TABLE I
LIPID QUALITY ANALYSIS RESULT OF VCO WITH PRE-TREATMENT PROCESS

| Sample | Free Fatty Acid (mg KOH/g sample) | Iodine Value (g iodine/g sample) | Peroxide Value (meq peroxide/ kg sample) | TBARS Value(mg MDA/g sample) |
|---|---|---|---|---|
| T1: Control | 0.0320±0.0009[a] | 5.877±0.079[a] | 0.0106±0.0083[a] | 5.62±0.12[a] |
| T2: 95ºC, 5 min | 0.0306±0.0021[ab] | 6.003±0.082[ab] | 0.0259±0.0086[a] | 5.76±1.27[a] |
| T3: 95ºC, 5 min + citric acid | 0.0206±0.0012[c] | 6.340±0.094[bc] | 0.0159±0.0041[a] | 5.40±0.59[a] |
| T4: 80ºC, 10 min | 0.0300±0.0025[ab] | 6.411±0.094[c] | 0.0197±0.0054[a] | 3.35±0.66[b] |
| T5: 80ºC, 10 min + citric acid | 0.0241±0.0023[bc] | 6.612±0.085[c] | 0.0239±0.0113[a] | 2.76±0.23[b] |

Blanching with citric acid showed the different FFA values between the VCO samples. FFA value was decreased with the pre-treatment of blanching and the addition of citric acid during blanching. Moreover, a lower FFA value was obtained in the blanching at 80ºC for 10 minutes. The results indicate that blanching inhibits lipid hydrolysis during storage. Based on [15], the FFA of the VCO with blanching is lower than the control due to the inactivation of lipase that can hydrolyze oil during processing. Moreover, according to [27], the FFA of super-heated steam-treated buckwheat grain was lower than untreated after storage due to the inactivation of lipase enzyme, causing the low release of free fatty acid. In addition, citric acid has chelating ability properties, acting as a metal complexing agent and preventing metal from oxidizing lipids [13]. Moreover, the low pH of citric acid reduces the reaction rate of radical compound production [14]. This result did not align with the FFA result, which showed decreased antioxidants due to blanching. The reduction might be the reason for partially washing out the initial FFA in the coconut flesh during blanching [16]. Blanching with citric acid decreases the formation of free fatty acid in VCO.

*2) Iodine value:* The determination of iodine value was conducted to measure the susceptibility of VCO toward lipid oxidation. Table 1 shows the result of iodine value measurement on the VCO with different blanching methods. After the blanching process, the iodine value increased at a lower temperature and with the addition of citric acid during blanching. The iodine value of all samples showed a low value compared to the Asian and Pacific Coconut Community, which is around 4-11 g $I_2$/100 g fats due to the saturation degree of VCO. The precision might cause a slightly different value from samples during titration [1]. A low iodine value indicates that VCO is resistant to rancidity due to better oxidative stability. Moreover, IV correlates with overall quality properties such as sensory properties and shelf life [28].

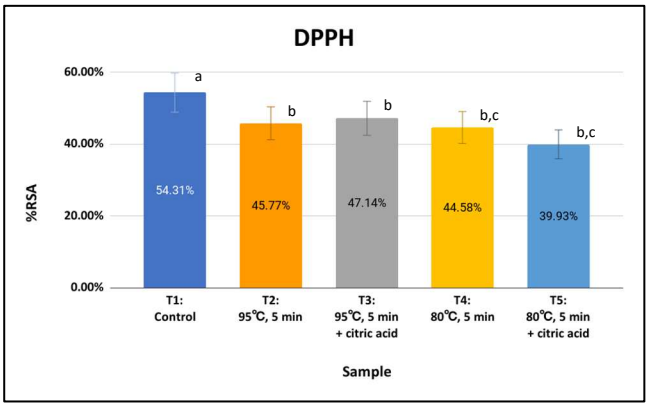
*3) Peroxide value:* Peroxide value measurement was done to assess peroxide production due to oxidation. The result of the peroxide value of different VCO samples is shown in Table 1. The peroxide value of the VCO with blanching was similar to that of the control without blanching. The results indicate no oxidation by the peroxidase enzyme during the process because VCO contains no protein. According to [16], blanching of coconut kernel results in low peroxide value and reduction in the activities of peroxidase enzyme as well as lipoxygenase enzyme, proofing that the inactivation of peroxidase and lipoxygenase enzyme causes the decrease of peroxide value. Blanching creates lower peroxide value because blanching prevents oxidation by lipoxygenase and peroxidase that produce peroxide [15]. The result was contrary to the previous study due to different extraction processes. VCO extraction using the chilling thawing method was done at low temperatures without a drying process, resulting in no susceptibility towards oxidation by peroxidase.

*4) TBARS:* TBARS measurement was done to determine lipid oxidation by calculating (malondialdehyde) MDA concentration in the sample. The result of the TBARS value is presented in Table 1. Blanching resulted in different TBARS values between the VCO sample, especially blanching with the low temperature at 80ºC for 10 minutes (T4 and T5). This result was linear with the antioxidant activities result, and the antioxidant activities were decreased because of the prevention of the oxidation process, resulting in a low MDA value. According to [29], blanching at 80ºC for 20 min inhibits peroxidase formation compared to unblanched cane stalk during sugarcane juice production. Furthermore, the similar peroxide value might indicate that the primary oxidation was started, but antioxidant compounds can prevent the secondary oxidation. Therefore, the MDA value can be reduced in the sample with lower antioxidant activities.

### *B. Antioxidant Activities and Phenolic Content*

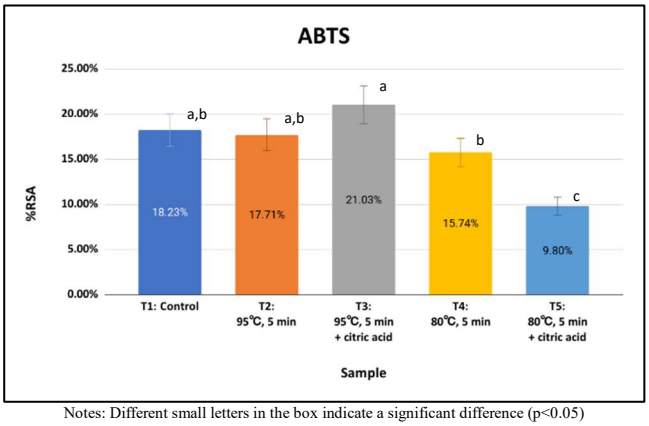
*1) Antioxidant activities:* Antioxidant activities were carried out using DPPH and ABTS methods, with the results shown in Fig 1 and Fig 2. DPPH radical scavenging activities showed that the blanching method reduced the antioxidant activities compared to the sample without blanching (T1). The highest decrease was the blanching with citric acid at 80ºC for 10 minutes (T5), while other blanching methods resulted in a similar result. The antioxidant activities were decreased in the T2 sample, followed by T3, T4, and T5. The result of antioxidant activities by the ABTS method obtained similar results in VCO with pre-treatment except for T5. The antioxidant activity was identical between T1, T2, T3, and T4 but decreased in T5. The blanching process with citric acid 0.05% at 80ºC for 10 minutes created lower antioxidant activities in the VCO sample than without pre-treatment. The result between DPPH and ABTS was linear. However, the slight difference in the percentage of RSA might be due to the sensitivity of each measurement. According to [30], heating at a high temperature decreases the antioxidant activities of some products due to protection from antioxidant compounds against thermal oxidative degradation. Based on the previous study [31], phenolic compounds and medium-chain fatty acids promote antioxidant activities in virgin coconut oil as bioactive compounds, scavenging free radicals, chelating metal ions, and preventing lipid oxidation. The different types

of bioactive compounds in the VCO create interesting results between antioxidant activities and total phenolic content results, which show a contrary result.




Notes: Different small letters in the box indicate a significant difference ($p<0.05$)

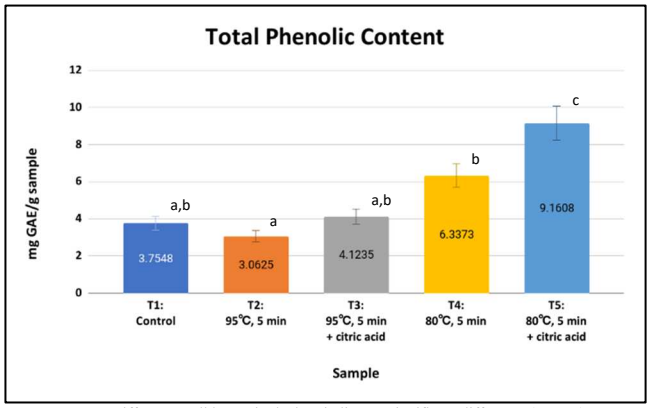
Fig. 1 DPPH of virgin coconut oil with different pre-treatment processes




Notes: Different small letters in the box indicate a significant difference ($p<0.05$)

Fig. 2 ABTS of virgin coconut oil with different pre-treatment processes

*Total Phenolic Content:* Total phenolic content was measured in this work to determine the level of bioactive compounds after pre-treatment. The result of the total phenolic content on the VCO can be seen in Fig 3. Sample with pre-treatment blanching increased the phenol content in the VCO, followed by T3. T4, and T5. The phenolic content of the VCO with the blanching added by citric acid at 80ºC for 10 minutes (T5) obtained the highest value. However, blanching with a high temperature of 95ºC for 5 minutes (T2) showed a similar result in the total phenol content compared to the sample without pre-treatment. The result was contrary to the result of antioxidant activities, which showed a decrease in the sample with the blanching process. This might be caused by other bioactive compounds rather than phenol, which play a role in the antioxidative properties of VCO. Other than phenolic compounds, medium-chain fatty acids are available in the VCO that might degrade during blanching, resulting in lower antioxidant activities [31]. Based on [32], phenolic compounds are mostly hydrophilic with many hydroxyl groups and more soluble in water; the compounds were removed during VCO extraction. On the other hand, phytosterols, another source of bioactive compounds, are hydrophobic and are concentrated in the VCO in approximately 90mg/100g VCO. The higher amount of phytosterols showed that phytosterols play a more important role in the antioxidant activities of VCO than polyphenols. Phytosterol might degrade during the blanching process, resulting in lower antioxidant activities. Therefore, the amount of polyphenol was still high even though the antioxidant activities result showed a lower value in the sample with the blanching process.




Notes: Different small letters in the box indicate a significant difference ($p<0.05$)

Fig. 3 Total phenolic content of virgin coconut oil with different pre-treatment processes

## IV. Conclusion

Blanching as a pre-treatment in the coconut kernel affects the lipid quality of VCO extracted using the chilling thawing. Water blanching at lower temperatures and more extended time with the addition of 0.05% citric acid resulted in the best lipid quality of VCO. Water blanching with 0.05% citric acid at 80ºC for 10 minutes showed high IV (6.612±0.085 g iodine/g sample), low FFA (0.0241±0.0023 mg KOH/g sample), and TBARS value (2.76±0.23 mg MDA/g sample). However, contrary to previous studies, the antioxidant activities were decreased. Still, higher TPC was obtained (9.16±1.56 mg GAE/g sample), showing different bioactive compounds such as phytosterols and medium-chain fatty acids might play a role in promoting the antioxidant activities. These findings might give VCO producers and consumers new insight regarding the blanching process that can prevent lipid deterioration, such as rancidity and hydrolysis, resulting in higher-quality VCO products.

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