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Physicochemical Characteristics and Antioxidant Activities of Functional Beverages with *Phaleria macrocarpa* (Scheff.) Boerl Fruit

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Abstrak: *Phaleria macrocarpa (Scheff.) Boerl or mahkota dewa fruit contains flavonoids that can be beneficial as antioxidant, it can be processed to functional beverages. The brewing process is an important stage, it can influence the antioxidant activity. This study aims to analyze the physicochemical characteristic and antioxidant activity of mahkota dewa fruit functional beverage with variation in brewing temperature. Dried mahkota dewa fuit was measured the water and ash content, then functional beverage was made with variation of brewing temperature of 60, 80, and 100 °C. The functional beverages were subjected to physicochemical test (organoleptic and pH) and antioxidant activity with DPPH method. The result of water content of dried mahkota dewa was 7,159% and ash content was 0,048%. The physicochemical characteristic of mahkota dewa fruit functional beverage was light brown color, distinctive aromatic smell of mahkota dewa, sour and bitter taste, and pH 6,298-6,301. The antioxidant activity interpreted in IC50. The IC50 in temperature 60 °C was 129,67 ppm (medium category), temperature 80°C was 99,23 ppm (strong category) and temperature 100°C was 94,84 ppm (strong category). The result showed that the antioxidant activity of mahkota dewa fruit functional beverages increased with increasing brewing temperature. The strongest activity at temperature 100°C.*

BACKGROUND

The use of traditional medicines and herbal medicines derived from plants (herbal remedies) are continues to increase, as evidenced by the growing number of herbal medicine/pharmaceutical industries producing them. Several reasons for this growing use include their accessibility, affordability, and potential efficacy. One medicinal plant that has received much attention in recent years is the mahkota dewa plant.

Mahkota dewa (*Phaleria macrocarpa* (Scheff.) Boerl.) originates from Papua. The parts of the plant used medicinally are the leaves, flesh, and skin of the fruit. The leaves and skin of the fruit

can be used fresh or dried, while the flesh of the fruit is used after drying. The leaves and skin of mahkota dewa contain alkaloids, saponins, flavonoids, essential oils, and tannins. Mahkota dewa leaves contain antihistamines, alkaloids, saponins, and polyphenols (lignans). The skin of the fruit contains alkaloids, saponins, and flavonoids. The mahkota dewa fruit contains alkaloids, saponins, flavonoids, and polyphenols. The mahkota dewa can be used by eating or drinking, and as an external medicine by applying it to the skin. Empirically, this plant is used for diabetes, liver disease, hypertension, heart disease, cancer, gout, rheumatism, kidney disease, and for minor ailments such as eczema or acne (Meiyanti, et. al., 2022). Mahkota dewa is also known to have antioxidant activity with flavonoid content which plays a major role as an antioxidant (Sirumapea et al., 2022).

Antioxidants can be broadly defined as substances that delay or inhibit oxidative damage to target molecules. The main characteristic of antioxidants is their ability to trap free radicals. Antioxidants are needed by the body to protect it from free radical attacks that can damage cellular components such as DNA, lipids, proteins, and carbohydrates. This reaction occurs continuously in the body and, if left unchecked, can cause diseases such as premature aging, heart disease, skin cancer, cataracts, and other degenerative diseases. Cells of living organisms have defense mechanisms that prevent free radical production and oxidative damage in the form of natural and synthetic antioxidants. The use of synthetic antioxidants such as butylated hydroxytoluene (BHT), butylated hydroxyanisole (BHA), and terbutylated hydroxyquinone (TBHQ) is known to be carcinogenic and should not be added to food, thus limiting its use Natural antioxidants are naturally produced by animals, plants, and the body and can be used as traditional therapeutic agents (Sirumapea et al., 2022). Antioxidants can be produced endogenously within the body or obtained from exogenous sources outside the body (Fadlilah & Lestari, 2023). This is necessary to prevent the formation of oxidative stress, which is characterized by an imbalance between oxidants and antioxidants in the body. In conditions of oxidative stress, there are changes in endogenous antioxidant activity and also increased oxidative damage to biomolecules. Excessive oxidative stress can be controlled by regulating intake, especially antioxidant sources (Khadim & Al-Fartusie, 2021). Antioxidant sources can be obtained from functional foods in the form of food or drinks.

Functional beverages are a type of functional food. Functional foods are foods or beverages that, due to their active components beyond their nutritional content, provide health benefits, are part of a daily diet, and have acceptable sensory properties. Functional foods offer health benefits and a lower risk of side effects and drug dependence, making them a preferred natural, healthy lifestyle alternative to medications (BPOM, 2019). Functional beverages have been widely developed using natural ingredients such as tea leaves and spices, known as herbal ingredients. These beverages are also quite easy to prepare, either by boiling or brewing. The processing of herbal plants is crucial in the production of functional beverages (Amriani, et al., 2019). The temperature during the brewing process can affect the antioxidant activity of functional beverages. This study aimed to determine the physicochemical characteristics and antioxidant activity of a functional beverage made from mahkota dewa fruit (*Phaleria macrocarpa* (Scheff.) Boerl) at varying brewing temperatures.

MATERIALS AND METHODS

The type of reseach used is experimental laboratory. The dried mahkota dewa were tested for water and ash content, then processed with different brewing temperature (60, 80, and 100°C). The evaluation of mahkota dewa functional drink includes organoleptic, pH, and antioxidant activity

using UV Vis Spectrophotometry. The research flow can be seen in Figure 1.

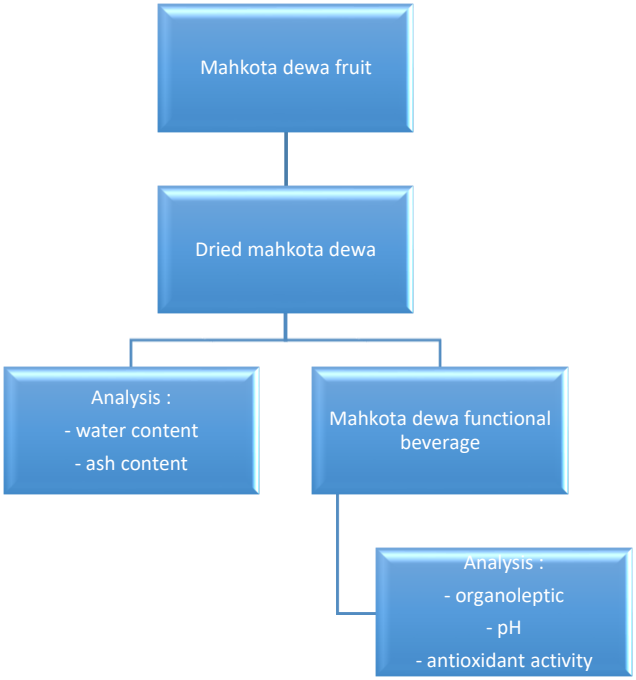

Figure 1. Research flow

1. **Tools and Materials**

   The tool used are UV Vis Spectrophotometry (Thermo Scientific), oven drying (Memmert), grinder, 60 mesh sieve, muffle furnace, hotplate, analytical balance (Satorius), pH meter, crucible cup, volumetric flask (Pyrex), beaker glass (Pyrex), and micropippete (Hitech). The materials used are the mahkota dewa plant which obtained from a plantation in Tawangmangu area and has been determined at the Pharmaceutical Biology Laboratory of Gadjah Mada University, 2,2-diphenyl-1-picrylhydrazyl (Sigma Aldrich), and methanol (Merck).

2. **Drying Process**

   The mahkota dewa fruit is sorted and washed thoroughly using running water. The seeds and shells of the fruit are removed, leaving the flesh. The flesh is cut crosswise using a stainlesssteel knife with a thickness of ± 0.3 cm, then dried in an oven at 60°C until dry and broken. Next, the dried mahkota dewa fruit was powdered using a grinder and sieved with a 60 mesh sieve. The dried mahkota dewa fruit powder then tested for water content and ash content before being made into a functional beverage.

3. **Water Content of Mahkota Dewa Fruit Powder**

   Moisture content was determined using the oven method, which calculates the difference in sample weight before and after combustion until the weight is constant. The sample was weighed as much as 1 gram and placed in a tared container. Then dried at 105°C for 5 hours and weighed. Drying was continued and weighing was carried out at 1-hour intervals until the difference between two consecutive weighings was no more than 0.25% (Kementerian Kesehatan Republik Indonesia, 2017).

4. **Total Ash Content of Mahkota Dewa Fruit Powder**

Determination of ash content using a muffle furnace. A porcelain cup is cleaned and heated in an oven for 15 minutes, then placed in a desiccator until cool, then weighed. A sample of 2 g is weighed and placed in a porcelain cup, then heated using an electric bath in a fume hood until the smoke on the sample disappears and the sample color turns black. Next, the sample is opened by placing it in a muffle furnace at a temperature of 550°C until it turns to ash. Place it in the oven for 15 minutes, after which it is placed in a desiccator until cool, then weighed (Zainuddin, et. al., 2023).

5. Processing of the Mahkota Dewa Functional Beverage

Traditionally, mahkota dewa functional beverage is made by boiling dried mahkota dewa fruit in water at high temperatures (100°C) until half the water remains. High temperatures and long periods can damage the bioactive components in mahkota dewa fruit, weakening its antioxidant activity. This study was conducted by soaking 5 g of dried mahkota dewa fruit in 250 ml of water at temperatures of 60, 80, and 100°C in a covered glass until the total solids dissolved. Furthermore, the mahkota dewa fruit drink was tested for organoleptic, pH, and antioxidant activity.

6. Organoleptic

Organoleptic testing is based on the sensory process. Organoleptic testing of powdered drinks includes color, odor, and taste.

7. pH value

The pH testing is performed using a pH meter. The meter is dipped into the sample until an indicator number appears on the meter screen, indicating the sample's pH value (Dwiloka, et.al., 2022).

8. Antioxidant Activity Test

Antioxidant activity testing was carried out using the DPPH (2,2-diphenyl-1-picrylhydrazyl) method with quercetin as a comparator. The DPPH solution was prepared with concentration 50 ppm in methanol solvent, then measured for its maximum wavelength in the range 400-500 nm. The standard quercetin and sample was prepared with a concentration 20, 40, 60, 80 and 100 ppm in methanol solvent. The antioxidant test was carried out by taking 2 ml of standard quercetin solution and samples at each concentration, then adding 2 ml of DPPH solution. Each solution was incubated at room temperature in a dark room for 30 minutes, then the absorbance is measured using a UV-Vis spectrophotometer at the maximum wavelength. Antioxidant activity is determined by the *inhibition concentration* (IC50) value. The IC50 is the antioxidant concentration (ppm) that can reduce free radicals by 50% compared to the control through a linear equation.

RESULT AND DISCUSSION

The mahkota dewa plant which obtained from a plantation in Tawangmangu area and has been determined at the Pharmaceutical Biology Laboratory of Gadjah Mada University (No. 27.27.9/UN1/FFABF/PT/2021) to ensure the truth of the plant. The mahkota dewa fruit is sorted and washed thoroughly using running water. The seeds and shells of the fruit are removed, leaving the flesh. The flesh is cut crosswise using a stainlesssteel knife with a thickness of ± 0.3 cm, then dried in an oven at 60°C until dry and broken. Then, the dried mahkota dewa fruit was powdered using a grinder and sieved with a 60 mesh sieve. The dried mahkota dewa fruit powder then tested for water and ash content before being made into a functional beverage.

Water content is one of the physical properties of the material which shows the amount of water contained in the material. Water content is usually expressed as a percentage of water weight

to wet material or in grams of water for every 100 grams of material called wet basis water content. The weight of dry or solid material is the weight of the material after having been heated for a certain amount of time so that the weight remains (constant). Ash content is a mixture of inorganic or mineral components found in a portion of food. Food consists of 96% inorganic material and water, while the rest is mineral elements. Determination of total ash content can be used for various purposes, including determining whether the processing is good or not, knowing the type of material used, and determining the nutritional value parameters of a food ingredient. That the ash content is an inorganic substance leftover from the combustion of organic material. The ash content and composition depends on the type of material and how it is ignited. (Anggraini, et. al., 2019). The result of water and ash content of dried mahkota dewa can be seen in table 1.

Table 1. Water and Ash Content Result of Dried Mahkota Dewa

Parameter	Result	Requirement
Water content	7,159 %	<10%*
Total ash content	0,048 %	<5,6%*

*Requirements source from Indonesian Kementerian Kesehatan Republik Indonesia (2017)

The water content result of dried mahkota dewa fruit is 7,16 % which means that the dried mahkota dewa fulfilled the water content requirements for mahkota dewa fruit based on the Indonesian Herbal Pharmacopoeia (Kementerian Kesehatan Republik Indonesia, 2017). The presence of water is often related to the quality of products, as a measure of dry or solid parts, determinants of stability indexes during storage, and determinants of organoleptic quality (Anggraini, et. al., 2019). High water content can serve as a medium for the growth of bacterial and fungi which can degrade the active compounds in the simplicial (Mulyati, et.al., 2025).

The total ash content of dried mahkota dewa fruit is 0,048 %, while the requirement of total ash content in dried mahkota dewa is no more than 5,6% based on Indonesian Herbal Pharmacopoeia (Kementerian Kesehatan Republik Indonesia, 2017). High levels of heavy metals can endanger health, therefore it is necessary to determine the total ash content and acid insoluble ash content to provide assurance that the extract does not contain certain heavy metals exceeding the specified value because it is dangerous (toxic) for health (Yanti, et. al., 2022).

The water content and total ash content result of dried mahkota dewa have fulfilled the requirements so it's safe to be use as functional beverage. The functional beverage was made by soaking 5 g of dried mahkota dewa fruit in 250 ml of water at temperatures of 60, 80, and 100°C in a covered glass until the total solids dissolved. Furthermore, the mahkota dewa fruit drink was tested for organoleptic, pH, and antioxidant activity. The result of physicochemical characteristic can be seen in table 2 and antioxidant activity can be seen in table 3.

Table 2. The Physicochemical Characteristic of Mahkota dewa Functional Beverage

Parameter	Brewing Temperature (°C)		
	60	80	100
Organoleptic			
- **Color**	Light brown	Light brown	Light brown
- **Odor**	Aromatic of mahkota dewa	Aromatic of mahkota dewa	Aromatic of mahkota dewa
- **Taste**	Sour and bitter	Sour and bitter	Sour and bitter
pH	6,301	6,299	6,298

Based on table 2, the mahkota dewa functional beverages has light brown color, distinctive aromatic smell of mahkota dewa, sour and bitter taste and pH value 6,298-6,301. The brown color can be caused by tannin and flavonoid compounds that are oxidized when the mahkota dewa dried (Yuliana, et.al., 2020). The mahkota dewa functional beverages has a distinctive aromatic smell due to the essential oil content. According to Rayman et. al., (2020), the mahkota dewa fruit contains bioactive compounds such as alkaloids, flavonoids, saponins, tannins, phenols, lignans, sterols and essential oils. The sour and bitter taste of mahkota dewa functional beverages can be caused by alkaloid, saponin, tannin and phenol compounds. The pH value of the mahkota dewa functional beverages in brewing temperature 60°C is 6,298; in brewing temperature 80°C is 6,299 and in brewing temperature 100°C is 6,301. The pH of solution will decrease (become more acidic) as the temperature increases. This occurs because higher temperatures increase the ionization of water, creating more hydrogen ions (H^+), and affecting the pH meter electrode.

Table 3. The Antioxidant Activity of Mahkota dewa Functional Beverage

Sample	IC50 (ppm)	Antioxidant Category
Quercetin	11,89	Very strong
Brewing temperature 60°C	129,67	Medium
Brewing temperature 80°C	99,23	Strong
Brewing temperature 100°C	94,84	Strong

Antioxidant activity was determined by the DPPH method using spectrophotometry UV-Vis. The DPPH method is used to measure the level of antioxidant activity of a substance which is interpreted in the Inhibition Concentration 50 (IC50). The IC50 value is used to classify antioxidant activity in several categories, namely very strong antioxidant activity if the IC50 value is <50 ppm, in the strong category the IC50 value is in the range of 50-100 ppm, in the medium category the IC50 value is in the range of 100- 150 ppm, in the weak category the IC50 value is in the range of150-200 ppm and very weak category IC50 value >200 ppm. The IC50 value is inversely proportional to the compounds that has antioxidant activity, a lower IC50 value indicates a stronger antioxidant activity (Pujiawati, et.al., 2022).

In this study, quercetin was used as a comparison for antioxidant activity because quercetin is one of the most abundant and widespread types of flavonoids of the flavonol type in nature (plants), acting as a powerfull antioxidant (Susiani, et al., 2024), and mahkota dewa have antioxidant activity with flavonoid content which plays a major role as an antioxidant (Sirumapea et al., 2022). The antioxidant activity of quercetin was 11,89 ppm which is categorized as very strong.

The dried mahkota dewa functional beverages are made by brewing dried simplicial at different temperatures. This is because temperature can affect the antioxidant activity. The brewing temperatures used are 60, 80 and 100°C. The antioxidant activity result of dried mahkota dewa functional beverages interpreted as IC50. The IC50 in temperature 60 °C was 129,67 ppm (medium category), the IC50 in temperature 80°C was 99,23 ppm (strong category) and the IC50 in temperature 100°C was 94,84 ppm (strong category). The result showed that the antioxidant activity of mahkota dewa fruit functional beverages increased with increasing brewing temperature, the strongest antioxidant activity was obtained at brewing temperature of 100°C. Fauzan et al., (2022) stated that the higher brewing temperatures increased the antioxidant activity of pedada fruit

peel extract. This is thought to because the greater extraction of phenolic compounds such as phenols, flavonoids, and tannins. The increase in antioxidant activity is influenced by the increase in total phenol content. Increasing temperatures can accelerate the extraction of secondary metabolites from a material. This is because high temperatures can damage plant tissue, resulting in more extracted compounds. However, excessively high temperature can cause changes or damage to the structure of secondary metabolites, so the remommended maximum brewing temperature is 100°C.

CONCLUSION

The physicochemical characteristics of the mahkota dewa functional beverages was light brown in color, distinctive aromatic smell of mahkota dewa, sour and bitter taste and pH value 6,298-6,301. Antioxidant activity of the mahkota dewa functional beverages in temperature 60 °C was 129,67 ppm (medium category), in temperature 80°C was 99,23 ppm (strong category) and in temperature 100°C was 94,84 ppm (strong category). The strongest antioxidant activity was obtained at brewing temperature of 100°C.

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