Pattern of coconut oil quality during storage

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Abstract. Coconut oil can be deteriorated by oxidation during storage and formed a rancid odor. The objective of the research is to evaluate coconut oil quality during storage by the addition of tocopherol as an antioxidant. The 11-12 months of coconut fruits harvested from Mapanget Tall coconut are used as raw materials. The oil is extracted by the wet method, and it was then formulated by the addition of tocopherol as an antioxidant on various concentrations (0; 0.5; 1.0 and 1.5 % w/v). The oil samples were then stored at room temperature for 2 months and evaluated for their quality for 0, 2, 4, 6, and 8 weeks. The oils are measured for moisture, free fatty acids, peroxide value, and TBA value. The results of the research showed that the moisture of coconut oil is stable during storage with or without antioxidants. The addition of antioxidants affected the free fatty acid of coconut oil, whereas the oil without antioxidants having free fatty acid compared to others treated with antioxidants.

1. Introduction

Coconut oil is the oil extracted from the mature nut of coconut fruits. Extraction of oil can be done by various methods, either through the wet or dry process. The dry process is the most widely used form of extraction. The oil is pressed from the copra and then must be refined, bleached, and deodorized. The other process is wet processing which entails the extraction of the cream from fresh nature nuts. This process is more desirable due to the free usage of chemical solvents. Thus, it is more environmentally friendly than solvent extraction. The wet method is much simpler, which can be applied at the farmer or farmers’ group level.

Coconut oil is categorized as a functional food and the healthiest oil [1–3]. Coconut oil has specific characteristics compared to other vegetable oils because it contained a high proportion of medium saturated fatty acids. Lauric acid, the dominant fatty acid in VCO, is proven to provide excellent health benefits [4]. Numerous studies proved that VCO has properties as anti-virus, anti-bacterial, and anti-protozoa [3]. Nevin and Rajamohan (2006) reported that coconut oil has the ability as a superior antioxidant through in vitro and in vivo testing using Sprague Dawley [5]. Lauric acid is proven in vitro and in vivo can be used as a natural antibiotic on skin infected with Propionibacterium acnes, Staphylococcus aureus, and Staphylococcus epidermidis [6].

Diets containing coconut oil and Medium Chain Fatty Acids (ALRM) have been shown to have significant changes in patients with Alzheimer’s [7]. Subjects who consumed a diet containing coconut oil as much as 35 g/day and after 37 days of treatment showed a significant effect on memory. Other research conducted by Hu Yang et al. (2015), by giving 40 ml of coconut oil per day can improve the cognitive abilities of sufferers of Alzheimer’s [8].
The medium-chain fatty acids content in coconut oil ranged from 60 to 63%, whereas lauric acid is the main fatty acid with a percentage ranging from 46 to 48% [2]. The content of unsaturated fatty acids present in coconut cooking oil allows oil damage due to oxidation. Unsaturated fatty acids content in coconut oil extracted by the wet process is only about 7.09% [8]. Commercial VCOs sold in Malaysia have almost the same unsaturated fatty acid content of 6.70-8.25% [2].

Oils with high saturated fatty acid content are relatively more stable to the oxidation process than unsaturated fatty acids. Oxidation is a process of fat deterioration and results in the formation of off-flavor compounds, and this condition is called rancid. Rancid processed food products can change color and lose nutritional value due to the oxidation of vitamins and unsaturated fatty acids that have an impact on product quality degradation. Oxidized compounds such as peroxide, aldehydes, and ketones are harmful to human health [9]. Oils or fats containing mono Unsaturated Fatty Acids (MUFA) or double (Poly Unsaturated Fatty Acids, PUFA) can be oxidation targets. The result is primary, secondary, and tertiary oxidation products which can cause a decrease in product quality. Factors that influence the speed of oxidation include oxygen amount and type, the chemical structure of lipids (degree of unsaturation), antioxidants, prooxidants (ferrous metals, sensitizers such as chlorophyll, riboflavin, erythrosine, and light), lipoxygenase enzymes, storage temperature, and packaging properties.

Measurement of peroxide value is a very useful way to monitor the initial phase of oxidation or the measurement of primary oxidation products. Organoleptic changes are more closely related to secondary oxidation products, which can be measured among others by the thiobarbituric acid (TBA) test, which is a very popular test for measuring oil rancidity. The addition of antioxidants can inhibit the deterioration of oils due to the oxidation process [10]. The tocopherols can inhibit lipid oxidation in foods, and some homologues can also do in the biological system [11]. The objective of the research is to evaluate coconut oil quality during storage by the addition of tocopherol as an antioxidant.

2. Materials and methods
The research was conducted at Indonesian Palm Crops Research Institute (IPCRI), Manado, North Sulawesi, Indonesia. VCO was extracted from the fruit of Mapanget Tall Coconut variety (11-12 months) which was obtained from Kima Atas experimental garden Manado. All solvents were of analytical grade and were purchased from Merck, Germany.

2.1. Preparation of coconut oil
The oil from coconut fruits was extracted by a wet process using the heating technique. It was a modification of the processing of coconut oil with a gradual heating method. The processing of oil is as follows: the fresh mature nuts are dehusked, cut, and deshelled. The meat is then shredded using grated machines. Tap water is added into the grated meat in the ratio of 1:1 (w/v), then squeezed using an expeller to get milk. Coconut milk is poured in a transparent plastic container fitted with taps on the bottom. Coconut milk is then allowed to stand for ±1-2 hours, so it would form a layer on the bottom (skim) and cream on top. Skim and cream are separated by opening the tap on the bottom of the container to remove the skim. The cream is then put in a transparent plastic container and allowed to stand for 12-14 hours, so it will form two layers, namely the oil-rich layer on the top and the non-oil layer on the bottom. The further oil-rich layer was poured into a frying pan. The heating is done until it becomes a light brown coconut press cake. The resulting oil is separated from the press cake, cooled, and then filtered using sterile cotton.

2.2. Addition of antioxidant
The resulting oil was filtered and then added with antioxidants tocopherol in various concentrations, namely 0; 0.5; 1.0, and 1.5% (w/v). The oils were filled in a plastic bottle and wrapped in aluminum foil during the storage period for 2 months which was placed at room temperature.
2.3. Determination of oils quality
The quality of oils was determined during 0, 2, 4, 6, and 8 weeks of storage duration. The moisture, free fatty acid, peroxide value, and thiobarbituric acid/TBA of the oils were analyzed by AOCS method.

3. Results and discussion

3.1. Moisture
The results showed that the water content of coconut oil with variations in the addition of antioxidant Vitamin A as a whole had almost the same value during storage. At 8 weeks of storage, the moisture content was 0.08-0.09% compared to before storage 0.04-0.08%. In coconut oil which was added with antioxidant Vitamin E, the value of the water content was almost the same, except for the treatment without the addition of Vitamin E at 8 weeks storage by 0.15% (figure 1). Stable water content because during storage, coconut oil is packaged using a plastic bottle as secondary packaging and wrapped in aluminum foil. This storage condition does not allow the absorption of water from the environment.

The highest water content (0.15%) up to 8 weeks of storage is still at a value in accordance with the quality standards of Virgin Coconut Oil (VCO) set by the Asian Pacific Coconut Community, which is 0.1-0.5%. The results obtained in this study are slightly lower than the VCO water content in the Yogyakarta commercial market, reaching 0.185% [13]. Tenda et al. [14] reported, the VCO produced by the heating method had a moisture content of 0.14-0.22%, while fermentation 0.12-0.25%. The results obtained prove that the processing carried out is capable of producing good quality coconut oil, which is characterized by the initial moisture content of only 0.04-0.08%. This is also supported by controlled storage conditions, especially the storage container so that it does not result in changes in the water content of coconut oil.

![Figure 1. The moisture content of coconut oil for up to 8 weeks of storage.](image)

Noted: A without tocopherol, B addition 0.5% (w/v) of tocopherol, C addition 1.0% (w/v) of tocopherol, D addition 1.5% (w/v) of tocopherol

3.2. Free fatty acid
The data in Figure 2 showed that up to 4 weeks of storage, the highest free fatty acid levels were 0.05%, almost the same as the initial free fatty acid levels. At 6 and 8 weeks of storage, free fatty acid levels slightly increased from 0.06 to 0.8%. The low increase in fatty acid levels due to coconut oil used has
low water content, and the bottle is wrapped in aluminum foil. Free fatty acids will form due to oxidation and hydrolysis reactions. Oxidation reactions can take place through auto-oxidation and photooxidation. Photooxidation takes place faster than auto-oxidation. In this study, the possibility of a hydrolysis reaction is very small due to the low water content. Photooxidation reactions can be inhibited because the plastic bottle packaging is wrapped in aluminum foil.

Oil-free fatty acid levels at the start of storage were 0.02-0.04%, which were thought to be formed during processing. Coconut oil processing is done by heating. So the resulting fatty acids are formed due to hydrolysis and oxidation reactions which cannot be avoided during processing.

Figure 2. Free fatty acid of coconut oil for up to 8 weeks of storage.

Noted: A without tocopherol, B addition 0.5% (w/v) of tocopherol, C addition 1.0% (w/v) of tocopherol, D addition 1.5% (w/v) of tocopherol

Based on the data in figure 2 shows that the addition of tocopherol until 8 weeks storage appears to have lower free fatty acid values than without tocopherol. The value of coconut oil-free fatty acids before storage is 0.02-0.05%, lower than reported by Karouw and Indrawanto [15], which is 0.13%. In this study, the processing time from coconut milk to oil production was less than 5 hours, while Karouw and Indrawanto (2015) took more than 18 hours to process. The longer the processing, the higher the value of free fatty acids.

Free fatty acid levels of coconut oil produced in different ways, namely white copra oil 0.43-0.45% [16], fermented coconut oil 0.19-0.24%, coconut oil centrifugation 0.11% [9] and coconut oil heating 0.15% [12]. White copra oil has higher free fatty acid levels because the processing time to produce coconut oil is longer than other processing methods. The longer the processing, the more triglycerides will be hydrolyzed into diglycerides and monoglycerides and free fatty acids. Appaiah et al. (2014) reported that in white copra oil, the proportion of triglycerides (TG) was 90.0%, diglyceride (DG) 8.4%, and monoglyceride (DG) 1.7% [1]. Oil extracted from fresh coconut in the proportion of TG, DG, and MG were 97.7%, 1.6%, and 0.6%, respectively.

3.3. Peroxide value and TBA
The results showed that the peroxide number of coconut oil with and without the addition of antioxidants tended to increase during storage (figure 3). Coconut oil which is added with antioxidant tocopherol has a lower peroxide number than without the addition of antioxidants. The results obtained indicate that the oil added by tocopherol has lower peroxide and TBA numbers than without the addition of
antioxidants (figure 4). The results prove that the oxidation process can be inhibited using antioxidants to delay the decomposition of the oxidation product to undesirable levels. This result is supported by the flavor of coconut oil, which is the oil without the addition of antioxidants, which has a slightly rancid aroma, compared with Vitamin E, the distinctive aroma of coconut for up to 8 weeks of storage. The TBA number is one way of measuring secondary oxidation products. The secondary oxidation product is the result of hydroperoxide decomposition. Therefore the TBA number is closely related to the peroxide number.

![Graph showing peroxide value of coconut oil for up to 8 weeks of storage.](image)

**Figure 3.** Peroxide value of coconut oil for up to 8 weeks of storage.

Noted: A without tocopherol, B addition 0.5% (w/v) of tocopherol, C addition 1.0% (w/v) of tocopherol, D addition 1.5% (w/v) of tocopherol.

As shown in figure 3 and figure 4, the peroxide value (PV) and TBA tend to fluctuate over the time of storage. The decrease in the PV is due to the decomposition of hydroperoxide into secondary oxidation products during storage. The PV decreases with the increase of the storage period. During storage, there is the oxidation of hydroperoxide, which is very unstable at high temperatures. Hydroperoxides will be oxidized to secondary oxidation products [13]. If the rate of hydroperoxide formation is lower than the rate of decomposition of hydroperoxide in oil, it will result in a lower number of peroxide [2,14]. The antioxidant acts to inhibit the oxidation reaction of oils.
Figure 4. Thiobarbituric content of coconut oil for up to 8 weeks of storage.

Noted: A without tocopherol, B addition 0.5% (w/v) of tocopherol, C addition 1.0% (w/v) of tocopherol, D addition 1.5% (w/v) of tocopherol.

4. Conclusions
The water content of coconut oil with and without the addition of tocopherol tends to be stable during storage. The levels of free fatty acids with the addition of antioxidants are lower than those without the addition of tocopherol. During 8 weeks of storage, the oil added with tocopherol has a lower peroxide and TBA number than without tocopherol.

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