, as well as the level of favourite mayonnaise from very dislike to very like according to the range of 1-5 numbers.

2.2.5 Photo-oxidation kinetics
The photo-oxidation stability of mayonnaise was studied by calculating the kinetics model using the following equations.

\[ \frac{dQ}{dt} = -kQ^n \]  

The Q value was the change in peroxide number, TBA, carotene total, and tocopherol total in mayonnaise at t time (mg.kg\(^{-1}\)), k was the constant reaction rate at certain light exposures, n was the reaction order, and t was the time (hour).

2.2.6 Analysis of photo-oxidation stability
Kinetics of mayonnaise photo-oxidation stability was displayed in the graphic using the MS. Exel 2010 application. Sensory evaluation data on colour, aroma, texture, and overall assessment of the mayonnaise were statistically analyzed using Analysis of Variance (ANOVA). If the F count is greater or equal to the F table, then proceed with duncan new multiple range test (DNMRT) at 5% level. Statistical analysis was performed using the SPSS version 21 application.

3. Results and Discussion

3.1 Mayonnaise Photo-Oxidation Stability

3.1.1 Peroxide Value
Peroxide value (PV) is the most widely used method for determining oil quality. The value of PV is important for identifying oil oxidation levels. Peroxide number is measuring the level of peroxide and hydroperoxide formed in the early stages of the oil oxidation [19]. The high rate of formation of PV indicates that oil is oxidation quickly and causes the oil to quickly break down. The increase in the PV of the oil in the mayonnaise followed the zero and first-order kinetic model can be seen in Figures 1 and 2.

**Figure 1.** Peroxide value changes in the mayonnaise with different light condition storage; P1 (coated aluminium foil), P2 (uncoated aluminium foil), and P3 (7500 lux light intensity) followed the zero-order kinetic model

**Figure 2.** Peroxide value changes in the mayonnaise with different light condition storage; P1 (coated aluminium foil), P2 (uncoated aluminium foil), and P3 (7500 lux light intensity) followed the first-order kinetic model.
The determination of the right model for the PV increasing pattern was determined by selecting the highest R² value of the two models used. Figure 1 indicated that all treatments (P1, P2 and P3) followed zero-order kinetics with k value of 0.0048, (R² 0.90), 0.0061, (R² 0.94), and 0.0067 meq O₂.kg⁻¹.h⁻¹ (R² 0.99), respectively. The increase in the number of mayonnaise PV in dark and light conditions was lower when compared to mayonnaise stored at a light intensity. This was because the higher the intensity of light given, the more peroxides are formed so that hydroperoxides are further breakdown, resulting in other derivative compounds that can accelerate the damage and degradation of the mayonnaise oil. This was in line with [20] stated that the greater the intensity of light given (15,000, 10,000, 5,000 lux) then the damage of palm oil fortified with RPO will occur more quickly. The amount of peroxide formed during photo-oxidation was comparable with the amount of light absorbed [21,22].

Mayonnaise exposure to the light intensity of 7500 lux (P3) indicated the highest rate of peroxide formation compared to other treatments (P1 and P2). The photo-oxidation mechanism involves the sensitizer being excited when capturing light energy, then the release of energy by an excited sensitizer to its ground state activates atmospheric oxygen (triplet oxygen, ¹⁰O₂) into highly reactive oxygen (singlet oxygen, ¹⁰O₂) [23,24]. Singlet oxygen reacts directly with double bonds in unsaturated fatty acids producing peroxides and capable of initiating free radical auto-oxidation reactions to produce peroxides [13].

3.1.2 Thio barbituric acid value
Thiobarbituric acid (TBA) number is a testing method for determining the level of oil damage that is indicated by the amount of malonaldehyde as a result of secondary oxidation reactions. The oil damage is characterized by the absence of a rancid aroma. The increase in the TBA number of the mayonnaise oils followed by the zero and first-order kinetics model can be seen in Figures 3 and 4.

The precise determination model for the TBA number increase pattern is determined by selecting the highest R² value from both models used. Figure 3 shows that on the coated aluminium foil, uncoated aluminium foil, and light intensity treatments following a zero-order kinetic model with k values of 0.0048 mg malonaldehyde.kg⁻¹.h⁻¹ (R² 0.91), 0.0059 mg malonaldehyde.kg⁻¹.h⁻¹ (R² 0.99), and 0.0061 mg malonaldehyde.kg⁻¹.h⁻¹ (R² 0.99), respectively. The rate of increase in the TBA number in the mayonnaise oil which coated aluminium foil is lower compared to the uncoated aluminium foil, and the light intensity treatment indicated that the formation of malonaldehyde occurs faster in light conditions.
when compared to dark conditions. The light is one of the factors that affect the oxidation rate of fats and oils. [23] explains that oxidation of edible oils is influenced by an energy input such as light or heat, the composition of fatty acids, types of oxygen, and minor compounds such as metals, pigments, phospholipids, free fatty acids, mono- and diacylglycerols, thermally oxidized compounds, and antioxidants. Light accelerates lipid oxidation, especially in the presence of photosensitizers such as chlorophylls [24].

The higher the rate of increase in TBA numbers indicated that further oxidation levels in the oil are increasingly occurring with the increasing number of malonaldehyde components formed as a result of hydroperoxide degradation. According to [23], the oxidation process is a very complex reaction that usually begins with the formation of free radicals in oil molecules. In the absence of one or more initiators, oil that has polyunsaturated fatty acids (PUFA) will lose radical hydrogen, thus forming a free alkyl radical. The lipid alkyl radical reacts with $^3$O$_2$ and forms lipid peroxy radicals, another reactive radical. The lipid peroxy radical abstracts hydrogen from other lipid molecules and reacts with the hydrogen to form hydroperoxide and another lipid alkyl radical. Hydroperoxide is then degraded into smaller molecules of saturated and unsaturated ketone groups or aldehydes and short-chain carboxylic acid that contribute significantly to fish oil and oxidation [25]. The faster the oxidation reaction, the formation of hydroperoxide degradation molecules in the form of ketone, aldehydes, and short-chain carboxylic acid are increasing.

3.1.3 Total carotene

Carotene is a natural pigment in palm oil that is yellow to red. Some studies state that carotene exhibits antioxidant activity during photo-oxidation, but some other studies state that carotene has no antioxidant activity, especially in auto-oxidation (dark) conditions and pro-oxidant at high concentrations and temperatures [26]. The decrease in the total of carotene in the mayonnaise oil followed the zero and first-order kinetics model can be seen in Figures 5 and 6.

![Figure 5](image1.png)

**Figure 5.** Total carotene changes in the mayonnaise with different light condition storage; P1 (coated aluminium foil), P2 (uncoated aluminium foil), and P3 (7500 lux light intensity) followed the zero-order kinetic model.

![Figure 6](image2.png)

**Figure 6.** Total carotene changes in the mayonnaise with different light condition storage; P1 (coated aluminium foil), P2 (uncoated aluminium foil), and P3 (7500 lux light intensity) followed the first-order kinetic model.

The precise determination model for the total carotene pattern is determined by selecting the highest R$^2$ value of the two models used. Figure 5. indicated that on the coated aluminium foil, uncoated aluminium foil, and light intensity treatments followed the first-order kinetic model with k values of 0.0046 mg.kg$^{-1}$.h$^{-1}$ (R$^2$ 0.94), 0.0045 mg.kg$^{-1}$.h$^{-1}$ (R$^2$ 0.98), and 0.015 mg.kg$^{-1}$.h$^{-1}$ (R$^2$ 0.99), respectively.
The rate of decrease in the total carotene content in the coated and uncoated aluminium foil treatments experienced a decrease that was not as sharp as in the light intensity treatment. This statement indicated that the carotene in RPO is relatively more stable during storage in dark conditions. However, in the uncoated aluminium foil treatment, there was a decrease in the total carotene content, which had a lower value (0.0045 mg.kg⁻¹.h⁻¹) compared to coated aluminium foil treatment.

The decrease in total carotene in the coated aluminium foil treatment was lower than coated aluminium foil, and this was due to the change of isomer β-carotene which has a higher molar extension so that the measured absorbance was high. This was in line with [27,28], trans-β-carotene changes to 9-cis-, 13-cis-, 15-cis-, and 13,15-di-cis-β-carotene occur during light exposure. Isomer 13,15-di-cis-β-carotene was the main isomers formed by exposure to light that has a higher coefficient of molar extensions than trans-β-carotene. A high coefficient of molar extensions led to increased absorbance at a measurable 446 nm wavelength in the sample. Also, tocopherol in RPO can act as an antioxidant that protects β-carotene by slowing down the process of trans-β-carotene isomerization [29,30].

3.1.4 Total tocopherol

Tocopherol is one of the most common natural phenol antioxidants found in vegetable oils. Tocopherol is known as vitamin E and has many double bonds that are easily oxidized, so it will protect the oil from oxidation [30]. During photo-oxidation, tocopherol acts as an antioxidant, so it decreases. The decrease in the total tocopherol content followed by the kinetics model of the zero and first-order can be seen in Figures 7 and 8.

The determination of the right model for the total decrease pattern of the tocopherol was determined by selecting the highest R² value of the two models used. Figure 7 indicated that on the coated aluminium foil, uncoated aluminium foil, and light intensity of 7500 lux treatments following a first-order kinetic model with k values of 0.0161 mg.kg⁻¹.h⁻¹ (R² 0.98), 0.0149 mg.kg⁻¹.h⁻¹ (R² 0.95) and 0.0089 mg.kg⁻¹.h⁻¹ (R² 0.96), respectively. Figure 8 showed that P1 and P2 treatment experienced a very sharp decrease in the total tocopherol content. This statement is due to both treatments being stored in a dark condition (coated aluminium foil) and uncoated aluminium foil (low-intensity light). [31] state that the tocopherol compound is an effective antioxidant in both photo-oxidation and auto-oxidation (dark) conditions.

![Figure 7](image1.png)  
**Figure 7.** Total tocopherol changes in the mayonnaise with different light condition storage; P1 (coated aluminium foil), P2 (uncoated aluminium foil), and P3 (7500 lux light intensity) followed the zero-order kinetic model.

![Figure 8](image2.png)  
**Figure 8.** Total tocopherol changes in the mayonnaise with different light condition storage; P1 (coated aluminium foil), P2 (uncoated aluminium foil), and P3 (7500 lux light intensity) followed the first-order kinetic model.
Exposure to high light intensity provides energy to produce more singlet oxygen and initiates a series of auto-oxidation reactions. This triggers the tocopherol to act as an antioxidant. In this study, tocopherol showed faster degradation in mayonnaise oil containing β-carotene in dark conditions. According to [23,24] tocopherol has a higher ability to react with free radicals than carotene due to the lower potential value of tocopherol reduction (500 mV) than carotene (700 mV to 1000 mV).

Figure 8. showed that the total tocopherol in P3 treatment experienced a decrease that was not as sharp as in the P1 and P2 treatments. This statement was due to the P3 treatment stored at a high light intensity, when the light exposure the oil, the tocopherol was protected by carotene that serves as an antioxidant. In acted as an antioxidation, the tocopherol sacrificed itself so that it will be quickly oxidized [30]. This was in line with the decrease of carotene content experiencing in high light intensity treatment. [26] stated that carotene exhibits antioxidant activity during photo-oxidation, but some other studies state that carotene has no antioxidant activity, especially in auto-oxidation (dark) conditions and pro-oxidants at high concentrations and temperatures.

3.1.5 Descriptively and hedonically sensory evaluation

Descriptive sensory assessment of mayonnaise results showed that the treatment of light during storage had a significant effect on descriptive tests. The panellist average descriptive score on colour, aroma, texture, and overall assessment of mayonnaise after further testing with a DNMRT test at 5% can be seen in Table 1. The assessment of the colour of mayonnaise descriptively ranged from 3.00-4.13 (yellowish-orange to orange). The highest mayonnaise colour rating score obtained in the P1 treatment was 4.13 (orange). The lowest mayonnaise colour rating score obtained in P3 treatment was 3.00 (yellowish orange). P3 treatment showed the lowest value compared to others which stated that mayonnaise exposed to the light intensity of 7500 lux faster-damaged carotene levels due to oxidation which caused discoulouration into yellowish-orange.

The discolouration of mayonnaise that was originally orange to yellowish-orange related to carotene decreased in P3 treatment (7500 lux light intensity) due to an increase in light intensity. The average colour descriptively and hedonically sensory of mayonnaise were shown in Table 1.

| Treatments | Sensory attribute | Descriptive | Hedonic |
|------------|------------------|-------------|---------|
| P1 (coated aluminium foil) | Color | 4.13*** | 3.82**** |
| P2 (uncoated aluminium foil) | 3.40** | 3.75**** |
| P3 (7500 lux) | 3.00** | 3.71**** |
| P1 (coated aluminium foil) | Aroma | 3.66*** | 3.00**** |
| P2 (uncoated aluminium foil) | 2.86b** | 2.93**** |
| P3 (7500 lux) | 2.43*** | 2.88**** |
| P1 (coated foil) | Texture | 4.53c*** | 3.50**** |
| P2 (uncoated aluminium foil) | 4.13b*** | 3.47**** |
| P3 (7500 lux) | 3.70c*** | 3.45***** |
| P1 (coated foil) | Overall | - | 3.51***** |
| P2 (uncoated aluminium foil) | - | 3.46***** |
| P3 (7500 lux) | - | 3.43***** |

Note: Figures followed by lowercase letters in the same column show insignificant differences according to the DNMRT test at the 5% level.

*Descriptive scores of colour: 1. Very yellow; 2. Yellow; 3. Yellowish orange; 4. Orange; 5. Very orange.
**Descriptive scores of aroma: 1. Very flavorful of SPO; 2. Scented of SCO; 3. Slightly scented of RPO; 4. Scented of RPO; 5. Very scented of RPO.
***Descriptive scores of texture: 1. Very dilute; 2. Dilute; 3. Somewhat viscous; 4. Viscous; 5. Very viscous.
****Hedonic scores of colour, aroma, and texture: 1. Very dislike; 2. Dislike; 3. Rather like; 4. Like; 5. Very like.
*****Hedonic scores of overall: 1. Very dislike; 2. Dislike; 3. Rather like it; 4. Like; 5. Very like.

The descriptive assessment of the aroma of mayonnaise ranged from 2.43-3.66 (scented of SCO to scented of RPO). Table 1 showed that the higher the light intensity given the smell of mayonnaise more rancid. The resulting aroma was related to the TBA number where decomposition peroxide components
that can be formed into aldehyde derivative compounds, such as malonaldehydes that indicate that the oil was experiencing further oxidation. This statement was seen in the lowest aroma score of P3 treatment (2.43) which stated that mayonnaise was exposed to the light intensity of 7500 lux scented with SCO (rancid smell). This result was in line with the results of [20] which stated that the stability of photo-oxidation of palm oil fortified with RPO indicated that the higher the intensity of light given (5,000. 10,000. 15,000 lux) the faster the rate of peroxide formation, resulting in an unwanted aroma.

Assessment of the texture of mayonnaise descriptively ranged from 3.70-4.53 (viscous to very viscous). The highest mayonnaise texture score obtained in P1 treatment was 4.53 (very viscous). The lowest mayonnaise texture score obtained in P3 treatment was 3.70 (viscous). Textures can be influenced by the intensity of light used. The higher the intensity of the light used will affect the texture of the mayonnaise, this statement was seen in the lowest texture score in P3 treatment of 3.70 which stated that mayonnaise exposed to a light intensity of 7500 lux was viscous. Changed in the texture of mayonnaise that was initially very viscous became viscous (increasingly dilute) due to the direct contact of light on the mayonnaise.

Sensory assessment results showed that the treatment of light during storage had no significant effect on the hedonic tests of the mayonnaise. The average hedonic panellist assessment of mayonnaise colour attributes ranged from 3.71 to 3.82 (like). Panellist assessment of the colour of mayonnaise was like because the resulting mayonnaise colour was different from the creamy and golden yellow commercial mayonnaise colour.

The average hedonic panellist assessment of mayonnaise aroma ranged from 2.88 to 3.00 (somewhat like). This was because the panellists used are untrained; it was difficult to distinguish the aroma of the mayonnaise. The aroma assessment was a subjective assessment that required sensitivity in feeling and smell. [32] stated that the aroma of food determines the delicacy of the food and that it can recognize how good food is.

The average hedonic panellist assessment of the mayonnaise texture ranged from 3.45 to 3.50 (rather like to like). Panellist assessment of the texture of 7500 lux light-exposed mayonnaise was rather like by panellists compared to mayonnaise that was not exposed to light (like). However, the texture of mayonnaise in this study was still different when compared to the texture of commercial mayonnaise. Commercial mayonnaise branded Maestro had a soft texture that was not too dilute and not too viscous, while the texture of mayonnaise in this study was viscous to very viscous. If the mayonnaise applied to food products, commercial mayonnaise was easier and softer compared to mayonnaise resulting in this study.

Table 1 showed that the overall hedonic rating score on the mayonnaise ranged from 3.43 to 3.51. meaning rather like to like. Hedonic testing was subjective because its assessment depends on a person's level of preference. Hedonic tests were performed to determine the best treatment among all the treatments. Based on Table 1, mayonnaise that was likely to be favoured by panellists was the P1 treatment with a score of 3.51. The mayonnaise from the P1 treatment had descriptive characteristics of yellowish-orange colour, RPO aroma, and very viscous. The hedonic characteristics of P1 were like by panellists on colour and texture but rather like on the aroma.

4. Conclusion
The results showed that light exposure increased peroxide and TBA value, but lowered the total carotene and tocopherol in the mayonnaise during storage. The highest increase in peroxide and TBA numbers was shown by exposed to a light intensity of 7500 lux treatment with k values of 0.0067 meq O₂.kg⁻¹.h⁻¹ and 0.0061 mg MDA.kg⁻¹.h⁻¹. The highest decrease in total carotene was shown by exposed to a light intensity of 7500 lux treatment with a k value of 0.0155 mg.kg⁻¹.h⁻¹, while the highest total tocopherol decrease was shown by coated aluminium foil treatment with a k value of 0.0161 mg.kg⁻¹.h⁻¹. Light also affected the descriptively characteristic but not hedonically of colour, aroma, texture and overall sensory assessment of the mayonnaise.

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