COMBINATION OF PHYSICAL METHODS AND ACTIVE CHARCOAL IN REDUCING CALCIUM OXALATE LEVELS IN KIMPUL TARO FLOUR (*Xanthosoma sagittifolium*)

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Abstract: Kimpul Taro tuber is a source of carbohydrates that is widely grown in Indonesia but contains anti-nutritional compounds, namely calcium oxalate. Calcium oxalate can cause itching, irritation, and burning sensation in the mouth, skin, and digestive tract. This study was conducted to determine the effect of the combination of physical methods and activated charcoal on the reduction of calcium oxalate levels in Kimpul taro flour from Aceh Province, Indonesia. The physical method of boiling and steaming with and without the addition of 6% activated charcoal was used in this study. The parameters observed in this study were calcium oxalate content, water content, ash content, crude fiber content, water absorption, and total starch. The results showed that physical treatment can reduce levels of calcium oxalate in Kimpul taro flour. The lowest levels of calcium oxalate were obtained in the boiling method, with calcium oxalate levels of 25.82 mg/100 g. Low oxalate Kimpul taro flour can be used as a local food raw material for food diversification and to reduce the use of wheat flour.
Keywords: Activated charcoal; boiling; calcium oxalate; kimpul; steaming

Abstrak: Talas Kimpul merupakan sumber karbohidrat yang banyak dibudidayakan di Indonesia, namun mengandung komponen anti nutrisi yang disebut kalsium oksalat. Kalsium oksalat dapat menyebabkan gatal, iritasi, sensasi terbakar pada mulut, kulit, dan saluran pencernaan. Penelitian ini bertujuan untuk menentukan pengaruh kombinasi metode fisik dan arang aktif terhadap penurunan kadar kalsium oksalat pada talas Kimpul di Provinsi Aceh, Indonesia. Metode fisik yang digunakan pada penelitian ini adalah perebusan dan pengukusan dengan dan tanpa penambahan 6% arang aktif. Parameter yang diamati adalah kadar kalsium oksalat, kadar air, kadar abu, kadar serat kasar, daya serap air, dan total pati. Hasil penelitian menunjukkan bahwa perlakuan fisik dapat menurunkan kadar kalsium oksalat pada talas Kimpul. Kadar kalsium oksalat terendah diperoleh pada perlakuan metode perebusan yaitu 25,82 mg/100 g. Tepung talas kimpul rendah oksalat dapat dimanfaatkan sebagai bahan baku pangan lokal untuk diversifikasi pangan dan mengurangi penggunaan tepung terigu.
Kata kunci: Arang aktif; kalsium oksalat; kimpul; perebusan; pengukusan

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Introduction

Kimpul taro tuber (*Xanthosoma sagittifolium*) is one of the many varieties of taro that lives in Indonesia, including Aceh Province. Kimpul tubers contain various nutritional components such as protein, fat (Jatmiko and Estiasih, 2014), vitamin C, riboflavin, thiamin, iron, phosphorus, niacin, zinc, copper, manganese, potassium, and fiber with carbohydrates as the main component (Wariyah, 2012). Generally, chemical compounds including oxalate depend on variety and growth conditions such as soil nutrition, precipitation, etc. One of the advantages of Kimpul tubers is that they contain diosgenin compounds which are known to have anti-cancer properties, have a hypoglycemic effect, and inhibit cell proliferase (Jatmiko and Estiasih, 2014). The productivity of Kimpul taro can reach 4-5 tons per hectare so it has the potential to become an alternative staple food to replace rice (Sudomo and Hani, 2014). However, Kimpul is one of the commodities that is easily damaged by microbiology, because it has a high-water content of 63.1 g (Ayu and Yuwono, 2014). Currently, Kimpul taro processing is still very simple, which is only boiled, fried, and turned into vegetables or chips (Wariyah, 2012). In addition, Kimpul taro can also be processed into taro flour to extend product shelf life and as a potential raw material for various food products such as cookies (Yuliatmoko and Satyatama, 2012), and cake (Ndisya et al., 2020). The use of Kimpul flour can reach 100% or can be substituted with wheat flour depending on the product produced (Ndisya et al., 2020). Based on Budiarti et al., (2021) Kimpul flour contains 76,85% carbohydrates, 4,81% protein, 0,31% fat, 5,81% fiber, and 319,27 Cal/100 g energy.

However, Kimpul taro contains anti-nutritional compounds, namely calcium oxalate which can cause itching, irritation, and burning sensation in the mouth, skin, and digestive tract if consumed in high amounts (Dewi et al., 2017). Oxalate is the main component of kidney stones which contain calcium oxalate crystals. Oxalates induce an inflammatory response that will decrease the immune system's ability to remove kidney crystals (Misiewicz et al., 2023). The level of calcium oxalate in Kimpul taro tubers is known to be 95.5 mg/100 g (Ukom and Okerue, 2018). Meanwhile, the limit for daily consumption of oxalate that is allowed for the body is 70 - 150 mg (Noonan and Savage, 1999). However, for people with kidney failure, daily oxalate consumption should be below 40 – 50 mg/day (Rofi'ana et al., 2018).

Calcium oxalate levels can be lowered by several methods, one of which is physical methods. Physical methods such as boiling and steaming have the advantage of being easier to apply and safer compared to other methods (Pancasasti, 2016; Dewi et al., 2017), such as chemical methods immersion with acetic acid (Rozali et al., 2021; Wardani and Arifiyana, 2020) and soaking with alcohol, salt, and vinegar (Sugiarto et al., 2022), fermentation methods used *Saccharomyces cerevisiae* and *Rhizopus oryzae* (Sulaiman et al., 2020), and a combination of physical (blanching) and chemical (soaking in salt) methods (Puspitasari et al., 2023). The ability to reduce oxalate using water is influenced by several factors including time, temperature, sample size, ratio of water to sample, and soaking media (Huynh et al., 2022). Soaking in water for 7 – 10 hours, or cooking for up to 60 minutes, can significantly reduce the oxalate content (Hang et al., 2013). Boiling was able to reduce taro oxalate levels from 1,714 ppm to 506 ppm (Catherwood et al., 2007) and the combination of soaking and boiling for 30 minutes reached a decrease of 79.53% (Amalia and Yuliana, 2013). The process of reducing oxalate levels in the boiling and steaming methods is thought to be increased by the addition of other compounds as binders, one of which is activated charcoal. Steaming taro tubers (*C. esculenta*) with the addition of 6% activated charcoal is known to reduce oxalate levels from 175.91 to 137.27 ppm (Dewi et al., 2017). Therefore, this study will produce low-oxalate Kimpul taro flour with the boiling and steaming method combined with and without the addition of 6% activated charcoal to Kimpul taro cultivated in Aceh, Indonesia. It is hoped that it can increase its utilization as a potential raw material for several food products.

Materials and Methods

Chemical materials

The chemicals used in this study for analysis are HCl (Smart Lab), H_2SO_4 (Smart Lab), NaOH (Merck), K_2SO_4 (Merck), $KMnO_4$ (Merck), and ethanol (Merck), obtained from the food and agricultural product analysis laboratory, department of agricultural product technology, faculty of agriculture, Universitas Syiah Kuala.

Preparation sample

The material used in this study was fresh taro Kimpul tubers purchased from Lambaro market in traditional Aceh Besar, Indonesia. The Kimpul taro tubers were sorted, peeled, and washed under running water to remove impurities. Fresh Kimpul taro was sliced to 1 cm thickness (Amalia and Yuliana, 2013), and separated for initial analysis.

A combination of Physical Methods and Activated Charcoal

Kimpul taro slices were then treated with boiling (T1), boiling with activated charcoal (T2), steaming (T3), and steaming with activated charcoal (T4) at a temperature of ± 99-100˚C for 20 minutes. Each treatment was carried out 3 times. The ratio of sample and water in each treatment was 1: 2 (w/v). Activated charcoal (6%) is mixed in water, but in the boiling treatment, it was wrapped in a cloth first. Furthermore, the taro Kimpul slices have been washed under running water and drained (Dewi et al., 2017). The drying process is carried out in an oven for 48 hours at 60˚C. The dried taro Kimpul slices were ground using a grinder and sieved with 80 mesh. Taro Kimpul slices were stored in closed packaging before analysis.

Observed Parameters

The parameters of chemical content were the levels of calcium oxalate (Maulina et al., 2012), moisture content, ash content, crude fiber, and total starch for the sample with the lowest level of calcium oxalate (AOAC, 2005).

Analysis of Calcium Oxalate Levels (Sulaiman et al., 2021)

Analysis of calcium oxalate levels was carried out using the titration method. The sample as much as 1 gram was put into 250 mL Erlenmeyer and suspended with 95 mL of distilled water and 5 mL HCl 6 M. The suspension was heated at 100˚C for 1 hour, followed by cooling. Add water to 125 mL and filtered using filter paper. The filtrate 62.5 mL was diluted to 150 mL and 62.5 mL was taken and then heated to a boil. Titrated with 0.1 N KMnO4 solution until it turns pink which lasts for 30 seconds. Calcium oxalate levels are calculated according to the following equation:

$$\text{Calcium oxalate} = \frac{\text{solution } KMnO_4 \text{ (mL) x 0.00225 x 2.4}}{\text{weight sample (g)x 5}} \text{ x } 10^5 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Statistical Analysis

The data were analyzed by Analysis of Variance (ANOVA) and continued analysis with Duncan's Multiple Range Test (DMRT) at a confidence level of 5% if there was a significant difference at the treatment level.

Results

The chemical content of Kimpul taro flour can be seen in Table 1. Based on the results of the study, it was found that physical treatment had a significant effect ($p < 0.05$) on decreasing levels of calcium oxalate and ash content, but no significant effect ($p > 0.05$) on the moisture content and crude fiber content in Kimpul taro flour.

Table 1. The chemical content of Kimpul taro flour

Treatment (T)	Calcium Oxalate (mg/100 g)	Water content^{tn} (%)	Ash content (%)	Crude fiber^{tn} (%)
T1 : Boiling	25.82 ± 8.20^{a}	5.55 ± 0.70	5.09 ± 0.74^{ab}	9.17 ± 1.41
T2 : boiling + activated charcoal	34.89 ± 4.22^{a}	7.48 ± 1.72	5.53 ± 0.26^{b}	7.77 ± 2.92
T3 : Steaming	48.04 ± 6.63^{b}	5.51 ± 0.92	4.25 ± 0.12^{a}	10.17 ± 1.47
T4 : Steaming + activated charcoal	38.06 ± 6.95^{ab}	7.25 ± 0.33	4.47 ± 0.20^{ab}	9.99 ± 1.86

Mean values ± standard deviation (n=3). Different letters in the same column are significantly different by Duncan's Multiple Range Test ($p < 0.05$). tn = not significant.

Discussion

Calcium Oxalate Content

The calcium oxalate level in fresh Kimpul taro was 54 mg/100 g. The calcium oxalate levels in Kimpul taro flour after treatment ranged from 25.82 - 48.04 mg/100 g (Table 1). The results obtained are comparable to previous studies using the fermentation method with *Rhizopus oryzae* microbes (24.81 mg/100 g), but it takes 72 hours, so it is less efficient (Sulaiman et al., 2020).

The decrease of calcium oxalate level in the Kimpul taro flour was greater in the boiling treatment (25.82 mg/100 g) and boiling with activated charcoal (34.89 mg/100 g) than steaming treatment (48.04 mg/100 g). Aboubakar et al., (2009) stated that there was a significant reduction in oxalate content during the boiling method compared to the steaming method, which could be caused by cooking temperature and direct contact with water. According to previous research, boiling decreased total calcium oxalate in Kimpul taro flour from 1714 ppm to 506 ppm (Pancasasti, 2016), and steaming with 6% activated charcoal reduced calcium oxalate from 175.91 to 137.27 ppm (Dewi et al., 2017). It is suspected that Kimpul taro flour will come into direct contact with water, so boiling treatment can reduce the calcium oxalate level even further. When this material comes into direct contact with boiling water, the cell wall of the material is damaged more quickly, allowing more oxalates to leak out and dissolve into the water. The solubility of calcium oxalate in water at 90^{o}C is quite high (0.0014 g/g H_2O) (Widari and Rasmito, 2018). The boiling process can dissolve calcium oxalate in the cooking water, thereby reducing calcium oxalate levels (Catherwood et al., 2007).

Boiling treatment with the addition of activated charcoal tends to have a higher calcium oxalate level. This may happen because some of the cations contained in activated charcoal such as calcium can bind with oxalate acid to form calcium oxalate. Steaming of taro tubers with the addition of 6% and 8% activated charcoal showed an increase in calcium oxalate, namely 85.46 and 124.68 (respectively), from the initial value of 75.63 (Dewi et al., 2017). This is thought to occur because the increase in the concentration of activated charcoal added is associated with an increase in the mineral calcium in taro. This calcium then binds with some of the insoluble oxalate compounds to form calcium oxalate. According to Dewi et al., (2017), the addition of activated charcoal has a significant effect on reducing total oxalate, but it is not effective in reducing calcium oxalate compounds.

The steaming treatment without and with the addition of activated charcoal had a higher calcium oxalate content value than the boiling treatment. This occurs because the steaming process only drains hot steam from boiling water and does not come in direct contact with the sample, so the process of reducing calcium oxalate levels becomes less effective.

Moisture Content

The moisture content of fresh taro Kimpul in this study was 69.26%. This result is like previous research 69.66% (Suharti et al., 2019). The average water content of taro flour can be seen in Table 1. The moisture content of taro flour ranged from 5.51 to 7.48%. The water content value of the Kimpul taro flour obtained is by the requirements of SNI 3751:2009 for the limit of the moisture content of wheat flour, which is a maximum of 14% (BSN, 2009). The water content of Kimpul taro flour obtained is low enough that it can increase shelf life because it can inhibit microbial growth and enzyme activity which can cause damage to the quality of flour (Atlaw and Kumar, 2018).

Table 1. shows that the treatment of boiling and boiling with the addition of activated charcoal tends to have a higher moisture content than steaming and steaming treatments with activated charcoal. This is most likely due to variations in the heating process and the heat contact media used. The water in the ingredients is more easily evaporated and the water content of the Kimpul taro flour is lower because steaming uses hot steam flow media and there is no direct contact between the ingredients and boiling water. The heat generated by the steam reduces tuber tissue rehydration, resulting in a decrease in the material's ability to bind water content. (Nugroho, 2013). In the boiling method using hot water media, there is direct contact between the sample and water. Therefore, the bonds between the components in the sample are broken so that they tend to bind with boiling water (Sulthoniyah et al., 2013). It is assumed that more water enters the sample so that the water content of the sample increases and it is more difficult to get out. Previous research stated that the percentage of water content in Kimpul taro flour using the boiling method at 95^{o}C for 20 minutes was 6.63% (Putra et al., 2017).

Ash Content

The average value of the ash content of Kimpul taro flour ranged from 4.25-5.53% (Table 1). Kimpul taro flour with the lowest ash content value (4.25%) was obtained in the steaming treatment and the highest ash content was obtained in the boiling treatment with activated charcoal (5.53%). There was an increase in the value of the ash content in Kimpul taro flour when compared to the ash content in fresh Kimpul taro which was 1.21%. This can occur due to the influence of other nutritional content in taro flour, one of which is protein. The treatment process using high temperatures can cause denatured protein and bind with some minerals, thereby reducing the solubility value and the minerals being retained in the material (not soluble in water) (Salamah et al., 2012).

In addition, it is suspected that the drying time and temperature can cause greater evaporation of water which tends to increase the ash content in the flour. This is due to previous reports that factors in the type of material, method of ashes, drying time, and temperature can affect the results of ash content (Erni et al., 2018).

Boiling and steaming treatments with the addition of activated charcoal also have higher ash content than those without the addition of activated charcoal. This may happen because activated charcoal contains potassium, calcium, magnesium, and silicon cations which can accumulate in the sample (Dewi et al., 2017).

Crude Fiber

The percentage of the crude fiber content of Kimpul taro flour ranged from 9.17-10.17% (Table 1). When compared to the crude fiber content in the steaming treatment, the boiling treatment with and without activated charcoal had lower crude fiber content, 9.17%, and 7.77%, respectively (without and with the addition of activated charcoal). The results obtained were following previous research which states that taro flour with boiling treatment has a lower fiber content. Boiling treatment can result in the rupture of the lignin in the plant cell wall due to the high temperature and duration of boiling, resulting in a decrease in crude fiber content (Amon et al., 2014). In general, the process of cooking food at high temperatures such as boiling and steaming does not affect the crude fiber content contained in the sample. This may occur because of the characteristics of crude fibers that are difficult to decompose even in high temperatures and long heating times (Nilasari et al., 2017).

Total Starch

The total starch analysis was carried out on samples with the lowest levels of calcium oxalate, namely Kimpul-Boiled taro flour. The total starch content of Kimpul taro flour in the boiling treatment was 28.65%. Previous research showed that different boiling temperatures and times affect the total starch content of taro flour. Kimpul taro flour had a total starch content of 52.76% and 55.04% after boiling at 75^{o}C for 10 and 20 minutes, respectively. Kimpul taro flour had a total starch content of 50.79% and 55.04% after boiling for 20 minutes at temperatures of 85^{o}C and 95^{o}C (respectively) (Putra et al., 2017).

The total starch of fresh Kimpul taro in this study was obtained at 36.74%, different from the previously reported 21.98% (Suharti et al., 2019). The total starch content of Kimpul taro flour in boiling treatment (28.65%) decreased when compared to fresh Kimpul taro (36.74%). This decrease is thought to have occurred due to swelling of the sample starch granules during the boiling process so that it undergoes gelatinization. This is in line with the opinion of previous researchers who reported that there was a decrease in the starch content of cotton seed flour that was boiled for 30 minutes due to gelatinized starch (Diana, 2016). The low yield of total starch obtained is also thought to be due to taro's mucus content inhibiting the starch hydrolysis process (Suhery et al., 2015).

Conclusion

Physical treatment had a significant effect on decreasing levels of calcium oxalate and ash content of Kimpul taro flour. Kimpul taro flour with boiling treatment had the lowest calcium oxalate content (25.82 mg/100 g). Boiling treatment with activated charcoal had a slightly higher oxalate content, namely 34.89 mg/100 g. A straightforward boiling treatment showed that it produced low-oxalate Kimpul taro flour. Low-oxalate Kimpul taro flour is safer for consumption and can be used as raw food material.

Conflict of interest

The authors declare that there is no conflict of interest. Authorship contribution statement:
Santi Noviasari (Author 1): Conceptualization, methodology, data analysis, writing draft, review, and submitting article.
Zaidiyah (Author 2): Data analysis, evaluating, writing draft, and editing
Yanti Meldasari Lubis (Author 3): Methodology, validation, and review.

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