Research Article

DOI: 10.22146/ifnp.91257 https://journal.ugm.ac.id/ifnp
ISSN 2597-9388

Journal of Indonesian Food and Nutrition Progress

Antioxidant Compound of *Curcuma mangga* Val. with Variation in Rhizome Parts and Soil Types

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Submitted: November 30th, 2023; Revised: January 16th, 2024; February 1st, 2024;
Accepted: February 1st, 2024; Published: November 15th, 2024

ABSTRACT: The scientific name of *Curcuma mangga* Val. (CM), that is commonly known as *temu mangga*, contains polyphenols, categorized as antioxidant compounds. These antioxidant compounds can neutralize free radicals. The study aims to determine the influence of rhizome parts and soil types on the antioxidant properties of CM. The research stages include sorting, peeling, washing, blanching, drying, and compositional analysis (antioxidant activity, total phenolic, flavonoid, and tannin). The study utilized a Completely Randomized Design (CRD) with rhizome parts (main, 1st tiller, and 2nd tiller) and soil types (clay, lime, and sand) as variables. Both rhizome part and soil type have significant effects on the antioxidant activity and antioxidant compounds of CM. The chosen CM, specifically the main rhizome with clay soil type, exhibits an antioxidant activity of 82.50% RSA, total phenolic of 647.50 mg GAE/100 g db, flavonoids of 620.2 mg QE/100 g db (dry basis), and tannins of 167.07 mg CE/100 g db.

Keywords: antioxidant compound, blanching, *Curcuma mangga*, soil type

INTRODUCTION

Indonesia is rich in rhizomes, which have been used for generations as herbal medicines, containing various health-promoting ingredients. CM is a rhizome utilized as an herbal medicine because it is rich in antioxidants. Antioxidants are compounds that can scavenge free radicals. Free radicals cause oxidation-related diseases, such as cardiovascular disease and cancer (Kontoghiorghes & Kontoghiorghe, 2019). Antioxidant systems are naturally present in the body, such as superoxide dismutase (SOD) and glutathione-S-transferase (GST), as well as dietary antioxidants such as phenolic compounds and flavonoids (Pérez-Torres *et al*., 2021). A lack of antioxidants can result in poor protection against free radical attack. CM extract has tannins and curcuminoids that can inhibit oxidation. CM contains essential phytochemicals and has several potential health benefits as antidiabetic (Pujimulyani *et al*., 2022), antioxidative properties (Pujimulyani *et al*., 2020), and antiaging (Pujimulyani *et al*., 2019). CM processed products include syrup (Pujimulyani, 2003), instant powder (Pujimulyani *et al*., 2010), and effervescent tablets (Pujimulyani *et al*., 2013). Rhizomes contain curcuminoids that impart a yellow color. Curcuminoids in CM were 132 ppm (Pujimulyani, 2003) and contained phenolic and condensed tannins (Pujimulyani *et al*., 2010). CM has bioactive compounds such as curcumin, which is known as an antiaging agent (Pujimulyani *et al*., 2019). Drying rhizomes can be done by three methods, namely conventional drying using solar heat and modern drying using a cabinet dryer and freeze dryer (Pravitajaty *et al*., 2021). Drying in this study used conventional methods with solar heat.

CM is a 50-70 cm tall plant in the form of a pseudostem composed of leaf midribs. The length of the leaves is about 30-60 cm, and the width of the leaves is 7.5-12.5 cm. The petiole is as long as the leaves. The upper and lower surfaces of the leaves are relatively smooth and glabrous.

White turmeric has a skin filled with fine fibrous roots that resemble hairs. The main rhizome is hard, and when split, the flesh is yellowish on the outside and yellowish-white in the middle. The rhizome smells aromatic and tastes like mango, so people call it CM (Lianah *et al*., 2020; Jalil *et al*., 2021).

CM, a rhizome, is commonly used by the people of West Java as a vegetable salad. Besides that, CM also has health properties (Srirod & Tewtrakul, 2019), including reducing belly fat. CM rhizome can be used as an appetite stimulant (Lianah *et al*., 2020), enhancing lust (Salman & Indriana, 2019), lowering body heat due to fever (Salman & Indriana, 2019), laxative (Sommano & Tangpao, 2021),

treating itching (Awin *et al*., 2020), and bronchitis (Yuandani *et al*., 2021).

CM can grow in various types of soil. Soil type is the factor that has the most impact on the content of planted material (Neina, 2019). Passive soils are soils with weak structure, low water retention properties, high permeability, and are sensitive to adverse compaction. According to Kusuma & Ifadah (2023), latosol is a type of soil rich in iron and aluminium, whose main characteristics are reddish, brownish, to yellowish. Often called laterite or red soil because of its color, latosol is a relatively young soil that has not yet developed (Adriani *et al*., 2021; Schaefer *et al*., 2022). The definition of andosol soil is soil that has A mollic horizon or an umbric horizon (Hartemink *et al*., 2020), usually above the B cambic horizon (Santos & Almeida, 2021), which consists of fine soil fractions and is mainly composed of volcanic ash, and other vitrified pyroclastic materials. of fine soil fractions and is mainly composed of volcanic ash, other vitrified pyroclastic materials (Widiasmadi, 2023). CM generally has parts of the rhizome that contain mains and tillers, which have different amounts of content. Rhizomes can grow well on latosol andosol soil types, but if planted in swampy, heavy soils, it does not grow well due to the clay fraction (Hu *et al*., 2021) and soil dominated by coarse sand content (Rahman *et al*., 2022). Fertile soil that is loose and well-drained is required to obtain an optimal harvest yield of *temu mangga* (Subagia *et al*., 2021).

Blanching is preheating in food processing. Blanching is a pre-processing step in food processing, commonly used to dry fruit (Mandliya *et al*., 2023). Blanching inactivates enzymes that cause discoloration (Adetoro *et al*., 2020), hydrolysis (Huang *et al*., 2019), or oxidation (Magangana *et al*., 2021). Blanching is also intended to remove air from fruit tissues, reduce the number of microbes, and facilitate filling by softening the material. Blanching is part of the thermal process and generally requires temperatures of 75-95 °C (Pandey *et al*., 2019). The aim of blanching is to inactivate enzymes that allow changes in the color, texture, and flavor of food ingredients (Shrestha *et al*., 2020; Wang *et al*., 2021). Browning can be prevented by adding citric acid, so the combined treatment of blanching and citric acid reduces the effects of browning (Eshun *et al*., 2022; Al-Jeddawi *et al*., 2023). The citric acid soaking process can inhibit the occurrence of browning because it can complex copper ions, which in this case act as a catalyst in the browning reaction. In addition, citric acid can also inhibit browning by lowering the pH, as with acetic acid, so that the PPO (polyphenol oxidase) enzyme becomes inactive (Zhou *et al*., 2020). In some rhizomes, the blanching process can enhance antioxidant activity. For example, in white turmeric (Pujimulyani *et al*., 2020).

Therefore, the study aimed to determine the antioxidative capacities of several blanched CM rhizome parts in different soil types.

MATERIALS AND METHODS

Materials and Equipment

The main materials were CM main rhizomes, first and second tillers from Plawonan RT04 Agromulyo, Dunglarangan RT35 Argosari, and Kalaan RT02 Argorejo, Sedayu, Bantul. The blanching process was carried out with citric acid media. Chemicals for analysis were ethanol, $NaNO_3$ (Merck, 10%), $AlCl_3.6H_2O$ (Merck, 10%), NaOH (Merck, 10%), Folin-Ciocalteu (Merck), and Na_2CO_3 (Merck).

CM powder preparation equipment includes a basin, gas stove (Rinnai RI-620 BGX), knife, grater, pan, spatula, sieve, spoon, and scales (Ohaus Pioneer PA214 Sartorius BL201S). Chemical analysis equipment includes beaker glass (Pyrex), measuring flask, weighing bottle, Whatman no. 42 filter paper, porcelain chair, oven, erlenmeyer, micropipette (Acura 825 autoclavable), measuring pipette, vortex (Barnstead Type 37600 Mixer), vacuum evaporator, muffle, and UV-VIS spectrophotometer (Shimadzu UV mini1240).

Procedure

The stages included preparation (sorting, peeling, washing, blanching, and drying) and implementation (analysis). The blanching stage uses citric acid media with a concentration of 0.05% with a blanching time of 5 minutes. The chemical analyses were of antioxidant value, total phenolic, flavonoids, and tannins, each carried out twice, and the experiment and the replication were repeated twice. This procedure is based on research Pujimulyani *et al*. (2019) research that blanching for 5 minutes can increase the antioxidants of food ingredients.

There is no specific treatment for different soils planted with *temu mangga*. The first stage includes the preparation stage (sorting, peeling, and washing) and the implementation stage (blanching and analysis). The preparation stage is sorting, stripping, and washing. The CM sorting stage selects the main, 1st tiller, and 2nd tiller parts of the rhizome. The appearance of rhizome parts is indicated in Figure 1.

Figure 1a. Main rhizome

Figure 1b. 1st tiller

Figure 1c. 2nd tiller

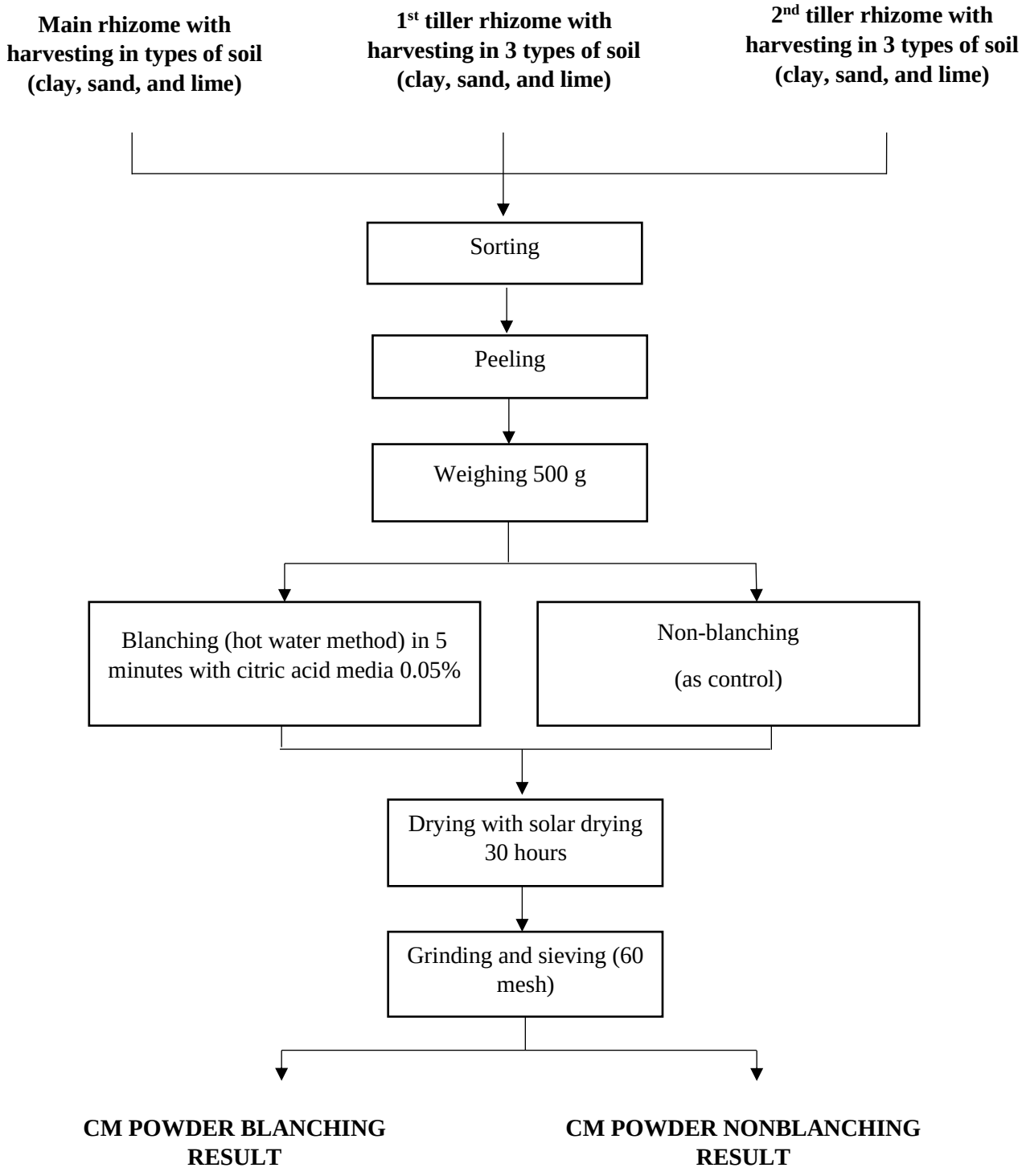

Figure 2. The flowchart of CM powder preparation

Stripping is done after rhizome sorting and continues in the washing stage, which aims to remove the remaining dirt carried during the stripping stage. The CM rhizome is put into a water-filled basin until the entire material is submerged. The last washing of the material is rinsed with running water.

The implementation stage includes the blanching stage and the analysis stage. The blanching stage is performed with 0.05% citric acid media for 5 minutes. After that, the blanched CM was dried using a cabinet dryer for 30 hours; after drying, it was ground and sieved (60 mesh). Blanching and non-blanching are variables to analyze. The blanching stage is carried out with 0.05% citric acid media. The chemical analysis includes analysis of antioxidant activity, total phenolic, flavonoids, and tannins. The flowchart of CM powder preparation is presented in Figure 2.

Antioxidant Activity Analysis

A 0.2 ml aliquot of the sample was added with 3.8 ml of 0.1 mM DPPH solution. The blank solution was prepared by mixing 0.2 ml ethanol with a 3.8 ml DPPH solution and then mixed using a vortex. All mixtures were incubated at 37 °C for 30 minutes and protected from sunlight. Absorbance was then measured at a wavelength of 517 nm. The radical scavenging capacity was expressed as %RSA (Radical Scavenging Activity) (Volden *et al*., 2008). Antioxidant activity is calculated using the following equation:

$$\%RSA = \frac{Abs\ control - Abs\ sampel}{Abs\ control} \times 100\% \quad (1)$$

Total Phenolic Content Analysis

A 15 µl sample, 250 µl Folin-Ciocalteu solution was added and allowed to stand for 1 minute, 750 µl $NaCO_3$ 20% was added, vortexed, and distilled water was added to a volume of 5 ml. After incubation for 2 hours at room temperature, the absorbance was measured at λ 760 nm (Pujimulyani *et al*., 2010). Phenolic content is calculated using the following equation:

$$\text{Phenolic content (mg GAE/g wb)} = \frac{Conc.ppm \times 100}{Sample\ weight} \quad (2)$$

$$\text{Phenolic content (mg GAE/g db)} = \frac{Phenol\ content\ wb}{dry\ weight\ of\ sample} \quad (3)$$

Flavonoids Analysis

The principle is based on adding distilled water, 10% $NaNO_2$ reagent, 10% $AlCl_3.6H_2O$, and 10% NaOH. Absorbance was measured at λ 510 nm against the distilled water blank (Dewanto *et al*., 2002). The total flavonoid content was calculated using the quercetin standard and expressed as mg quercetin equivalent (QE)/g. Flavonoids are calculated with the following equation.

$$Flavonoid\ (ppm) = \frac{Conc.ppm - dilution\ factors}{Sample\ weight\ (wb)} \quad (4)$$

Tannin Analysis

The principle is that by adding Follin-Denis reagent to the sample containing tannin, a blue-colored complex bond will be formed, which can be measured. The absorbance is measured at λ 725 nm. The tannin content was quantified as milligrams of equivalent catechin (EC) per 100 grams of dry extract using a calibration curve (8.9-44.4 mg/L) with an R-value of 0.99 (Maryati *et al*., 2020).

Statistical Analysis

The research results were analyzed using Analysis of Variance (ANOVA) with a significance level of 95%. If a significant difference was found, further testing was conducted using the Duncan Multiple Range Test (DMRT) with IBM SPSS ver 25.

RESULT AND DISCUSSION

Antioxidant Activity

Table 1 shows that rhizome part, soil type, and blanching treatment affect the antioxidant activity of CM powder. The main part has higher antioxidant activity than the 1st and 2nd tillers, which are thought to be higher phenolic compounds in the main rhizome part connected to the roots. This is related to the role of roots in collecting and storing these compounds. Roots are part of the plant responsible for absorbing nutrients and chemical compounds from the soil. The highest curcumin content is found in the pith, followed by the 1st and 2nd tillers (Nihayati, 2023). Curcumin is a phenolic compound that is a source of antioxidants. The active components in *temu mangga* do not only include curcumin but also other compounds, such as phenolic compounds like catechin, epigallocatechin, and epigallocatechin gallate (Pujimulyani *et al*., 2013). Clay soil has good nutrient content and high water retention capabilities. *Lime* soil can influence soil acidity levels (pH) and provide calcium. Sandsoil tends to have good drainage and low water retention.

The antioxidant value of CM ranges from 70.98-82.50% RSA. The antioxidant activity of the main with blanching treatment was higher when grown on clay and sand soil. The correlation between sand soil and the increased antioxidant activity in the main rhizome can be associated with the plant's response to environmental stress (Hussein *et al*., 2019). When exposed to environmental stressors,

Table 1. Antioxidant value of CM grown on 3 types of soil

Sample		Antioxidant activity (%RSA)		
		Clay	Lime	Sand
Main	Blanching	82.38 ± 0.32^{j}	79.98±0.84^{hi}	82.50±0.76^{j}
	Non-blanching	80.59 ± 0.59^{i}	78.83±0.22^{gh}	80.40±0.75^{hi}
1st tiller	Blanching	80.18 ± 0.25^{hi}	77.23±0.59^{f}	75.47±0.22^{de}
	Non-blanching	79.09±0.09^{gh}	75.74±0.30^{e}	75.12±2.21^{de}
2nd tiller	Blanching	77.76±0.18^{fg}	74.00±0.28^{cd}	72.30±0.05^{ab}
	Non-blanching	75.56±0.51^{de}	73.40±0.18^{bc}	70.98±0.81^{a}

Notes: Numbers followed by the same superscript letter indicate no significant difference ($p < 0.05$)

Table 2. The phenolic content of CM grown on 3 types of soil

Sample		Phenolic Content (mg GAE/100 g db)		
		Clay	Lime	Sand
Main	Blanching	674.50±0.15^{k}	549.00±0.01^{i}	433.50±0.02^{cdef}
	Non-blanching	586.00±0.58^{j}	519.65±0.00^{gh}	422.67±0.01^{cde}
1st tiller	Blanching	478.00±0.85^{fgh}	505.60±0.01^{ghi}	365.00±0.01^{ab}
	Non-blanching	459.50±0.06^{efg}	481.99±0.00^{fgh}	345.26±0.01^{ab}
2nd tiller	Blanching	478.00±0.85^{fgh}	505.60±0.01^{ghi}	365.00±0.01^{ab}
	Non-blanching	459.50±0.06^{efg}	481.99±0.00^{fgh}	345.26±0.01^{ab}

Notes: Numbers followed by the same superscript letter indicate no significant difference ($p < 0.05$)

plants often produce higher levels of secondary metabolites, including antioxidants. Clay soil is optimal for CM growth because it can retain water and has nutrients for plant growth. Clay can store large amounts of water because the pores have high absorption (Kumari & Mohan, 2021). The surface of the clay is wide, so it can bind water and nutrients.

The %RSA value of CM blanching is higher than non-blanching. The increase in antioxidant activity is thought to be due to the fact that the blanching treatment facilitates the release of antioxidant compounds from the cells, thus increasing the extraction yield. Sambiloto extracts experienced an increase in antioxidant value because total phenolic and flavonoids increased (Usman *et al*., 2022). A 0.05% citric acid solution for blanching media can increase the antioxidant value. This is due to the hydrolysis of glycoside compounds into aglycones and sugars (Nurisyah *et al*., 2019). The high-temperature-heating process can also increase the total phenol content. Broccoli treated with blanching has increased antioxidant activity (Çubukçu *et al*., 2019).

Total Phenolic Content

The results of the analysis of the total phenol content of CM powder in Table 2 show a significant difference between rhizome parts. However, there is no significant difference between 1st tiller and 2nd tiller. The blanching treatment in white turmeric rhizomes in the above data does not damage phenolic compounds significantly, resulting in no significant difference in the outcomes. Rhizome parts, soil type, and blanching treatment affect total phenolic content. The difference in phenolic content between 1st tiller and 2nd tiller is suspected to be due to environmental factors such as light, temperature, and humidity, which influence secondary metabolite compounds, including phenolic (Ekawati & Saputri, 2022). The total phenolic content of CM blanching is higher than fresh. This suggests that blanching may deactivate enzymes. Heat can influence enzyme activity, resulting in an increased production of phenolic. Heat treatment causes cell wall damage, which allows more phenolic compounds to be extracted and results in an increase in total phenolic values (López-Gámez *et al*., 2020). The phenolic compounds are hydrolyzed phenolic

Table 3. Flavonoid levels of CM grown on 3 types of soil

Sample		Flavonoid Content (mg QE/100 g db)		
		Clay	Lime	Sand
Main	Blanching	620.20±0.00^{m}	540.90±0.00^{l}	220.30±0.01^{d}
	Non-blanching	540.90±0.02^{l}	530.30±0.02^{k}	170.20±0.00^{c}
1st tiller	Blanching	520.40±0.00^{j}	520.50±0.05^{j}	150.50±0.06^{b}
	Non-blanching	500.50±0.01^{i}	390.50±0.01^{g}	150.60±0.00^{b}
2nd tiller	Blanching	410.50±0.00^{h}	360.10±0.01^{f}	150.20±0.00^{b}
	Non-blanching	390.30±0.01^{g}	350.20±0.01^{e}	140.30±0.00^{a}

Notes: Numbers followed by the same superscript letter indicate no significant difference ($p < 0.05$)

Table 4. The tannin content of CM grown on 3 types of soil

Sample		Tanin Content (mg CE/100g)		
		Clay	Lime	Sand
Main	Blanching	167.07±0.30^{l}	133.23±0.32^{gh}	133.51±2.91^{h}
	Non-blanching	160.10±0.32^{k}	121.31±1.92^{ef}	126.50±1.80^{fg}
1st Tiller	Blanching	152.02±0.10^{j}	114.84±8.58^{d}	117.36±2.02^{de}
	Non-blanching	148.93±0.40^{j}	107.43±3.01^{bc}	112.38±2.02^{cd}
2nd Tiller	Blanching	140.07±0.27^{i}	103.56±0.80^{ab}	108.84±2.50^{bc}
	Non-blanching	130.11±0.72^{fg}	100.55±0.09^{a}	104.03±0.13^{ab}

Notes: Numbers followed by the same superscript letter indicate no significant difference ($p < 0.05$)

that will increase after heat treatment (Diniyah *et al*., 2020). Heat treatment can increase total phenolic due to the degradation of complex phenolic compounds into simpler ones (Pujimulyani *et al*., 2013).

The main CM root has higher phenolic content than the 1st and 2nd tillers because the compounds contained are different. Roots and rhizomes usually contain alkaloids (Dirks *et al*., 2021).

The main CM grown on clay soil has the highest total phenolic content. This is because in sandy and limestone soil, nutrients and water that are necessary for the growth of CM are not maximally available. Sand soil has low organic matter content and has low water storage ability (Lal, 2020). Limestone soil has low nutrients, which negatively affects metabolism, growth, and plant development (Febriati & Rahayu, 2019).

The total phenolic content ranged from 316.17 to 647.50 mg EAG/100 g db. The difference in total phenolic content is thought to be influenced by the type of CM soil. The highest total phenolic content is found in the main rhizome after blanching. Several factors, such as technology, genetics, and the environment, influence total phenolic content (Febriyanto *et al*., 2021).

Flavonoids Content

Table 3. shows that rhizome part, soil type, and blanching treatment significantly affect the flavonoid content of the CM powder. Main has a higher flavonoid content than the 1st and 2nd tillers. This is thought to be because the main has a diameter of 5.3 cm and the tiller 2.2 cm. The components in each part of the rhizome are the same, but it is suspected that the components in the main rhizome are more abundant compared to tiller 1 and 2 due to a higher synthesis. The measurement of the rhizome section was used to calculate the flavonoid cell density, with the main section exhibiting a flavonoid secretory cell density of 0.23 cells/mm² (Trimanto *et al*., 2018). Flavonoid levels of CM grown in clay soil are higher than in the other two types of soil because they serve as the most optimal planting medium. Clay soil exhibits low permeability, high cohesion, a capillary water rise, a high shrinkage growth rate, and a slow consolidation process, making it an excellent medium for the growth of CM plants (Hadiyatmo, 1999).

The flavonoid content of CM blanching is higher than fresh, this is because the blanching process can make flavonoid compounds easily extracted. Blanching of *Schinus terebinthifolius* makes the total flavonoid value can increase significantly (Dedvisitsakul & Watla-iad, 2022). The types of phenolic and flavonoid compounds in each plant are different. The heat treatment applied can also affect the total phenolic value to increase or decrease (Oziewicz *et al*., 2020).

Tannins Content

Table 4. shows that the rhizome section, soil type, and the blanching process significantly affect the tannin content. The tannin content of the main was higher than the 1st and 2nd tillers. The tannin value of CM grown in clay soil is higher than in sand and limestone soil. This is because the sand soil and limestone soil have fewer nutrients. Sandsoil has a sandy texture, grained, loose consistency, and porosity, so water and nutrients' buffer capacity is low. Sand soil texture dramatically affects the status and distribution of water (root system, root depth, nutrients, and pH) (Cai *et al*., 2021).

The tannin content of blanched CM was higher than non-blanching. The blanching results of CM 1st tiller show a higher tannin component compared to 2nd tiller. It was observed that the more branches in the rhizome part, the fewer secondary metabolites measured in the rhizome. Tannin compounds are polyphenols that have a bitter taste and can strengthen the network to produce a stable product shape and texture (Ikrawan *et al*., 2019)The tannin content of blanched CM is higher because the compound was condensed, so the amount remains high compared to non-blanching. It is suspected that the decrease in tannin levels is also influenced by its water-soluble nature, so the blanching process treatment results in more tannins dissolved in the blanching media.

CONCLUSIONS

Rhizome parts and soil types affect the antioxidant compound of CM. The main rhizome with clay soil type and blanching treatment produced CM with selected antioxidant compounds. The selected CM has antioxidant activity of 82.50% RSA, total phenolic 647.50 mg EAG/100 g db, flavonoids 620.2 mg QE/100 g db and tannins 167.07 mg EC/100 g db.

ACKNOWLEDGEMENT

Thank you to CV. Windra Mekar for funding the research.

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