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Article

Chemical Characteristics, Antioxidant Activities, and Lead (Pb)-Chelating Ability of Powdered Drinks made from Coriander (*Coriandrum sativum*) Leaves Extract

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Abstract

Coriander is one of the natural antioxidant sources that can be used as chelating agent of heavy metals, such as lead (Pb) due to the presence of its phenolic compounds. However, the coriander has only been used as one of the spices on some dishes, and the other potential benefits have not been widely explored. Therefore, the processing of coriander leaves into a ready-to-drink (RTD) powdered beverage would be one of the ways to utilize the coriander. The objective of this study was to analyze the effect of drying temperature and maltodextrin concentration on product quality of powder drink. This study applied a complete randomized design of factorial pattern with two factors. The first factor was the drying temperature of 40°C, 50°C, and 60°C, while the second factor was the addition of maltodextrin as filler with the concentration of 5%, 10%, and 15%. The optimum treatment was observed at drying temperature of 40°C with maltodextrin concentration of 15%, yielding powder drink with water content of 4.19%; solubility of 89.92%; total phenol of 131.93 mg TAE/g; primary antioxidant activity of 47.05%; secondary antioxidant activity of 79.30%; and Pb reduction ability of 95.36%.

Keywords: : antioxidant, coriander, metal-chelating, maltodextrin, powder drinks

1. Introduction

Coriander (cilantro) leaves are well known for their antioxidant properties which function as free radical binders [1]; [2]. Coriander leaves contain active phenolic compounds, such as caffeic acid, vanillic acid, p-coumaric acid, and ferulic acid (cis and trans). Flavonoids in cilantro have been identified as quercetin (an important radical binder), kaempferol, and acacetin [3]. According to the previous research, consumption of cilantro leaves can reduce the level of mercury poisoning in patients in a significant amount of time which is made possible through a mechanism of circumcision [4], [5].

Beside mercury, leads (Pb) are also heavy metals that is very dangerous for body health. Leads (Pb) are very toxic at very low levels, non-biodegradable, and possesses a very long half-life. Exposure to this heavy metal is potentially leading to death. Not only attacking blood cells, this heavy metal also attacks the kidneys since the kidneys have the ability to absorb so that heavy metals, resulting in the accumulation in the kidneys [6].

The existence of leads (Pb) in the environment generally comes from the pollution of motor vehicles, tin mines, plastic factories, paint factories, printing, tin smelting [7]. The method of removing Pb (II) ions from the body or heavy metal detoxification has been developed, for example by the process of lead therapy with

chelating agent such as EDTA, DMSA, and others. In these ways, Pb (II) ion concentration could decrease significantly, but those testing compounds are expensive and cause side health effects on the human body organs [8]; [2].

Therefore, the processing of coriander leaves into a ready-to-drink (RTD) powdered beverage would be one of the ways to utilize the coriander. Powdered drinks are processed food products in the form of powder, easily dissolved in water, easy to serve and have a long shelf life due to their low water content and large surface area [9].

In producing the powdered drinks, a drying process is required to convert the initially liquid product into ready-to-serve powder granules. According [10], the drying process in a food product aims to reduce the moisture content of the material to inhibit the development of decomposing organisms. Drying temperature factor is one of the important factors in the process of making powder drinks. The use of high drying temperatures can affect the bioactive components contained in coriander as well as the powder physical characteristics. According to [11], at a drying temperature of 60°C and with the addition of maltodextrin 20%, the best yield of curcumin powder was 26.21% compared to the drying temperature of 40°C and 50°C, which were 22.29% and 24.63%, respectively. According [12], the drying of passion fruit powder with a temperature of 50°C gave the results of antioxidant activity of 92.30% higher than drying with a temperature of 70°C at 88.21%.

Processing of coriander leaves into powder drinks was performed by adding filler ingredients, namely maltodextrin. According to [13], antioxidant activity of buni fruit powder drinks (*Antidesma bunius* Linn.) has the highest solubility value at the addition concentration of maltodextrin 20%. Another similar study showed that the best treatment of physical and chemical parameters of noni leaf powder was with the addition of maltodextrin with a concentration of 5%. Also, the organoleptic parameters for the best total value were observed on the product with the addition of 10% maltodextrin [9].

The combination of treatment with addition of maltodextrin and drying temperature of powder drink from cilantro leaf extract is needed to produce the best quality of product. Therefore, the objective of this study was to analyze the effect of drying temperature and maltodextrin concentration on product quality and to determine the optimum treatment to produce powder drink with a good quality.

2. Material and Method

All The main materials used in this research were coriander (cilantro) leaves, water, and maltodextrin. The supporting materials for analysis were distilled water, FeCl2, ferrozine, EDTA, Methanol, DPPH, tannic acid, Follin-Ciocalteu reagent (50% v/v), 96% ethanol, 2% Na_2CO_3, and Pb $(NO_3)_2$. The equipment used including baking pan, weighing bottle, glass beaker, cabinet dryer, AAS (Atomic Absorption Spectroscopy), oven, desiccator, UV-Vis-Spectrophotometer 21D, measuring flask, glass funnel, measuring cup, volume pipette, analytical balance, and blender.

The experimental design applied in this study used a Completely Randomized Design (CRD) which was arranged in two factors, where factor A consists of three levels drying temperature of 40^{o}C, 50^{o}C, and 60oC and factor B consists of three levels (concentration of maltodextrin as filler 5%, 10%, and 15%). The collected data ware analysed using the Analysis of Variance (ANOVA) and further tests using Duncan Multiple Range Test (DMRT).

2.1 Sample Preparation

Fresh coriander (cilantro) leaves were separated from the stalk, then the fresh and green leaves were selected, followed by washing with clean water until clean. The clean leaves were weighed as many of 250 grams, then blended with 500ml of water. The slurry produced was then separated between the leaves extract with the pulp by using a filter cloth. After getting the extract separated from the pulp, the leaves extract was then weighed 400 grams and maltodextrin was added with the concentration of 5%, 10% and 15%. Then, the mixture was placed in a cabinet dryer for 10 hours with variations in temperature (40^{o}C, 50^{o}C, and 60^{o}C). After the drying process, the product was reduced in size until it becomes a powder, then sieved with a 60-mesh size.

2.2 Determination of Total Phenolic Contents [14].

Preparation of standard tanic acid was carried out by dissolving 5 mg of tanic acid into distilled

water, obtaining the standard solution concentrations of 10, 20, 30, 40, 50, and 60 ppm. As many of 50 mg of sample was dissolved with distilled water in a 25-ml measuring flask and homogenized using a shaker. Then, an aliquot of 0.5 mL was taken from the solution and added with 1 ml of Follin-Ciocalteu reagent as much as 1 ml and was allowed to stand for 5 minutes. After that, 1 ml of 5% Na2CO3 was added and homogenized in the dark for 1 hour. The absorbance value was measured at a wavelength of 725 nm using a UV-VIS-Spectrophotometer.

2.3 Determination of Primary Antioxidant Activity using DPPH method [15].

The sample solution was made with a concentration of 60 ppm. Then, an aliquot of 1 ml was taken and mixed with 1 ml of DPPH solution (9.8 mg/50mL in methanol). Each mixture was vortexed and allowed to stand for 30 minutes at room temperature in a dark place. Then, the absorption was measured at a wavelength of 517 nm with spectrophotometer UV-Vis. As a control, a solution was made by mixing 1 ml of methanol-water (1: 1) with 1 ml of DPPH solution. Then, the value of primary antioxidant activity was calculated by using the formula below.

$$Primer\ Antioxsidant\ Activity\ (\%) = \frac{A_{control} - A_{sample}}{A_{control}} x100\%$$

2.4 Determininationof Secondary Antioxidant Activity using Ferrous Ion Chelating (FIC) [16].

A total of 0.5 ml of 60 ppm sample solution was added 1.85ml of distilled water. Then it was mixed with 0.5 mL 0.1 mM FeSO4 and 0.25 mM 0.5 ferrozine. After that, the solution was incubated for 10 minutes, then the absorbance was read at 562 nm. EDTA was used as a standard and the sample replaced with distilled water is used as a negative control. The amount of metal chelating activity (FIC) can be calculated by using the following formula:

$$Antioxidant\ activity\ FIC\ (\%) = \frac{(A_{control} - A_{sample})}{A_{control}} x100\%$$

2.4 Determination of Metal Reduction Capability [17].

The Pb (II) mother liquor was made by weighing as much as 0.5 g Pb (NO3)2 dissolved with distilled water in a 1000 ml flask. Then diluted to a concentration of 50 ppm. Total of 5 grams of sample were weighed, then dissolved in 100 ml of distilled water. Total of 10 ml of Pb mother liquor was put in a separating funnel and added with 10 ml of sample solution. Then the mixture was extracted using 10 ml of chloroform for one minute. The extraction process was repeated three times. After extraction, let stand for two phases (water phase and organic phase) separately. Take the water phase. The water phase was measured with an Atomic Absorption Spectrophotometer to determine the remaining Pb (II) ion concentration.

3. Results and Discussion

Analysis carried out on the raw material of fresh coriander (cilantro) leaves that were moisture content, ash content, total phenol, primary antioxidant activity of DPPH and secondary antioxidant activity by using Ferrous Ion Chelating (FIC) method. It is observed that that fresh coriander leaves have a moisture content of 82.56% and an ash content of 1.09% (Table 1). According to the USDA (2016), the moisture content of coriander leaves is 92% and the ash content is 2.5%. This difference can occur because the raw materials used may be different from the place of growth, leaf age, and sample preparation.

Table 1. The Characteristics of Fresh Coriander (Cilantro) Leaves.

Parameter	Result
Water content (%)	82.56±0.233
Ash content (%)	1.09±0.001
Total phenolic (mgTAE/g)	217.22±0.48
Secondary Antioxidant Activity (%)	92.14±0.086
Primary Antioxidant Activity (%)	51.35±0.067

Total phenolic content as well as the primary and secondary antioxidant activities in fresh coriander leaves were different from the research of [18], which stated that the primary antioxidant activity with the DPPH method of coriander leaf H2O extract by 52%, while the metal ion chelating ability showed a higher number (70%). According to [19], reported that there was a close relationship

between antioxidant activity and polyphenol components in plants. According to [18], there are many materials containing high phenolic components. Moreover, it possesses a low primary antioxidant activity whilst the secondary antioxidant activity is high. This is because the plants used are of different varieties and come from different environments, hence it affects the components contained inside.

3.1. Water content of Coriander Leaves Extract Powder

Based on the statistical data analysis, it was indicated that there was an interaction between the drying temperature and maltodextrin concentration on the water content of coriander (cilantro) leaves powder drink. The higher drying temperature and addition of maltodextrin would reduce the water content in the products. The higher drying temperature caused more water evaporated, because of which the higher concentration of filler would be absorbed. High moisture content in powdered products will greatly disrupt the stability of the product and will cause the product to clot when stored. The higher water content in a product can cause damage to the food because the activity of microorganisms quickly occurs. The water content in the coriander leaves powder can be seen at Fig 1.

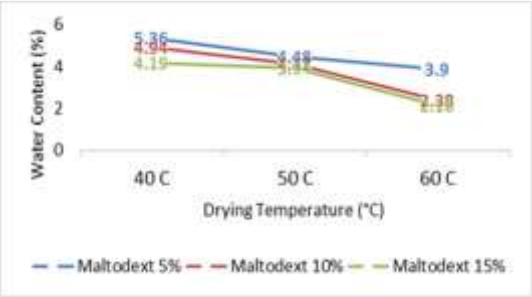

Fig. 1. Effect of drying temperature and concentration of maltodextrin on water content of powder drinks.

3.2. Solubility

Based on the results of variance analysis, it was found that there was an interaction between the drying temperature and maltodextrin concentration on solubility of cilantro leaves extract powder. In Fig.2, it is revealed that the increasing drying temperature and maltodextrin concentration leading to the higher solubility of powder drink. This is because the maltodextrin has high solubility and high drying temperature which cause the powder to have a lower moisture content, thus it is easier when dissolved in water. According to [9], the hydroxyl groups contained in maltodextrin would interact with water, so that the solubility of the powder will increase. A great abundance of free hydroxyl groups in the filler would elevate the solubility level. If the solubility value obtained is higher, it indicates the better of quality the product.

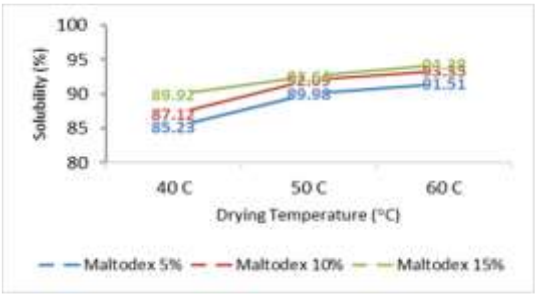

Fig. 2. Effect of drying temperature and concentration of maltodextrin on solubility of powder drinks.

3.3. Total Phenolic Content

According to the data analysis, it is found that there was an interaction between the drying temperature and maltodextrin concentration on the total phenol of coriander (cilantro) leaves extract powder. In the Fig 3, it is indicated that total phenol in the product decreases due to the high temperature during drying process. The content of phenolic compounds decreases with higher temperatures is caused by the decomposition of phenolic compounds, which is due to the fact that phenol compounds are volatile and sensitive to heat treatment [19]. By the presence of heat and oxygen, phenol compounds can be oxidized because the enzyme activity of polyphenol oxidase forms ortho-semiquinone radicals that are reactive can react further with amino compounds to form brown products with high molecular weight [20]. In addition to the higher maltodextrin concentration, the total phenol obtained was greater, which is consistent with the results of a previous study [19].

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That study on the processing of cinnamon instant powder indicated that maltodextrin as a filler serves to protect sensitive food ingredients and reduce nutrient loss due to high temperatures, add liquid food components to solid forms that are easier to handle and increase total solids.

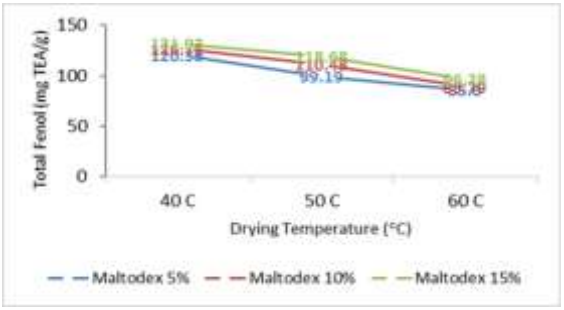

Fig. 3. Effect of drying temperature and concentration of maltodextrin on total fenol of powder drinks.

3.4. Primary and Secondary Antioxidant Activity

Based on results the analysis of variance, it was found that there was an interaction between drying temperature and maltodextrin concentration on primary antioxidant activity of cilantro leaves extract powder. In Fig 4, it is shown that the higher drying temperature and concentration of maltodextrin added to the product would decrease the primary antioxidant activity. This is due to the high drying temperature which can evaporate the antioxidant compounds and the low concentration of maltodextrin could contribute to coat the antioxidant components. Antioxidant activity increases with increasing levels of total phenols and flavonoids which are bioactive compounds that act as antioxidants [12]. According to [16], antioxidant activity and free radical captured by phenol compounds is due to hydroxyl donors on the aromatic ring, so that the decrease in total phenol levels due to heating temperature is also in line with the decrease in primary antioxidant activity in this product. Also, duration of drying and the use of high temperatures can reduce antioxidant activity [16]. Temperature is one of the most important factors affecting antioxidant activity. Generally, warming causes the acceleration of the initiation reaction and decreases in antioxidant activity [19].

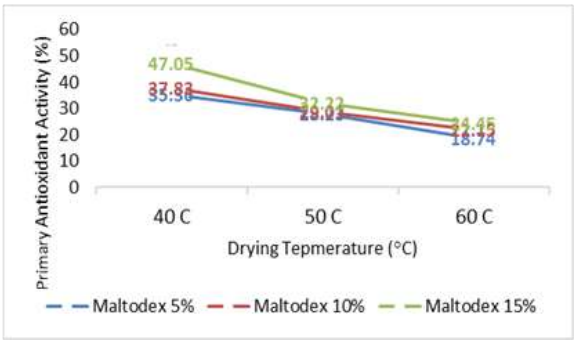

Fig. 4. Effect of drying temperature and concentration of maltodextrin on primary antioxidant of powder drinks.

Similarly, there was an interaction between the drying temperature and maltodextrin concentration on secondary antioxidant activity of cilantro leaves extract powder drink. Fig 5, shows that the secondary antioxidant activity in cilantro leaves extract powder decreases. This is caused by the phenol component decreases with increasing the temperature of the accompaniment. Metal chelating agents can originate from organic components, namely phenolic or polyphenol compounds. Organic components can function as metal chelating agents because of the presence of carboxyl groups and one phenolic group or two adjacent hydroxyl groups reacting with metal ions and forming a stable complex [15]. According to [12], there are many ingredients that have high phenolic components but have low primary antioxidant activity, but it generates high secondary antioxidant activity, which is consistent with the results of the analysis carried out on coriander (cilantro) leaves extract powder. This is also indicated on raw material analysis that the primary antioxidant activity in this product is lower than its secondary antioxidant activity.

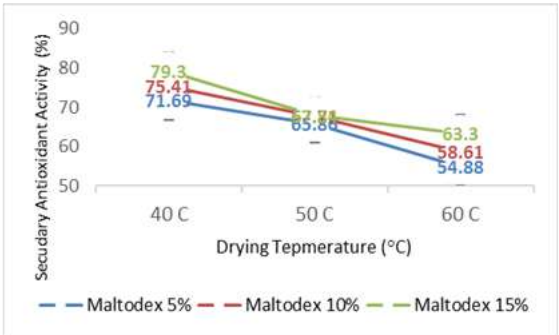

Fig. 5. Effect of drying temperature and concentration of maltodextrin on secundary antioxidant of powder drinks.

3.5. Chelating Ability of Coriander Leaf Powder on Pb Metal

Based on the results of the analysis of variance, there was no interaction between drying temperature and maltodextrin concentration on the Pb metal reduction ability of cilantro leaves extract powder. The average value ability of Pb metal reduction from coriander (cilantro) leaves extract powder can be seen in Table 2 and Table 3.

Table 2. Effect drying temperature on the chelating ability of Pb metal

Drying Temperature (°C)	**The Ability of Reducing Pb**
40	94.95[c]
50	92.38[b]
60	92.04[a]

Note: different letters following the values in each column indicates a significant difference

Table 2, it can be found that the higher drying temperature leading to the decrease of the reduction ability of Pb metal by coriander (cilantro) leaves extract powder. This is because the higher temperature can reduce of component that acts as chelating Pb metal including the phenol component. According to Samarth, *et al.* (2008), phenolic compounds such as flavonoids are not heat-resistant and easily oxidized at high temperatures. Flavonoids show different sensitivity in heat treatment depending on the structure. Flavonoids act as antioxidants by donating hydrogen atoms to free radicals or through their ability to chelate metals, in the form of glucosides (containing glucose side chains) or in the free form called aglycones (Ren, et al. 2012). The presence of one phenolic component would cause the change of polar properties in the material. The absorption mechanism that occurs between the –OH group which is bound to the surface with positively charged metal ions is an ion exchange mechanism. The interaction between –OH groups and metal ions also allow through coordination complex formation mechanisms because the oxygen atoms in the –OH group have free electron pairs (Samarth, et al. 2008).

Table 3. Effect concentration of maltodextrin on the chelating ability of Pb metal

Maltodextrin Concentration (%)	The Ability of Reducing Pb
5	91.12[a]
10	93.40[b]
15	94.84[c]

Note: different letters following the values in each column indicates a significant difference

Table 3 shows that the higher maltodextrin concentration would cause the reduction ability of Pb metal by cilantro leaves extract powder increases. This is because maltodextrin can protect volatile component such as polyphenol components in drying process. According to Ren, et al. (2012), polyphenol components, especially flavonoids, have the ability to heal or prevent oxidative stress by chelating metal ions and stopping free radical chain reactions. Phenol compounds in coriander (cilantro) leaves extract powder have been shown to reduce lead metal content. This compound can chelate heavy metals which are added to the product with the characteristics of two or more aromatic rings containing at least one or more hydroxyl groups and conjugated electron donors.

4. Conclusions

The coriander leaves extract powder drink with the drying temperature of 40oC and 15% maltodextrin concentration was the optimum treatment with a 4.19% water content; solubility of 89.92%; total phenol 131.93 mg TAE/gr; primary antioxidant activity 47.05%; secondary antioxidant activity 79.30%; Pb reduction ability 96.96%.

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