Decreased of calcium oxalate levels in the purple taro flour 
(*Colocasia esculenta*) from Aceh Province, Indonesia using 
three immersion methods

Z F Rozali1*, Zulmalisa Z1, I Sulaiman1, Y M Lubis1, S Noviasari1, K Eriani2, and 
C W Asrizal3

1Department of Agricultural Product Technology, Faculty of Agriculture, Universitas 
Syiah Kuala 
2 Department of Biology, Faculty of Mathematics and Natural Sciences, Universitas 
Syiah Kuala 
3 Department of Medicine, Faculty of Medicine, Universitas Syiah Kuala

*Corresponding author’s e-mail: zalniatifonnarozali@unsyiah.ac.id

Abstract. Cocoyam (Araceae family) tuber, like purple taro, traditionally are used as sources of 
non-rice carbohydrates in Aceh Province, Indonesia. But it contain high calcium oxalate, which 
contributes to kidney stones formation. Immersion in strong acid (HCl) solution can reduce 
calcium oxalate. However, it will cause a very strong taste and aroma in cocoyam flour. So, it is 
necessary to use other immersion methods. This research aimed to examine the effect of the 
immersion method to reduce calcium oxalate in purple taro flour. The immersion methods used 
in this research are weak acids (CH$_3$COOH), salt (NaCl), and alkaline salt (NaHCO$_3$). Calcium 
oxalate, moisture, and ash content were the parameters observed in this study. The result showed 
that all immersion methods can reduce calcium oxalate levels in purple taro flour. The lowest 
oxalate content (42.64 mg/100 g) was obtained by the NaHCO$_3$ immersion method. The NaHCO$_3$ 
had a significant effect to decrease calcium oxalate content in purple flour.

1. Introduction

There are 3 genera from the Araceae family that are widely grown in Indonesia, namely *Alocasia, 
Colocasia*, and *Xanthosoma*. The *C. esculenta* (Eng: taro/Indo: *talas*) is the main variety of cocoyam 
grown in different parts of the world and is a good source of nutrition [1]. Indonesian people process 
leaves and stems of taro into a side dish or snack, while the tuber is processed as one of the staple foods 
other than rice. Taro contains high carbohydrates (21.2%) and protein (6.6%) and low fat (0.67%) [2].

As a source of carbohydrates, processing taro tubers into flour will expand its use as a food 
ingredient. However, taro cannot be consumed directly because it contains calcium oxalate (CaC$_2$O$_4$). 
The calcium oxalate content in taro is 187.6 - 1,096.2 mg/100 g [2] [3]. The safe limit to the consumption 
of calcium oxalate for adults was 0.60-1.25 g per day for 6 consecutive weeks [4]. Oxalate is a natural 
compound found in a variety of plant foods. There are 2 forms of oxalate in plants which are soluble 
and insoluble. In soluble form, oxalate is often found as a sodium salt. Soluble oxalate can be absorbed 
directly from food. In insoluble form, oxalate is usually found as calcium oxalate crystal. It may affect 
calcium absorption in the gastrointestinal tract, and 75% of calcium oxalate crystal contributes to kidney 
stones formation [5]. Thus, some ideas emerged that kidney stone formation could be prevented if the
calcium oxalate concentration in food plants could be decreased sufficiently. Therefore the food is safe and healthier for consumption [5]. Plant foods genetic modification or food processing is one way that can be done to reduce plant oxalate content [5]. Some food processing has been reported to decrease calcium oxalate levels.

Calcium oxalate is insoluble in water but soluble in strong acids. Generally, a strong acid (HCl) application is used to reduce calcium oxalate [4]. However, it will cause a very strong taste and aroma in cocoyam flour. So, it is necessary to use other safer methods. Some immersion methods to decreased calcium oxalate have been reported. Immersion of malanga in 20% CH₃COOH solution for 30 minutes can reduce calcium oxalate content until 66% from 1,313 to 443 mg/100 g [4]. Immersion of purple yam in 10% NaCl solution for 60 minutes can reduce calcium oxalate content until 20.96% from 1,024.4 to 807.7 mg/100g [6]. Immersion of white taro in 6% NaHCO₃ solution for 60 minutes can reduce calcium oxalate contents until 44% from 1,096.2 to 483.2 mg/100 g [3].

Taro is often consumed by Acehnese, Indonesia. One of the taro varieties that grow in Aceh has a purple tuber. However, it has a very annoying itching effect. The itching sensation after handling a plant is a characteristic that the plant containing calcium oxalate. The calcium oxalate content of purple taro from Aceh is unknown. For this reason, it is necessary to carry out a calcium oxalate reduction process in the taro so it can be consumed without itching and also safe for the body without harming health. This research has studied the effect of 3 immersion methods using NaCl, CH₃COOH, or NaHCO₃ to decreasing calcium oxalate content in purple taro growing in Aceh, Indonesia.

2. Materials and Methods
2.1. Material and Equipment
The material used in this study was purple taro tuber from South Aceh, Aceh Province, Indonesia. Furthermore, it was peeled and cut to a thickness of 1 cm to maintain a relatively equal size in the drying process. The immersion solution was acetic acid (CH₃COOH, Merck), sodium chloride (NaCl, Merck), and sodium bicarbonate (NaHCO₃, Merck). The chemicals used for analysis were sodium hydroxide (NaOH, Merck), hydrochloric acid (HCl, Merck), sulfuric acid (H₂SO₄, Merck), Pb acetate (Pb(CH₃COO)₂, Pudak), and (potassium permanganate (KMnO₄, Merck). The equipment used in this study were disk mill, centrifuge, drying oven, stirrer, vortex, water bath, and chemical glassware.

2.2. Immersion Method
The immersion methods used in this study are each 500 g of chopped purple taro was immersed in 1 L of 20% CH₃COOH for 30 minutes, 1 L of 10% NaCl for 15 minutes, or 1 L of 6% NaHCO₃ solution for 60 minutes. All immersion methods were carried out at room temperature. Subsequently, each sample was washed with distilled water until clean. It was then put into a baking sheet for oven drying at 60 °C for 2 days, then mashed so that it becomes flour

2.3. Observed Parameters
Parameters observed in the fresh and flour of purple taro were calcium oxalate content with volumetric permanganate-metric titration method [4], water, and ash with AOAC method [7].

2.4. Calcium Oxalate Analysis
A total of 1 g of fresh tuber taro (fresh taro) or taro flour was suspended in 95 ml of distilled water and 5 ml of 6 M HCl was added. The suspension was heated at 100 °C for 1 hour, followed by cooling. Then, 125 ml of water was added and filtered using a filter paper. A total of 62.5 ml of filtrate diluted to 150 ml and boiled. Then, titrated the solution with 0.1 N KMnO₄ solution until it turns pink which lasts for 30 seconds. The total calcium oxalate content calculated by the following equation:

\[
\text{Calcium Oxalate (mg/100g)} = \frac{\text{Volume KMnO₄} \times 0.00225 \times 2.4 \times 10^5}{\text{weight sampel (g)} \times 5}
\]
3. Results and Discussion

3.1. Calcium Oxalate Content

The reduction of calcium oxalate (CaC$_2$O$_4$) from fresh taro and taro flour is presented in Figure 1. In a previous study, calcium oxalate contents in untreated white taro flour from Thailand ranged from 317-435 mg/100 g [8], but in untreated purple taro in this study is 78.35 mg/100 g. This difference can occur due to differences in varieties and places to grow. The results showed a decrease in calcium oxalate levels in taro flour after immersion method treatment. The highest decrease in calcium oxalate levels was in the NaHCO$_3$ treatment (42.64 mg/100 g). The difference in the proportion of decreased levels of calcium oxalate was due to the concentration of the solution and the immersion time of each method. In the NaHCO$_3$ method, the concentration of NaHCO$_3$ used was 6% and the immersion time was 60 minutes, while in the CH$_3$COOH and NaCl methods the concentration of the solution used was 20% and 10% and the immersion time was 20 and 15 minutes.

![Figure 1. The calcium oxalate content of fresh and flour taro in different immersion method.](image)

Decreased calcium oxalate by sodium bicarbonate (NaHCO$_3$) method because NaHCO$_3$ can change the pH of the solution. The solution that is initially acidic will turn into an alkaline. This alkaline condition is caused by Na ions in NaHCO$_3$ reacting with cell wall components such as pectin, protein, fat so that it can cause changes in permeability in the taro cell wall (enlarged). Altered cell wall permeability causes the outer portion of taro tuber. The softer taro tissue, the easier it is for calcium oxalate to escape [9]. The limit of calcium oxalate levels in this study is still the normal and safe limit for consumption, where the maximum limit for consumption of calcium oxalate is 71 mg / 100g and the safe limit for consumption of calcium oxalate for adults was 0.60-1.25 g per day for 6 consecutive weeks [10].

3.2. Water Content

The reduction of water content from fresh taro and taro flour is presented in Figure 2. The results showed a decrease in water content in taro flour after the immersion method treatment. The lowest decrease in water content was in the NaHCO$_3$ treatment (0.82%). The decrease in moisture content from fresh taro to taro flour is 95 - 98%. According to [11] the water content of taro flour is 7.7%. Immersion of taro tubers in acetic acid (CH$_3$COOH), salt (NaCl), and sodium bicarbonate (NaHCO$_3$) convert water-insoluble calcium oxalate into water-soluble oxalic acid so that the oxalic acid is also wasted with the immersion solution. Besides that, acetic acid, salt, and sodium bicarbonate can reduce the permeability of the taro tuber cell wall so the cytoplasm/fluid in the cell comes out with other components from the taro tuber cell during the immersion treatment [4] [9].

Based on the observations, the water content of taro flour in this study fulfilled the SNI requirements for the water content of cassava flour, which was a maximum of 12% [12]. The value of water content
in taro flour is low enough so that it is assumed that the flour will have a longer shelf life because microbial growth and enzyme activity that can damage the quality of the flour can be inhibited. Food ingredients or products with a water content of less than 14% are safe enough to prevent mold growth, while the maximum moisture content of dry products such as flour and starch is 10% [13].

![Figure 2](image-url)  
**Figure 2.** The water content of fresh and flour taro in the different immersion method

### 3.3. Ash Content

The increase of ash content from fresh taro and taro flour is presented in Figure 3. The results showed an increase in ash content in taro flour after the immersion method treatment. The highest increase in water content was in the NaHCO₃ treatment (4.79%), followed by NaCl (3.14%) and CH₃COOH (4.14%). This is because the NaHCO₃, CH₃COOH, and NaCl solution cause cytoplasm/fluid in the cell come out with soluble components from the taro tuber cell during the immersion treatment so it will change the taro cell composition. Most of the Na ions in NaHCO₃ and NaCl reacting and bonding with cell wall components such as pectin, protein, fat, so they are involved in the ashing process [9].

![Figure 3](image-url)  
**Figure 3.** The ash content of fresh and flour taro in the different immersion method.

### 4. Conclusions

The CH₃COOH, NaCl, or NaHCO₃ immersion method had a significant effect on decreasing calcium oxalate content in purple taro flour. Purple taro tubers from Aceh Province, Indonesia contain low levels of oxalate (78.35 mg / 100 g) than other. The purple taro tuber has the potential to be developed into taro flour which is lower in oxalate by one method of soaking, making it safer to be used as a food ingredient.
Acknowledgements
This research was supported by Universitas Syiah Kuala and all member in Departemen Agriculture Product of Technology. Thank you to LPPM Unsyiah and all member taro who helped carry out this research.

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