Effect of pretreatment on oxalate content and physicochemical properties of taro starch tuber grown in North Sumatra, Indonesia

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ABSTRACT Oxalate acid is one of the most common antinutrients found in many agricultural materials. Anti-nutritional factors are compounds capable of causing a reduction in the utilisation of nutrients when consumed as foods. Limitations in the use of food and feed occur due to the presence of these endogenous substances. This study investigates the effect of soaking in sodium chloride (NaCl) and boiling treatments on oxalate content in taro grown in North Sumatra. The results showed that all treatments had no significant effect on yield value. The soaking at 5% NaCl and boiling significantly reduced the oxalate acid content in direct relation to the longer soaking period and boiling time, respectively. The study found that boiling treatment for 5 min gave the best result in oxalate acid reduction, with 96.63% remaining at 42.42 mg/100 g compared to the fresh sample (1272.56 mg/100 g). Among all treated samples, only samples boiled for 5 min were considered safe to consume based on their toxicity level, which was below 50 mg/100 g but still not recommended since the value was above 25 mg/100 g. Further treatments need to be considered to lower the amount to below its safe level. All treatments showed no significant difference in colour property, which indicated that the treatments did not affect the sample characteristics, but the total starch content of the soaked sample was significantly reduced due to starch diffusion in water.

KEYWORDS: Taro; Oxalate; Sodium chloride; Soaking; Boiling
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INTRODUCTION

Anti-nutritional factors are compounds capable of causing a reduction in the utilisation of nutrients when consumed as foods. Limitations in the use of food and feedstuff occur due to the presence of these endogenous substances (Joshi *et al.,* 2020). Their existence as a diverse range of natural compounds is also said to be the dominant obstacle to the wider utilisation of many tropical plants as they can reduce nutrient utilisation, in particular vitamins, proteins, and minerals, thereby resulting in the prevention of optimal exploitation of the nutrients present in the foods and subsequently causing a reduction in the nutritive value of the foods. If the nutritional value of food ingredients is meant to be preserved, they must be reduced or eliminated. They are present in many food substances in varying amounts, which are dependent on the chemicals employed in growing the crops, the chemicals used during storage for the purpose of preserving the food substances, the type of food, and the mode of propagation. However, large consumption of these antinutrients has been proven to have deleterious effects on health, such as headaches, rashes, bloating, nausea, and nutritional deficiencies. There are many types of antinutrients in plants, such as phytate, alkaloids, cyanogenic glycosides, gossypol, and oxalates. In the case of oxalate, the consumption of excessive amounts can induce hyperoxaluria, increase the risk of calcium oxalate stones, and even be fatal to humans (Saiener *et al.,* 2021). Humans should limit the intake of oxalate with a safety limit between 40 and 50 mg per day, especially patients with kidney stone problems, who are advised to limit their total oxalate intake not to exceed 10 mg per day according to Brown *et al*. (2009). Therefore, determining the oxalate content of foods prior to their sale in marketplaces is crucial. According to Abdel-Moemin (2014), foods are classified as having low oxalate content when less than 10 mg/100 g and as having high oxalate content when more than 50 mg/100 g.

Oxalates are tasteless and odourless but we consume this compound every single day, and they exist naturally in human bodies and in many fruits and vegetables, especially seeds and nuts. This compound is widely distributed in plants in two forms, namely water-soluble and water-insoluble forms, where the former contains sodium, potassium, and ammonium oxalate, while the latter consists of calcium, magnesium, and iron oxalate (Joshi *et al.*, 2020). The ability of oxalates to form insoluble salts with divalent cations like magnesium or calcium is the dominant reason why large dietary intake poses a considerable health concern to the public (Saiener *et al.*, 2021). The most dominant health effect of consuming large amounts of foods high in oxalates is the formation of calcium oxalate (CaOx) kidney stones. Kidney stones are said to be one of the most painful and common disorders of the urinary tract. This disorder starts with the stimulation of precursors to CaOx kidney stones, which are urinary CaOx crystals, as a result of increased consumption of meals high in oxalate content (Kumar *et al.*, 2021). The most widely seen urinary stone is the calcium oxalate stone (about 80%), with approximately 70% of stones containing calcium oxalate.

Due to its negative effect on human health, there is an intention to reduce its concentration to a level that is safe to consume. One of the methods to inactivate or reduce oxalate in different foods is through soaking. According to Saleh (2019), soaking the taro corm chips for 60 min using a salt solution of calcium chloride of 5% was considered the optimal conditions to reduce their amount of oxalate, whereby the content of oxalate in the taro corm chips showed a significant decrease from 294.3 mg/100 g to 35.1 mg /100 g. Furthermore, cooking by boiling is also used to inactivate or reduce the oxalate content in different foods. According to the study carried out by Wanyo (2020), the total, soluble, and insoluble oxalate contents of oxalate were generally reduced after the cooking by boiling process. Moreover, the combination methods of soaking and boiling can be used to inactivate or reduce the oxalate content in different foods as well. This can be seen from the study carried out by Kumoro *et al.* (2014), in which soaking the taro corm chips in a 10% w/w baking soda solution for 2 h prior to boiling them for 60 min at 90 °C could best reduce the content of calcium oxalate in the taro corm chips. In this study, the effect of soaking with 5% NaCl and boiling treatment were investigated based on the oxalate content and physicochemical properties of taro samples.

METHODOLOGY

Sample Collection and Preparation

The taro tubers planted for 24 months were harvested from a farm located at Tanjung Morawa, North Sumatra, at a latitude of 3.5300°N and a longitude of 98.8078°E. The samples were then taken to the Medan Healthy Polytechnic Laboratory for pretreatment before further analysis. The tuber samples were peeled with a stainless-steel knife by removing the peel up to 1.0 ± 0.1 cm in thickness. The peeled taro was washed properly with tap water and rinsed with distilled water before being cut into small pieces (2 x 2 x 2 cm^3). Pretreatment was done to the samples by soaking them in 5% sodium chloride (NaCl) for 30 and 60 min, respectively, before rinsing with tap water. Another pretreatment was boiling for 2 min and 5 min, respectively. All treated samples were then rinsed and control sample with the same dimension (without treatment) were subjected to a drying process in the cabinet dryer set at 60 °C for 16-18 h until the moisture content was consistent. The samples were then ground and sieved into a powder with an 80 μm mesh. The weight of all samples was measured to determine the yield recovery by using Equation 1.

$$\text{Yield recovery (\%)} = \frac{\text{Weight of dried sample}}{\text{Weight of fresh sample}} \times 100 \quad (1)$$

Oxalate Acid Determination

The taro samples were analysed for total, soluble, and insoluble oxalate in 0.50 ± 0.01 g of each finely ground sample in duplicate using the method outlined by Savage *et al.* (2000). Insoluble oxalate content (as calcium oxalate) was calculated by difference. Soluble oxalate was extracted with 40 mL of nanopure water and incubated in a water bath at 80 °C for 15 min. Total oxalate was extracted using 40 mL of 0.2 M HCl at 80 °C for 15 min. Extracted supernatants were filtered through a 0.45 mm cellulose nitrate filter, followed by chromatographic separation and analysis using a Rezex ROA ion exclusion organic acid column (Phenomenex).

Physicochemical Analysis

Physicochemical analysis of the taro samples included determination of moisture content, colour and total starch. Moisture content was determined according to AOAC by the oven method (AOAC, 2000). The 2 g of sample was weighed into the crucible and weighed together with the crucible as B. The crucible was put into an oven at 103°C overnight. Then, the crucible was cooled in a desiccator and weighed again after dried. The difference in the weight of the sample before and after dried was calculated as moisture content. Meanwhile, colour analysis was conducted according to the method of Ng *et al.* (2018) with minor modifications using the colorimeter (HunterLab ColorFlex) with CIELAB system. The total starch content analysis was done according to the method of Nilusha *et al.* (2021) and the absorbance was measured by using the UV-Vis spectrophotometer at 490 nm at room temperature.

Statistical analysis

Data analysis was performed using Statistical Package for Social Sciences (SPSS) version 28 with significance levels set at $p<0.05$. Sensory evaluation test ranking data were analysed using Friedman's test, one-way ANOVA test and Tukey post hoc test.

RESULTS AND DISCUSSION

Yield Recovery

There was no significant difference ($p>0.05$) in the yield recovery of the treated samples in the range of 15.21%–15.82%, indicating that the treatments did not influence the yield recovery. Based on the yield obtained, the taro is considered good since most agricultural materials obtained a recovery yield of 10–15% (Sadia *et al.,* 2015). During drying treatment, free water in the sample will evaporate after passing through the cell in capillary movement to the sample surface before hot air removes it into the environment through the evaporation process (Jian & Jayas, 2021).

Oxalate Content

Table 1 indicates that the oxalate acid content in different treatments was significantly different ($p<0.05$). Overall, the treated samples were significantly reduced in oxalate content as compared to fresh samples. Fresh samples with the highest total oxalate acid (1272.56 mg/100 g) significantly reduced ($p<0.05$) in oxalate content with the treatment given. The sample that was boiled for 5 min significantly had ($p<0.05$) the lowest oxalate value (42.82 mg/100 g).

Table 1. Reduction of oxalate content in taro by soaking and boiling treatments.

Taro sample	Total oxalate acid (mg/100 g DM)	Soluble (mg/100 g DM)	Insoluble (mg/100 g DM)
Fresh	1272.56 ± 38.32[a]	133.44 ± 4.63[a]	1138.10 ± 40.24[a]
Soaking; - 30 min	377.87 ± 22.33[b]	76.41 ± 28.28[b]	301.07 ± 23.22[b]
- 60 min	149.10 ± 22.31[c]	40.67 ± 23.36[c]	108.43 ± 13.89[c]
Boiling; - 2 min	103.51 ± 19.92[d]	27.29 ± 5.71[d]	75.83 ± 16.31[d]
- 5 min	42.82 ± 7.10[e]	8.56 ± 1.90[e]	34.21 ± 2.62[e]

*Values are expressed as mean ± standard deviation; different letters indicate statistically significant difference ($p<0.05$).

The longer soaking time of the taro corm chips in the added calcium salt solution is a favourable condition for the leaching of the soluble oxalate (Saleh, 2019). The boiling treatment gave the best effect in reducing oxalate acid content due to the fact that the high temperature of cooking by boiling can result in the collapse of the calcium oxalate-containing cells and subsequently cause the oxalate structure to break down. This is because high temperatures can result in better breakdown of the spinach, and thus, the release of oxalic acid from the spinach is improved. Overall, from the treatment given to the samples, only boiling for 5 min was considered to give less than 50 mg/100 g sample, which is safe to consume based on toxicity level, but it is still not recommended since it is still higher than 25 mg/100 g, which can cause kidney stones. So further treatments should be considered for this taro sample to ensure it is safe for consumption.

Physicochemical Properties

Based on Table 2, it was indicated that all the control and treated taro samples had similar moisture content ($p>0.05$) ranging from 9.27% to 9.49%, which has normal moisture content for flours with less than 10% (Kumoro *et al.*, 2014). The colour characters of all treated taro samples showed no significant difference ($p>0.05$) based on L*, a*, and b* values.

Table 2. Moisture content, colour value and starch content of treated taro samples.

Taro sample	Moisture content (%)	Colour			Starch content (%)
		L*	a*	b*	
Fresh	9.45 ± 0.08[a]	93.95 ± 0.08[a]	0.22 ± 0.05[a]	9.66 ± 0.60a	77.91 ± 2.15[a]
Soaking; - 30 min	9.27 ± 0.07[a]	91.99 ± 0.05[a]	0.25 ± 0.03[a]	9.60 ± 0.56[a]	73.89 ± 1.08[ab]
- 60 min	9.45 ± 0.05[a]	92.77 ± 0.06[a]	0.25 ± 0.05[a]	9.61 ± 0.63[a]	69.13 ± 3.01[b]
Boiling; - 2 min	9.34 ± 0.08[a]	92.94 ± 0.07[a]	0.22 ± 0.04[a]	8.86 ± 0.43[a]	76.21 ± 2.25[a]
- 5 min	9.49 ± 0.03[a]	93.53 ± 0.05[a]	0.23 ± 0.02[a]	9.12 ± 0.67[a]	76.33 ± 2.18[a]

*Values are expressed as mean ± standard deviation; different letters indicate statistically significant difference ($p<0.05$).

According to Jadhav & Nirval (2019), the colour of soy flour treated by soaking and boiling did not have any significant effect on their moisture content and colour characteristics. The starch content of all samples in the range of 69.13% to 77.91% showed that all samples had no significant difference except for the sample treated by soaking with 5% NaCl for 60 min. Nagar *et al.* (2021) found that starch content in the taro sample was in the range of 70–80%, but treatments of soaking and boiling showed a decrease in their starch content, as observed by Soudy *et al.* (2010), who found that soluble components in water such as protein and ash significantly decreased due to soaking treatment. It seems that this also occurred to the starch component in this study. Boiling time showed significant reduction for soluble components that were boiled for up to 20 min (Amon *et al*., 2014), but in this study, the boiling time for up to a maximum of 5 min did not show a significant effect in starch reduction.

CONCLUSION

Based on the oxalate acid content in the treated sample, the sample treated by boiling for 5 min was reduced to 3.37% which is considered safe to consume because the daily limit of oxalate is 40 to 50 mg. The normal level of urine oxalate excretion is less than 50 mg per day (mg/day). However, the treatments should be given at a lower dose than 25 mg/100g DM since a higher level of urine oxalate may increase the risk of developing kidney stones. The risk of stone formation seems to increase even at levels above 25 mg/day, which is considered a normal level. Therefore, further treatments and modifications must be made to the sample to lower the oxalate acid content to 10 mg per 100 g of sample. The combination of soaking and boiling pretreatment should be considered in future studies with a variety of parameters such as soaking time, boiling time, and NaCl concentration. Another parameter to look into is the size dimension of the taro slice, it can be made smaller to produce the most effective treatment effects. Additionally, baking is one of the methods used to inactivate or reduce the oxalate content in food.

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