RESEARCH ARTICLE | OCTOBER 17 2018

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AIP Conf. Proc. 2021, 070020 (2018)
https://doi.org/10.1063/1.5062818

Phenolic and Volatile Compounds, Antioxidant Activity, and Sensory Properties of Virgin Coconut Oil: Occurrence and Their Relationship with Quality

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Abstract. Virgin coconut oil (VCO) is a vegetable oil extracted from fresh coconut meat and processed using only physical without contamination by chemicals usage. Some phenolic acids identified in VCO include: protocatechuic, vanillic, caffeic, syringic, ferulic, and p-coumaric acids. Some study suggested that the contribution of antioxidant activity in VCO could be due to phenolic compounds. Volatile compounds identified included ethyl acetate, acetic acid, 2-pentanone, hexanal, *n*-octane, 2-heptanone, limonene, nonanal, octanoic acid, ethyl octanoate, δ-octalactone, ethyl decanoate, δ-decalactone, and dodecanoic acid. The sensory properties identified and quantified in VCO had slightly detectable acid aroma, sweet and salty tastes, and perceptible nutty aroma and flavor. This paper primarily discusses the findings associated with phenolic compounds, volatile compounds, antioxidant activity, and the sensory properties of VCO.

Keyword: Antioxidant activity, phenolic compounds, sensory properties, virgin coconut oil, volatile compounds

INTRODUCTION

Coconut oil is extensively used for food and industrial purposes. The oil is rich in medium chain fatty acids (MCFA) and exhibits good digestibility.[1] Various method have been developed to extract coconut oil, either through dry or wet processing. Dry processing is the most widely used form of extraction. Clean, ground and steamed copra is pressed by wedge press, screw press or hydraulic press to obtain coconut oil, which then goes through the refining, bleaching, and deodorizing (RBD) process. During the RBD process, heat is applied, especially during the deodorization process, which is carried out at temperatures between 204°C and 245°C.[2] The copra industry has faced problems including contamination by aflatoxin in the copra and cake, and the presence of high free fatty acids due to its high moisture content.[3]

Recently, there has been a trend towards producing coconut oil that does not have to go through the RBD process. Rather than going through the normal dry process, this oil is obtained by wet processing, which entails the extraction of the cream from the fresh coconut milk and breaking the cream emulsion. This process is more desirable as no chemical or high heat treatment is imposed on the oil. The coconut oil produced through the wet method is called virgin coconut oil (VCO).[4]

The term VCO refers to oil that is obtained from fresh, mature coconut kernels by mechanical or natural means, with or without the use of heat and without undergoing chemical refining.[5] Unlike RBD coconut oil which is tailor-made for cooking purposes. In the Indonesian market, VCO is marketed lately as a functional oil. Since its first introduction, VCO has captured significant public attention. Knowledge of the beneficial properties of VCO are spreading fast, and the availability of VCO is increasing in the market, especially in Southeast Asia, including the Philippines, Thailand, Indonesia, and Malaysia.[4]

This paper presents an overview of the volatile compounds, antioxidant activity, and sensory properties of VCO, with a concentration on their occurrence and relationship with the VCO quality.

The 8th Annual Basic Science International Conference
AIP Conf. Proc. 2021, 070020-1–070020-4; https://doi.org/10.1063/1.5062818
Published by AIP Publishing. 978-0-7354-1739-7/$30.00

The different production methods of VCO samples could be a major factor contributing to the variation in phenolic content. VCO produced by the dry method contained the lowest amount of polyphenols from 22.88 to 32.37 mg catechin equivalent per kg oil, because of the destruction of phenolic compounds during the expulsion step in the dry processing of VCO. An increase in temperature of 47°C during oil expulsion may have altered some of the phenolic compounds originally present in the oil.[6]

The total phenolic compounds present in the fermentation-extracted oil and chilling-extracted oil were compared. The results indicated that the fermentation-extracted oil had the highest phenolic content, followed by the chilling-extracted oil, and then RBD coconut oil. In chilling extraction, coconut milk was subjected to centrifugation, which separated the coconut cream from the aqueous phase (coconut skim milk). It was possible that some water-soluble phenolic components were left in the aqueous phase, and so the total phenolic content in the coconut milk was reduced during chilling extraction. The heating process undergone in this process could further destroy some of the phenolic compounds in the sample. In fermentation extraction, coconut milk was left to ferment overnight. Based on the difference in specific gravity, the oil released would settle on the top layer, separated from the aqueous phase. The longer contact time of oil and phenolic solution in the fermentation extraction resulted in more phenolic compounds being incorporated into the oil, which might explain the higher total phenolic content in oil obtained through fermentation than chilling.[7]

The total phenolic of coconut oil extracted under cold and hot conditions was compared. The results indicated that hot-extracted coconut oil is richer in phenolic substances, compared to cold-extracted coconut oil. The coconut milk emulsion used in the cold and hot extraction methods contains an aqueous phase and an organic (oil) phase that makes the emulsion milky. Phenolic compounds are partitioned, preferably in the aqueous phase because of the polar nature of phenolic substances. In the cold extraction method, the phenolic substances are not properly incorporated into the coconut oil due to the mild temperature conditions that are used in cold extraction. However, in the hot extraction method the temperature of the coconut milk emulsion reaches above 100°C. The concentration of phenolic substances increases when the water in the emulsion evaporates during the hot extraction process. Higher phenolic concentrations and higher temperatures favor the incorporation of more phenolic substances into the coconut oil. Even though high temperatures may destroy or deactivate certain phenolic compounds, the results suggest that hot extraction is better than cold extraction for incorporating more phenolic substances into coconut oil. There are three main compounds in the phenolic region of the chromatogram of phenolic extracts from cold-extracted coconut oil; there are several compounds in the chromatogram of phenolic extracts from hot-extracted coconut oil. Eight major free phenolic compounds were identified in hot-extracted coconut oil.[8] The differences in the phenolic content among VCO samples can also be explained by varietal differences in the coconuts used.[4] For example, the VCO sample from the Laguna Tall coconut variety extracted with the wet method had the highest polyphenol content, which was 91.90 mg catechin per kg oil.[6]

The observed antioxidant activity of the studied samples correlated significantly with the total phenolic content. Thus, phenolic content might be attributed to the high antioxidant activity in VCO. Phenolic antioxidants inhibit autoxidation of lipids (RH) by trapping intermediate peroxyl radicals in two ways: first, the peroxyl radical abstracts a hydrogen proton from the phenolic antioxidant to yield hydroperoxide and aroxyl radicals and, second, an aroxyl radical undergoes radical–radical coupling to give peroxide products.[9] The antioxidant activity of VCO samples ranged from 52 to 80%.[7] Among the VCO samples, the VCO sample from the Laguna Tall coconut variety extracted with the wet method exhibited the highest antioxidant activity. The high antioxidant activity of this VCO sample can be explained by its high total phenolic content of 91.12 mg catechin equivalents per kg.[6]

The difference in antioxidant activity among VCO samples could be due to the differences in processing methods used, or antioxidant activity may also be affected by thermal treatment.[10] The introduction of heat during the production or extraction of VCO could therefore decrease the oil's antioxidant activity.[7] The VCO produced by the dry method showed the lowest antioxidant activity. This may be due to the destruction of the polyphenols by heat, 47°C, generated during the expulsion of oil from the desiccated coconut.[6]

Other investigations have shown, however, that the antioxidant activity of the phenolic extracts of hot-extracted coconut oil is superior to that of cold-extracted coconut oil at all tested phenolic concentrations. This means that the phenolic extracts of hot-extracted coconut oil display higher antioxidant capacities than those of cold-extracted coconut oil at any given total phenol concentration, which could be associated with the more complex phenolic composition of hot-extracted coconut oil.[8]

The total phenolic content in VCO produced from different methods show that VCO contains higher total phenolic content compared to refined coconut oil. A study on commercial VCO in Malaysian and Indonesian markets confirmed that VCO samples were significantly higher in total phenolic content compared to RBD coconut oil. The refining process undergone by RBD coconut oil removed some of the phenolic content. Oil obtained by both chilling and fermentation demonstrated higher total phenolic content than RBD oil. The result was in agreement with other studies that found coconut oil extracted through a wet process directly from coconut milk had a high phenolic content.[7,11]

Volatile Compounds

Early studies of coconut oil have identified a number of hydrocarbons, aldehydes, alcohols, methyl ketones, and δ-lactones as significant contributors to its aroma.[12,13,14] The distinct coconut odor has been shown to be due to δ-octalactone.[15,16] Hydrolytic rancidity in coconut oil has been attributed to the presence of free fatty acids (FFA),[17] while ketonic rancidity has been linked to the presence of methyl ketones.[18]

The volatile compounds in the headspace of twenty-four commercial VCO samples prepared by different methods (i.e., expeller, centrifugation, and fermentation with and without heat) were analyzed by solid-phase microextraction gas chromatography mass spectrometry (SPME-GCMS). Fourteen compounds were identified through their MS fragmentation patters, and these identifications were confirmed by comparison with pure standards as follows: ethyl acetate, acetic acid, 2-pentanone, hexanal, *n*-octane, 2-heptanone, limonene, nonanal, octanoic acid, ethyl octanoate, δ-octalactone, ethyl decanoate, δ-decalactone, and dodecanoic acid.[19]

The compounds most commonly associated with coconut—lactones—were present in all coconut products. The lactone that was found in the highest amount was δ-octalactone, followed by δ-decalactone. The compounds associated with peroxidation—hexanal and nonanal—were found in low quantities. The VCO produced by fermentation had higher amounts of acetic acid. Acetic acid was not detected in the headspace of the VCO produced by the centrifuge (CEN) method; however, this may be due to the use of vacuum drying by the producers. Low amounts of methylketones—2-pentanone and 2-heptanone—suggest that deterioration due to fungi is not a major process in these samples.[20] The volatile organic compounds that were present in the highest amounts in the headspace were MCFA—octanoic acid and dodecanoic acid—which are presumably formed from the hydrolysis of the triglycerides. The longer-chain fatty acids may be present in solution, but their low volatility would make them less likely to have a significant presence in the headspace.[21]

Sensory Properties

Villarino, et. al., (2007) investigated the descriptive sensory analysis with Philippine virgin coconut oil (VCO) and refined, bleached and deodorized (RBD) coconut oil samples. In this study, VCO samples used were produced using the fermentation (F), fermentation with heat (FH1 and FH2), and centrifugation with heat (CH) processes. A total of 14 terms were generated by 11 trained panelists to describe the coconut oil samples. Result of this study, RBD significantly differs in color, having a distinct yellow color while all VCO samples were almost colorless. Ratings on color demonstrated that the application of heat may affect the color of the samples. The RBD sample had no perceptible aroma, while the VCO samples were described as having acid, cocojam, latik, nutty and rancid aromas, depending on the sample. The differences in the aroma ratings among VCO samples may be attributed to the processes applied. The CH oil had the lowest acid aroma rating among all the VCO samples, while the F, FH1, and FH2 samples were described as having a slightly perceptible acid aroma. The acid aroma may be attributed to the acetic acid produced during the fermentation process. Samples produced using F, FH1, FH2, and CH, were rated as having significantly detectable cocojam and latik aromas. Cocojam is the aroma associated with roasted coconut with slight sweet sensation, while latik refers to cooked coconut with a distinctly sweet sensation. These descriptors are both associated with heating, and ratings for these attributes were significantly higher in heated samples than non-heated samples.[5] Octanoic acid was found to exert the strongest influence in terms of acid and rancid aroma.[19] RBD had a slight salty taste with no perceivable flavor, while all VCO samples had detectable sweet taste and nutty flavor. Heat-treated samples were found to have significantly more intense cocojam and latik flavors than fermented samples. The fermented sample was distinctly more rancid than the heat-treated samples.[5]

CONCLUSION

Some of the phenolic acids identified in VCO include protocatechuic, vanillic, caffeic, syringic, ferulic and p-coumaric acids. This study suggests that the contribution of antioxidant activity in VCO could be due to phenolic compounds. The volatile compounds identified were ethyl acetate, acetic acid, 2-pentanone, hexanal, *n*-octane, 2-heptanone, limonene, nonanal, octanoic acid, ethyl octanoate, δ-octalactone, ethyl decanoate, δ-decalactone, and dodecanoic acid. Based on sensory observation, VCO is nearly colorless, has a slightly detectable acid aroma, both sweet and salty flavors, and a perceptible nutty aroma and flavor.

ACKNOWLEDGEMENTS

We would like to thank Brawijaya University and Indonesia Kemenristek DIKTI also University of Natural Resources and Life Sciences Vienna, Austria that support my research and my doctoral study.

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