Incorporation of Young Coconut (*Cocos nucifera*) Mesocarp Increases the Antioxidant Activity, Phenolic Compounds and Oxidative Stability of Cookies

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Abstract

Young coconut mesocarp (YCM) contains considerable phenolic compounds that provide high antioxidant activity. However, the YCM is identified as an underutilized by-product in food industries. A novel functional food derived from YCM, *viz.*, cookies, was proposed through this study to take advantage of the containing antioxidants. The cookies were prepared using regular flour (CR) or substituted with YCM powder at 8 (C8) or 16 % (C16). The macro components (carbohydrate, protein, fat and ash), *in vitro* antioxidant activities, and the level of individual phenolic compounds in the cookies were measured. The addition of YCM powder increased the crude fiber by up to 5 % and moisture content by about 2 - 3 %. Conversely, the fat level was lowered by 1 %. The *in vitro* antioxidant activities of cookies C8 and C16 were noticeably increased compared to the CR. The increase was attributable to the presence of phenolic compounds such as catechin and 3 caffeic acid derivatives, which were retained after the baking process. The addition of YCM changed the visual appearance by darkening the color of cookies which was indicated by lightness at 45.33 and 23.87; a* value was 17.30 and 18.97; b* value was 29.47 and 19.83; and chroma at 34.15 and 27.49, for C8 and C16, respectively. The addition of YCM also reduced the hardness due to the presence of moisture content in the incorporated cookies. Additionally, the addition of YCM was effective in prolonging shelf-life by increasing the oxidative stability of YCM-based cookies, indicated by the lower peroxide value (0.1 mEq $O_2 \cdot kg^{-1}$) after 4 months of storage compared to the regular cookies. YCM powder can be an alternative source of antioxidants, and it may be possible to include YCM powder in cookies and other pastries to increase their nutritional value and antioxidant activity to produce functional food.

Keywords: Functional cookies, Coconut mesocarp, Phenolic acid, Antioxidant, Shelf-life

Introduction

Functional foods that provide health advantages beyond basic nutrition are receiving more attention these days. Sedentary lifestyles that contribute to conditions including arthritis, obesity, cardiovascular disease and diabetes are the main drivers of the global expansion of the nutraceutical industry. Butter cookies are common snacks with delicate flavors, but unfortunately, they contain a high level of sugar and fat, which contributes to their ingredients, such as butter, sugar and wheat flour. Recently, wheat flour may be substituted with other flours high in protein, fiber and bioactive compounds from agrifood by-products. The key factor driving the widespread use of underutilized agrifood by-products in cookie manufacture is the various bioactive components and antioxidant activities that display numerous beneficial health on humans. Several research has been innovatively incorporating cookies with several by-products, such as powders from seed [1-3], peel [4] and stem [5] of agrifood.

Young coconut mesocarp (YCM) is one of the underutilized by-products of the coconut industry. Former studies reported that YCM contains phenolic components such as flavanols like catechin and epicatechin as well as phenolic acids like protocatechuic, chlorogenic, vanillic, gallic and ellagic acids [6,7]. Attributable to their bioactive compounds, coconut mesocarp has health advantages, anti-diabetic action [8], anti-cardiovascular disease [9] and hypoglycemic activity [10]. The application of YCM aqueous extract can inhibit fungal growth by reducing mycelial growth and spore germination in citrus fruits [11].

Additionally, the phenolic extract from coconut mesocarp can improve the textural properties of sardine surimi [12] and positively affect its oxidative stability, such as preventing rancidity and lipid oxidation during refrigerated storage of surimi [13]. Due to the wide advantages of phenolic extracts, YCM in juice form has been incorporated into the Indian dessert product [14]. Henceforth, the utilization of YCM powder as a substitute or an incorporated ingredient in food products could be further studied to develop new functional foods.

The incorporation of biological material into cookies might affect their chemical composition (carbohydrate, protein, fat and moisture), physical appearance, texture and phytochemical properties, thus also affecting the storage time of cookies. Commonly, a shortened shelf-life is mainly caused by food spoilage due to the high moisture content [15,16]. However, the incorporation of biological ingredient prolongs the shelf-life, which contribute to the presence of phenolic compounds in the product [17].

Therefore, the purpose of this study was to develop a functional cookie by incorporating YCM and investigate its effect on the chemical composition (carbohydrate, protein, ash and fat levels) and phytochemical properties (phenolic compounds and antioxidant activity) of the developed functional cookies. The individual phenolic compounds were also determined using ultrahigh-performance liquid chromatography (UPLC). Additionally, the oxidative stability of cookies was investigated using a peroxide assay during storage to define the shelf-life of the developed product.

Materials and methods

Materials

Coconut (*Cocos nucifera*) fruit at 4 - 6 months of maturation stage was provided by local farmers (Yogyakarta, Indonesia). The substitute flour, young coconut mesocarp (YCM) powder, was made by the following procedures. The coconut fruit was cleaned and separate the mesocarp part from the fruit's other sections manually. The mesocarp was cut into pieces ($50 \times 10 \times 5$ mm^3) and dried for 48 h in a cabinet drier at 50 °C. The dried samples were then milled and sieved at 60 mesh and stored in a sealed container at room temperature. The cookie ingredients, such as wheat flour, powdered sugar, butter with salt and fresh egg (L grade), were obtained from local stores (Puerto Real, Spain).

Chemical reagents

The extraction solvents were ethanol (Fischer Scientifics, Loughborough, UK) and ultrapure water supplied by a Millipore Milli-Q system (Bedford, MA, USA). To determine antioxidant activities, 2,2-diphenyl-1-picrylhydrazyl (DPPH) (Sigma-Aldrich, St. Louis, MO, USA) was used. For the determination of phenolic compounds in samples, standards such as catechin, chlorogenic and caffeic acids were purchased from Sigma-Aldrich, Steinheim, Germany. All standards and solvents used were UHPLC-grade with purity ≥ 98.5 %. Milli-Q water, acetonitrile (Panreac Qumica SAU, Barcelona, Spain), and acetic acid (Merck KGaA, Darmstadt, Germany) were used as the mobile phases in ultrahigh-performance liquid chromatography (UHPLC).

Production of cookies

In this study, 3 types of cookies were prepared. The cookies were labeled as follows: Cookies prepared with basic ingredients and used as the reference (CR), 2 cookie samples were prepared with different addition of YCM powder of 8 and 16 % (w/w) to substitute the wheat flour and coded as C8 and C16, respectively. The addition level of YCM was decided by preliminary research that showed the addition of YCM above 16 % performs a crumble form of cookie dough, while 8 % of the addition produced similar dough characteristics as the reference.

The basic ingredients of the cookies were flour, powdered sugar, butter and egg. Three different batches of cookies were made by the following procedure. The regular cookies, as a reference, contained wheat flour (150.0 g), powdered sugar (62.5 g), butter with salt (75 g) and egg. In place of wheat flour, the cookies were prepared using YCM powder of 8 and 16 % (**Table 1**). The ingredients were combined to create the dough, which was then weighed 10 g per cookie and flattened about 50 mm. The cookies were cooked for 8 min at 180 °C in an electric oven for each side.

Table 1 Basic ingredients of the cookies.

Ingredients	Reference cookie (CR)	YCM-based cookie	
		8 % YCM, C8	16 % YCM, C16
Wheat flour (g)	150	127	104
Powdered sugar (g)	62.5	62.5	62.5
Butter with salt (g)	75	75	75
Egg (L size) (unit)	1	1	1
YCM powder (g)	0	23	46

Chemical composition analysis

Gravimetric analysis was used to determine the dry matter (DM) and ash contents. The total protein was determined by the Kjeldahl technique to estimate the total nitrogen content, and the crude protein (P) content was calculated by multiplying nitrogen content with a conversion factor (6.25). The crude fat (F) content was measured using the Soxhlet technique per AACC Method No. 30 - 25.01. Total carbohydrates (C) were calculated using the formula:

$$C = 100 - (F \% + P \% + Ash \% + moisture). \tag{1}$$

The total energy value was determined using the following formula:

$$(kcal/100 \text{ g) energy} = (4 \text{ g P}) + (4 \text{ g C}) + (9 \text{ F}). \tag{2}$$

Color analysis

The color was analyzed using a Chroma Meter (Minolta CR 400, Tokyo, Japan) with an aperture of 0.8 cm. The values of lightness (L^*), redness (a^*) and yellowness (b^*) defined the color characteristics of the cookies. The value of a^* represented the red-green, while the b^* value was for the yellow-blue color.

Texture analysis

The texture (hardness) of the cookies was measured using a texture analyzer (TA XT Plus, Stable Micro Systems, Surrey, UK) with a spherical probe. The pre-load and speed tests were 300 and 10 mm·min^{-1}, respectively, with a compression distance of 10 mm on a hard surface. The tests were performed in triplicate.

Extraction of phenolic compounds from cookies

The extraction of phenolic compounds from cookies was carried out using an ultrasound-assisted extraction method [7]. The cookies sample (1 g) was mixed with 20 mL of 50 % ethanol in a falcon tube. A probe with a 7 mm diameter, 200 W UP200St power and 26 kHz frequency (Hielscher Ultrasonics GmbH, Teltow, Germany) was used to generate the ultrasonic wave. The probe was immersed to a depth of roughly 0.5 cm with a pulse duty cycle of 1 s^{-1}. The temperature of extraction was regulated by a Frigiterm-TFT-10 thermostat at 70 °C (J.P. Selecta S.A., Barcelona, Spain). The extraction was performed for 5 min, and the supernatant was separated from the solid by using centrifugation force at 4,500 rpm for 15 min. The extract was stored in the refrigerator for radical scavenging activity analysis and identification of phenolic compounds.

Radical scavenging activity (RSA)

The antioxidant activity was measured using 2,2-diphenyl-1-picrylhydrazyl (DPPH) as described by Brand-Williams [18] with slight modifications. A 0.1 mL extract of cookies which obtained by ultrasound-assisted extraction was added by DPPH solution (0.06 mM), about 1.9 mL in volume and homogenized for 30 s. The mixture was then incubated in the dark for 30 min at room temperature. A UV-Vis spectrophotometer (UV-2450, Shimadzu Corporation, Kyoto, Japan) was used to measure the absorbance at 515 nm. As a control, the DPPH solution was employed. The antioxidant activity was calculated using the following formula:

$$RSA \ (\%) = \frac{\text{Absorbance of blank} - \text{Absorbance of sample}}{\text{Absorbance of blank}} \times 100 \tag{3}$$

Clean-up of phenolic extract from cookies

Solid-phase extraction (SPE) was performed to clean up the extract from interference that existed in the cookie matrix before injected to the UHPLC system. The SPE cartridge was Strata X (Phenomenex, Torrance, CA, USA) with modified divinylbenzene as the solid phase. The extract was diluted into 2,000 mL of Milli-Q water to allow maximum adsorption of phenolic compounds and complete separation from the residue in the SPE cartridge. The extract was cleaned up using the following protocol: The cartridge was conditioned with 10 mL of methanol and continued with 10 mL of water. The diluted extract (2,000 mL) was passed through the cartridges slowly. Then, the cartridge was washed by passing through 10 mL of water. To obtain the final extract of phenolic compounds, the cartridge was eluted with 2 mL of methanol. UHPLC-PDA was used to analyze the resulting extract and the washing residues.

Identification of individual phenolic compounds

The chromatographic studies were performed using an ultrahigh performance liquid chromatography (UHPLC) ACQUITY UHPLC H-Class System equipped with a photodiode array (PDA) detector (Waters, Milford, MA, USA). The individual phenolic compounds were identified using a 3D scanning mode of 210 - 600 nm by comparing the spectrum characteristics of the resulting peak with the standard compounds. At the temperature of 47 °C, 1.5 µL of the extract was injected, and the phenolic compounds were separated using a reversed-phase column C18 (100 mm length; 2.1 mm ID; RP 18 CORTECS UHPLC silica-based solid-core particle; 1.6 µm particle size from Waters). A binary solution was used as the mobile phase, which consisted of phases A (2 % acetic acid in water) and B (2 % acetic acid in acetonitrile) with a flow rate of 0.55 mL·min^{-1}. The gradient program for the mobile phases was as follows (% B): 0, 0; 3, 0; 4, 5; 5, 10; 8, 20; 9, 30 and 13 min, 100 %. The peak integrations were performed in 2 channels, i.e., 260 (catechin and protocatechuic acid) and 320 (chlorogenic acid and 3 caffeic acid derivatives). The level of phenolic compounds was represented by the total area of the individual peaks.

Peroxide value of cookies

The peroxide value (PV) is defined as the reactive oxygen contents and expressed in mEq of O_2 kg^{-1} oil. The peroxide value (PV) of the cookies was assessed by AOAC Official Method 965.33 using the titration method. The active oxygen (peroxide) produced in the cookies oxidized the iodide to iodine. The liberated iodine is titrated with a standardized sodium thiosulfate solution. Analysis was measured on the first day after baking. The same analytical process was then performed on days 30, 60, 90, 120 and 150.

Data analysis

The significance level of the examined parameter was statistically assessed using analysis of variance (ANOVA) with a Duncan test with 95 % confidence using IBM SPSS Statistics software (Version 20) to check the differences among the means (IBM Company, NY, USA).

Results and discussion

Chemical composition

The measurement of chemical composition was performed to investigate the changes in ash, moisture content, total fat, total carbohydrate, total protein and crude fiber of the cookies during the preparation. Subsequently, the resulting data were analyzed to correlate with the physical parameters. The chemical compositions of composite cookies with YCM and wheat flour are presented in **Table 2**.

Table 2 The chemical composition of the cookies (g 100 g^{-1}).

Compounds	CR	C8	C16
Ash	0.67 ± 0.01[c]	1.105 ± 0.015[b]	1.295 ± 0.005[a]
Total lipid	22.62 ± 0.03[a]	22.645 ± 0.025[a]	21.575 ± 0.005[b]
Moisture	6.485 ± 0.065[c]	8.21 ± 0.07[b]	9.655 ± 0.045[a]
Carbohydrate	62.105 ± 0.045[a]	61.07 ± 0.05[b]	61.01 ± 0.05[b]
Protein	8.12 ± 0.13[a]	6.97 ± 0.13[b]	6.465 ± 0.085[b]
Crude fiber	1.475 ± 0.025[c]	3.685 ± 0.035[b]	5.295 ± 0.055[a]

CR: Cookies for reference, C8: Cookies with the addition of 8 % YCM powder and C16: Cookies with the addition of 16 % YCM powder. Based on Duncan's multiple range test, bars with different letters indicate statistically significant differences at $p = 0.05$.

The level of total ash varied among the studied cookies. The YCM-incorporated cookies contained 2-fold of total ash (C8, 1.0 %; C16, 1.3 %) over the reference (CR, 0.7 %). Similar to this result, the YCM-incorporated cookies also provided higher crude fiber (C8, 3.7 %; C16, 5.3 %) compared to the control (CR, 1.5 %). YCM was reported as a source of fiber [19]; hence the addition of this coconut by-product could increase the amount of fiber in the cookies along with the high percentage of incorporation. Dietary fiber-rich foods could enhance the nutritional status and reduce the risk of certain illnesses, including diabetes, atherosclerosis and cancer [20]. According to FDA, a product considers a 'source of dietary fiber' if the product contains a minimum of 5 g of fiber per 100 g. Thus, the incorporated cookies of 16 % YCM can be considered a dietary fiber source [21]. Furthermore, the use of dietary fibers from fruits has been reported to increase the textural, rheological and sensory qualities of baked dishes [22]. Wheat flour is the main ingredient in cookie production; thus contributes to the highest composition of carbohydrates in the cookies. A similar proximate composition was observed in cookies prepared with melon, apple and pineapple fruit waste [23].

The addition of YCM also significantly increased ($p < 0.05$) the moisture content of composite cookies from 6.48 (CR) to 8.21 (C8) and 9.65 % (C16). The higher moisture content of cookies may be the result of the crude fiber in YCM absorbing more water. This condition was contributed by the presence of hydroxyl groups of cellulose in the fiber, which might form hydrogen bonds with free water molecules to increase water-holding capacity [24]. The result also supported by Ashoush and Gadallah [25] that conducted an incorporation of mango peel could increase the moisture content of biscuit products. The rising moisture content in the cookies product will affect the period of storage. The high presence of moisture content in products can shorten the storage time, which is caused by the high susceptibility to mold and fungal spoilage [26]. On the contrary, the level of protein lowered from 8.12 (CR) to 6.97 (C8) and 6.46 % (C16) due to the addition of YCM powder. These lower values might be explained by the substitution of low-protein YCM powders. The reduction of protein content was also found in the substitution of wheat powder for apple pomace in the composite cookies [27]. The lower protein content in the YCM-incorporated cookies affected the lowering texture of the cookies in the final production. Gluten is the major protein in wheat flour which has been reduced in YCM-based cookie production. Gluten plays an important role in dough formation during the mixing process [28]. Likewise, the fat content of C16 was significantly lower ($p < 0.05$) than CR (22.62 %). However, C8 was not statistically significant compared to the CR. The presence of fat in the product can contribute to the rancidity process during storage. Hence, the lower fat content in the cookies may reduce the possibility of the rancidity process in the cookies. The energy provided by fat and the total energy (kcal 100 g^{-1}) is listed in **Table 3**. The incorporation of YCM produced lower total energy compared to the reference (CR). Considering that each piece of cookie weighs about 8 g, the total energy provided by each cookie was 38.7, 38.0 and 37.0 kcal for CR, C8 and C16, respectively.

Table 3 The calculated energy of cookies.

	CR	C8	C16
Total energy (kcal 100 g^{-1})	484.48 ± 0.03^a	475.96 ± 0.02^b	464.07 ± 0.04^c
Energy from fat (kcal 100 g^{-1})	203.58 ± 0.27^a	203.81 ± 0.22^a	194.17 ± 0.04^b

CR: Cookies for reference, C8: Cookies with 8 % YCM powder and C16: Cookies with 16 % YCM powder. Based on Duncan's multiple range test, different superscript letters in the same row indicate statistically significant differences at $p = 0.05$.

Texture of cookies

The texture of cookies was expressed by the maximum force to break down the cookies for the first attempt (F maximum) in Newton (N) unit. With the different percentages of YCM powder addition, it was found that the hardness of cookies decreased. This might be a result of cookies still having a relatively higher moisture content after baking. The amount of force needed to break down the cookies was significantly reduced as a result of the increase in YCM flour addition. Additionally, the presence of fiber reduced the hardness of cookies, as occurred in the cookies incorporated in coconut cake powder [29].

The maximum power to break down the cookies dropped from 68.21 (CR) to 43.79 (C8) and 34.27 N (C16) with increasing YCM content. The substitution of YCM powder for wheat flour decreased the amount of gluten in the cookie dough and delayed the development of gluten matrices, which in turn led to a significantly reduced hardness [16]. The same findings were observed by Kuchtová *et al.* [30], which incorporated mango kernel in the biscuit with various amounts of mango peel and kernel powder. The

presence of phenolic compounds might restrict the works of amylases in the cookie dough, thus resulting in the decline of the hardness value of incorporated cookies [31].

Color of cookies

Color is considered one of the primary characteristic of food products and highly correlates with the physical, chemical and sensorial qualities of the products. The incorporation of YCM resulted in the darkening of the visual appearance of cookies compared to the CR, as can be seen in **Figure 1**.

CR   **C8**   **C16**
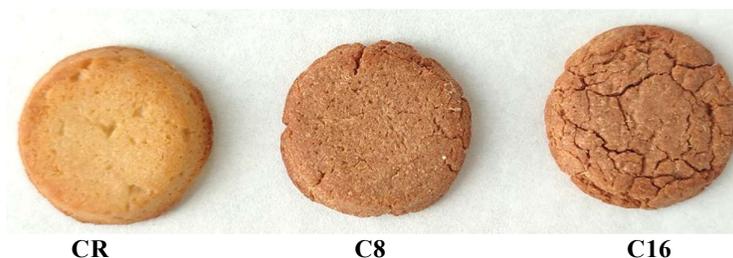
Figure 1 Three types of cookies which were produced in this study: CR (regular cookies), C8 (incorporated by 8 % of YCM) and C16 (incorporated by 16 % of YCM).

Further, the color attributes such as lightness (L), a* value, b* value and chroma were measured and displayed in **Table 4**. It was noted that cookies with 8 and 16 % YCM powder were noticeably darker than the reference. The lightness (L) value of YCM-incorporated cookies was reduced along with the increased addition of YCM powder. The color appearance of cookies was mostly affected by the brown color of the YCM powder, which was found to be an alternative natural colorant in food, as reported by Asma *et al.* [32]. The redness (a* value) of YCM-incorporated cookies increased while the yellowness (b* value) decreased in comparison to the reference cookies. A similar result was also explained when the grape seeds were added as a powder to prepare biscuits [33]. Grape seed contains phenolic compounds that may be a source of browning due to oxidation [34]. The YCM powder had an impact on the color saturation of the cookies, which lowered the chroma (C) values.

Table 4 The color attributes of cookies.

	CR	C8	C16
L	63.07 ± 2.44^a	45.33 ± 1.97^b	23.87 ± 1.20^c
a*	11.03 ± 1.70^a	17.30 ± 0.94^b	18.97 ± 2.06^c
b*	36.57 ± 1.24^a	29.47 ± 0.23^b	19.83 ± 3.06^c
Chroma	38.21 ± 1.51^a	34.15 ± 0.69^b	27.49 ± 3.44^c

CR: Reference cookies, C8: Cookies with 8 % YCM powder and C16: Cookies with 16 % YCM powder. Based on Duncan's multiple range test, different superscript letters in the same row indicate statistically significant differences at $p = 0.05$.

Antioxidant activity of cookies

The measurement of antioxidant activity was conducted to investigate the effect of YCM incorporation into the cookies by comparing it to regular cookies. The highest DPPH radical scavenging activity was found in C16 (77.72 %), followed by C8 (29.28 %), while the reference cookies merely provided 24.19 %. This finding indicates that the cookies containing YCM powder presented higher antioxidant activity than the regular cookies. The high DPPH radical scavenging activity in incorporated cookies can be due to the presence of phenolic compounds. This result demonstrated a favorable correlation between the cookies' phenolic content and their capacity to scavenge DPPH radicals. Similar findings have been disclosed that the incorporation of agricultural by-products significantly increased the antioxidant activities in the cookies [35,36].

**Individual phenolic compounds in cookies**

The individual phenolic compounds in the YCM powder and YCM-incorporated cookies were identified using UHPLC-PDA (**Figure 2**). Prior to the separation using a chromatographic system, the

analytical stages also involved ultrasound-assisted extraction and clean-up by solid phase extraction. The identified phenolic compounds in YCM powder were protocatechuic acid, catechin and chlorogenic acid. Additionally, tentative identification was made for 3 derivatives of caffeic acids. While the phenolic compounds that remained in the YCM-incorporated cookies were chlorogenic acid and 3 derivatives of caffeic acid, which were considered major compounds in YCM powder.
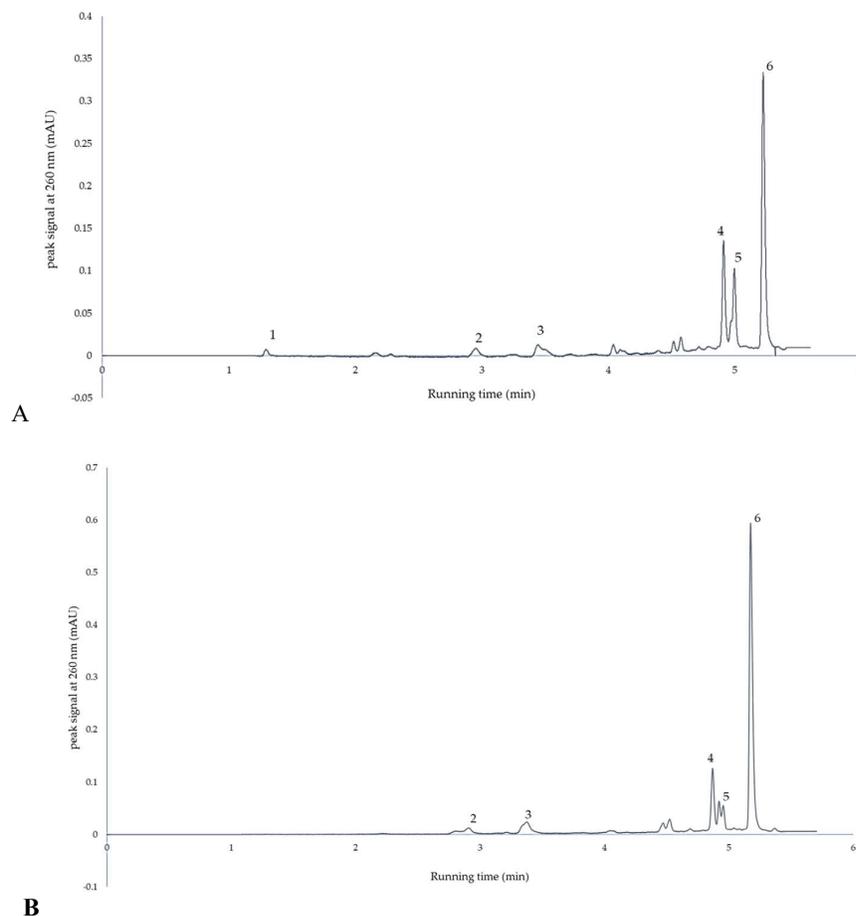
Figure 2 The chromatograms of UHPLC-PDA at 260 nm for the phenolic compounds extracted from, A) young coconut powder (YCM) and B) 16 % YCM-incorporated cookie (C16) represent protocatechuic acid (1), catechin (2), chlorogenic acid (3) and 3 derivatives of caffeic acids (4, 5 and 6).

Phenolic compounds are often linked to the structural proteins and carbohydrates of the cell wall of YCM. The disintegration of the cell wall due to high temperature during the cookie preparation may facilitate the release of the compounds, thus increasing the antioxidant activities of the resulting cookies. However, the baking process at 180 °C was not only affected the visual appearance and antioxidant properties but also the stability of phenolic compounds [37]. The presence of detected phenolic compounds in YCM and the YCM-incorporated cookies after baking was compared to check their stability due to cookie production as can be seen in the **Figure 3**. The low amount of protocatechuic acid and catechin was found in the YCM and was not found in the baked cookies. Hence, chlorogenic and 3 caffeic derivatives were detected in YCM and also retained in C8 and C16.
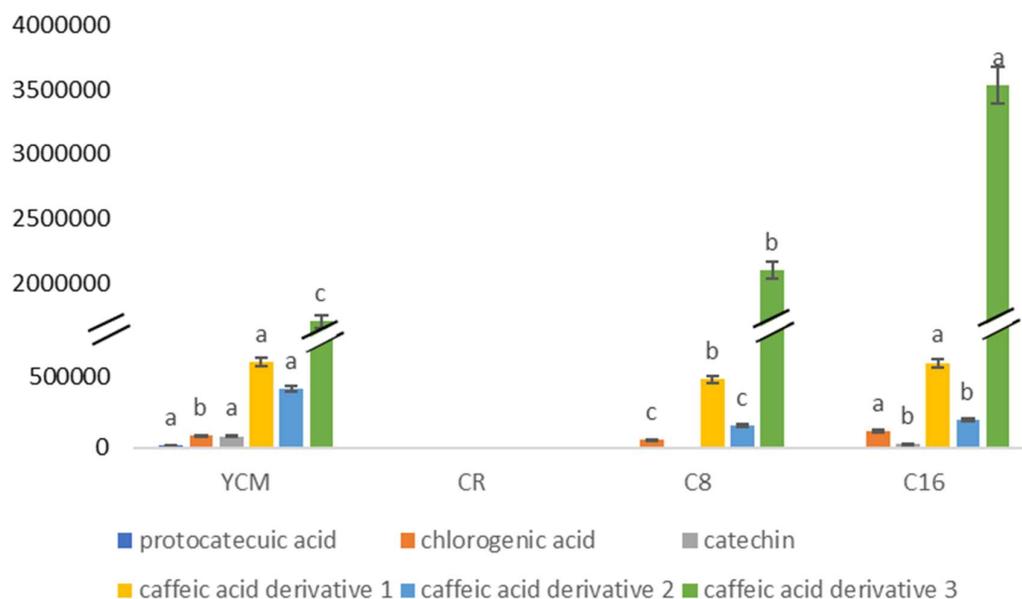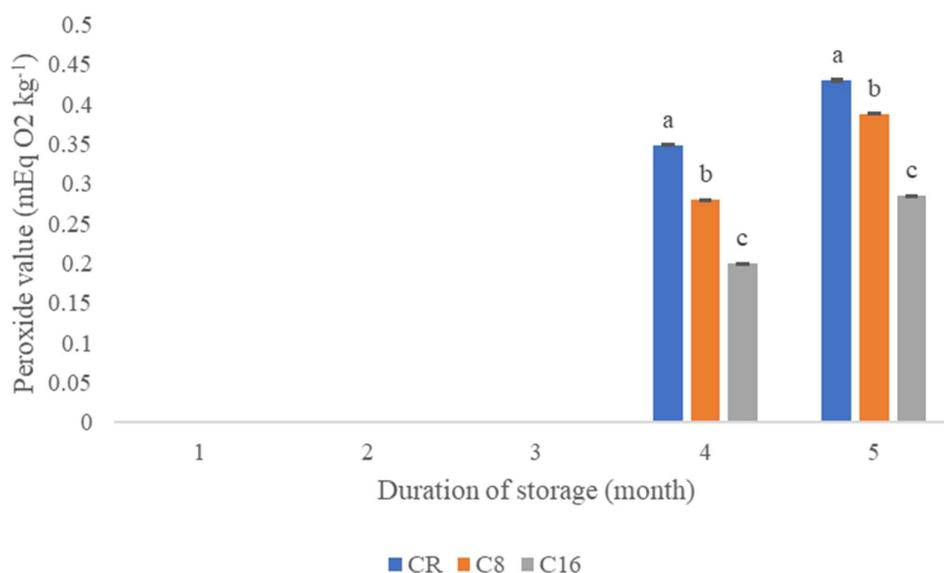
Figure 3 The peak area of identified phenolic compounds YCM (young coconut mesocarp), CR (cookies for reference), C8 (cookies with 8 % YCM powder) and C16 (cookies with 16 % YCM powder). Based on Duncan's multiple range test, bars with different letters for each phenolic compound indicate statistically significant differences at $p = 0.05$.

The high temperature during the baking process produces melanoidin due to the Maillard reaction may also increase the phenolic content of the resulting cookies. Additionally, the free phenolic compounds can be released at higher temperatures as a result of the breakdown of conjugated phenolic compounds, as occurs in whole-grain bread [38]. The finding was also supported by several similar works that showed biscuits incorporated by date seed powder [36], spent coffee ground [39] and apple peel powder [40] showed an increment in phenolic compounds when compared to biscuits made entirely of whole wheat.

Oxidative stability during storage

The cookies were packaged in separate containers for each treatment and kept at room temperature (relative humidity = 75 %). The peroxide value is one of the parameter to indicate an oxidation process occurs in a product. The peroxide value were measured every month and started being detected in month 4, as can be seen in **Figure 4**. As shown, the replacement of wheat flour with YCM powder has decreased the rancidity indicated by the lower peroxide value. In the first 3 months of storage, the peroxide value of cookies was not detected, and the cookies started to produce peroxide afterward. The CR was shown significantly higher than YCM-incorporated cookies. The peroxide value measurement for C16 was considerably lower than for C8. The peroxide levels of each cookie formulation were significantly different ($p < 0.05$) at months 4 and 5. A similar finding about the incorporation of pear's cladodes (stem part) reduced the peroxide value of incorporated cookies at a storage day of 30 [41].

Figure 4 The peroxide value of CR (cookies for reference), C8 (cookies with 8 % YCM powder) and C16 (cookies with 16 % YCM powder).

The low peroxide value was caused by the inhibition of oxidation reaction in the YCM-based cookies. The oxidation process was scavenged by the phenolic compounds in the cookies which posses high antioxidant activity. Additionally, the incorporation of YCM also reduced the fat content the cookies due to the high fiber as happen to the cookies incorporated by sapota ans beetroot leaf powders [42].

Conclusions

This study offers a novel perspective on the use of YCM as an ingredient in food production. The use of YCM as an ingredient of cookies has substantial effects on the physical and chemical qualities. The YCM-based cookies contain higher content of protein and ash, but lower protein and fat content compared to the regular cookies. In the RSA measurement, the cookies has higher antioxidant activity than regular cookies due to the presence of the phenolic compounds such as catechin, chlorogenic and 3 type of caffeic acid derivatives. In this study, YCM powder can be an alternative source of antioxidant, and it may be possible to include YCM powder in cookies and other pastries to increase their nutritional value and antioxidant activity to produce functional food. However, the investigation of the effect consumption of YCM-based products on the body and digestion system needs to be clarified by performing an *in vivo* research in the future study.

Acknowledgments

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