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Assessment of Soaking Solutions for Oxalate Reduction in Locally Known "Galyang" Collected from Cauayan City, Philippines

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Abstract

This study examined the effects of household processing methods on the oxalate content of a locally sourced "Galyang," a taro-type plant collected from Barangay Marabulig I, Cauayan City, Isabela. The study was anchored on the principle of oxidation-reduction reactions used in permanganometric titration for oxalate determination. A two-factor Completely Randomized Design (CRD) with subsampling was employed to evaluate oxalate reduction between raw and processed samples. Young leaves, stalks, and corms of Galyang were subjected to different immersion treatments, including water, 10% salt solution, 10% vinegar solution, and a combined 10% salt and 10% vinegar solution. Oxalate content was determined through permanganometric titration using standardized 0.05 N $KMnO_4$ solution, while statistical analysis was performed using the Linear Mixed Model through jamovi version 2.6.23.0. The findings revealed that the leaves exhibited the highest oxalate content, followed by the stalks, while the corms had the lowest oxalate level, with a significant difference observed between the leaves and corms. Significant differences were also observed among immersion treatments. The control treatment recorded the highest oxalate content, while the combined salt and vinegar treatment showed the lowest oxalate level. Soaking in salt solution and salt-vinegar solution effectively reduced oxalate content compared to untreated samples, whereas soaking in plain water was less effective. The reduction in oxalate levels was attributed to the leaching of soluble oxalates into the soaking medium. The study concluded that simple household immersion methods may improve the safety and potential utilization of Galyang as a food source and for possible product development. Future studies are recommended to investigate additional processing techniques, nutrient retention, sensory properties, and specific oxalate forms in Galyang. The study aligns with SDG 2 (Zero Hunger), SDG 3 (Good Health and Well-Being), and SDG 12 (Responsible Consumption and Production) through the promotion of food safety, improved utilization of underutilized crops, and practical household processing methods. The findings contribute to socio-economic, nutritional, and public health sustainability by encouraging accessible food processing techniques and safer dietary practices.

Keywords: Calcium Oxalate, Colocasia Esculenta, Galyang, Household Processing Methods, Immersion Treatments, Oxalate Reduction, Permanganometric Titration, Sustainability, Taro, Underutilized Crops

1. Introduction

Taro (*Colocasia esculenta*), locally known as gabi in the Philippines, is an important tropical crop valued for its nutritional contribution, adaptability, and potential role in food security. Its ability to grow with minimal agricultural inputs makes it accessible to many communities, particularly in tropical and subtropical regions (Aditika et al., 2021). Despite its benefits, several taro cultivars contain high levels of calcium oxalate, which causes irritation and may contribute to health complications such as kidney stone formation and impaired nutrient absorption (Watson et al. 2005; Brzezicha-Cirocka et al. 2016; Ghanati et al. 2024). Various processing methods have been explored to reduce oxalate content, including soaking, enzymatic treatment, drum drying, and fermentation (Rozali et al., 2021; Sefa-Dedeh & Agyir-Sackey 2002; Oke and Bolarinwa, 2011). This study examined the effects of household processing methods on the oxalate content of the locally known Galyang in Barangay Marabulig I, Cauayan City, Isabela, using permanganometric titration for oxalate determination.

1.1 Background of Taro (*Colocasia esculenta*) and Oxalate Content

Taro (*Colocasia esculenta*) is a tropical crop from the Araceae family commonly cultivated in tropical and subtropical regions. It is recognized as a valuable food source because of its nutritional benefits, contribution to dietary diversity, and capacity to grow under limited agricultural inputs, making it important for food security in many communities (Aditika et al., 2021). Taro cultivation is also considered less expensive compared to rice and corn production and generally experiences fewer pest and disease problems (Adejumo et al., 2013). However, many edible aroid plants possess a sharp and irritating taste caused by calcium oxalate crystals known as raphides. These compounds can produce toxic effects when consumed, including swelling, blister formation, and difficulty swallowing (Watson et al., 2005). Elevated oxalate levels may also contribute to kidney stone formation and interfere with nutrient digestion and absorption (Brzezicha-Cirocka et al. 2016; Ghanati et al. 2024).

1.2 Related Literature on Oxalate Reduction Methods and Permanganometric Determination in Taro

Several studies have explored methods for reducing oxalate content in taro and related products. Rozali et al. (2021) found that soaking taro flour in sodium bicarbonate effectively lowered oxalate levels through changes in pH and cell wall structure. Kizhakedathil et al. (2020) developed an enzymatic treatment using oxalate oxidase from *Fusarium oxysporum*, which significantly reduced oxalates in taro flour. Sefa-Dedeh & Agyir-Sackey (2002) reported that drum drying reduced oxalate content by nearly half, likely because heat facilitated oxalate breakdown. Oke and Bolarinwa (2011) also observed that fermentation reduced oxalate levels through leaching and enzymatic or acidic degradation processes. Related studies have also employed permanganometric titration to determine oxalate levels in taro accessions and mutant lines (Fufa et al., 2023; Nurilmala and Mardiana, 2019; Zainal et al., 2022). This method involves redox reactions in which potassium permanganate ($KMnO_4$) serves as the oxidizing agent while oxalate ions are oxidized under acidic conditions. The endpoint is identified through the appearance of a persistent faint pink color, indicating complete oxidation of oxalate ions (AOAC 1948).

1.3 Local, National, and Global Significance of Taro Utilization and Food Security

Globally, taro is recognized as an important crop that supports nutrition and food security in tropical and subtropical regions (Aditika et al., 2021). In the Philippines, locally known gabi varieties are widely utilized as food sources because of their accessibility and adaptability. The locally known Galyang from Barangay Marabulig I, Cauayan City, Isabela, represents an underutilized crop with potential nutritional and economic value. However, concerns regarding oxalate toxicity may limit its utilization and acceptance for regular consumption. The increasing interest in practical and affordable food processing techniques reflects both national and global efforts to improve food quality, nutrition, and public health. Household-based processing methods may provide accessible strategies for reducing harmful compounds in staple and underutilized crops while supporting healthier dietary practices.

1.4 Theoretical Basis of Permanganometric Titration for Oxalate Analysis in Taro

The study is anchored on the principle of oxidation-reduction reactions used in permanganometric titration for oxalate determination. In this process, potassium permanganate acts as the oxidizing agent, while oxalate ions undergo oxidation under acidic conditions. The reduction of permanganate ions from MnO_4^- to Mn^{2+} results in a visible color change from purple to colorless. The endpoint is detected when a faint pink color persists, indicating complete oxidation of oxalate ions (AOAC 1948).

1.5 Research Gaps on Household Processing Methods for Reducing Oxalate Content in Galyang

Although several studies have investigated oxalate reduction techniques in taro, limited information is available regarding the effectiveness of simple household processing methods on a locally known Galyang in Barangay Marabulig I, Cauayan City, Isabela. This study aimed to address this gap by examining practical household processing techniques that may effectively reduce oxalate content. The findings may provide useful information for households, food researchers, and health professionals while promoting the utilization of underutilized crops and supporting healthier dietary practices.

1.6 Alignment of the Study on Galyang Processing with Relevant Sustainable Development Goals (SDGs)

The study aligns with SDG 2 – Zero Hunger by supporting food security through the improved utilization of a locally known Galyang as an accessible and nutritious crop. It also relates to SDG 3 – Good Health and Well-Being because reducing oxalate content may help minimize health risks associated with kidney stone formation and impaired nutrient absorption (Brzezicha-Cirocka et al. 2016; Ghanati et al. 2024). Additionally, the study supports SDG 12 – Responsible Consumption and Production through the promotion of practical household processing methods that improve food safety and maximize the value of underutilized crops.

1.7 Importance of Oxalate Reduction Research in Galyang to Multidisciplinary Sustainability

The study contributes to socio-economic sustainability by promoting affordable and accessible food processing techniques that may increase the utilization of locally available crops. It also supports public health sustainability through efforts to reduce harmful oxalate compounds associated with adverse health effects. Furthermore, the research contributes to community and nutritional sustainability by encouraging healthier dietary practices and improving awareness of safe food preparation methods for underutilized crops.

2. Material and methods

2.1 Research Design

The study employed a two-factor Completely Randomized Design (CRD) with subsampling to evaluate oxalate reduction between raw and processed samples. Subsampling was applied because of the numerous treatment combinations and limited sample availability. Three replicates, including the control, were used for each treatment. Statistical analyses were conducted using jamovi version 2.6.23.0 through the Linear Mixed Model.

2.2 Locale of the Study

The plant materials were collected from Barangay Marabulig I, Cauayan City, Isabela, where the plant is locally known as Galyang. The collected plant material was identified based on the local name commonly used by residents in the area; however, no formal botanical identification was conducted. The collection was conducted early in the morning in June 2025.

2.3 Respondents of the Study

The study did not involve human respondents. Instead, young leaves and stalks of the Galyang plant were collected and used for laboratory analysis.

2.4 Sample and Sampling Procedure

Young leaves and stalks of Galyang were collected for analysis. The plant materials were cut into small pieces, while untreated samples served as the control. The stalk and corm were peeled prior to analysis. The samples underwent different immersion treatments, including soaking in water, soaking in 10% salt solution, soaking in 10% vinegar solution, and soaking in a mixture of 10% salt and 10% vinegar solution, following procedures adapted from Rofi'ana et al. (2018).

2.5 Research Instrument

The total oxalate content was determined through permanganometric titration using 0.05 N standard $KMnO_4$ solution. Prior to analysis, treated samples were immersed for 60 minutes at room temperature, rinsed, dried at 60 °C for 18 hours, and ground into powder using a food processor. Oxalate extraction was performed through hot acid extraction adapted from Sarifudin et al. (2022) with slight modifications. The percentage of total oxalates was computed using the designated equation, where N represented the normality of the standardized $KMnO_4$ solution, V referred to the volume of $KMnO_4$ consumed during titration, 44.01 represented the equivalent weight of oxalate in the reaction, and DF denoted the dilution factor when applicable.

2.6 Data Gathering Procedure

Plant materials were collected from Barangay Marabulig I, Cauayan City, Isabela, and prepared by cutting them into small pieces. The stalk and corm were peeled before treatment. Samples were subjected to different immersion methods, including water, salt solution, vinegar solution, and combined salt-vinegar solution. After immersion, samples were rinsed, dried, and ground into powder. Hot acid extraction was then conducted prior to oxalate quantification using permanganometric titration.

2.7 Data Analysis Techniques

Data analysis was performed using jamovi version 2.6.23.0. The Linear Mixed Model was applied to evaluate oxalate reduction between raw and processed samples under the two-factor Completely Randomized Design with subsampling. Three replicates were analyzed for each treatment, including the control.

3. Results and Discussion

3.1 Total Oxalate Content in Different Plant Parts of Galyang

3.1.1 Oxalate Levels in Leaves, Stalks, and Corms

The leaves exhibited the highest mean oxalate content at 14.5 ± 4.28%, followed by the stalk at 11.3 ± 4.31%, while the corm showed the lowest oxalate level at 10.4 ± 4.14%. Statistical analysis revealed a significant difference at the 5% level of significance ($p = 0.032$) only between the corm and leaf oxalate contents. The higher oxalate concentration observed in the leaves is consistent with the findings of Savage and Martensson (2010), were taro leaves generally contain greater oxalate concentrations than raw taro corms. This suggests that oxalate accumulation may vary depending on plant part and physiological function.

3.2 Effects of Immersion Treatments on Oxalate Reduction

3.2.1 Oxalate Reduction After Different Immersion Methods

Significant differences at the 5% level of significance ($p < 0.001$) were observed among the immersion treatments. The control treatment recorded the highest oxalate content at 18.0 ± 2.5%, followed by soaking in plain water at 14.9 ± 2.3%.

Lower oxalate levels were observed in samples soaked in 10% vinegar solution at 11.3 ± 2.0%, 10% salt solution at 8.11 ± 1.2%, and a mixture of 10% salt with 10% vinegar solution at 6.58 ± 3. The post-hoc analysis showed that the control treatment had significantly higher oxalate content than all treatments except soaking in plain water ($p = 0.101$). No significant differences were observed among salt, vinegar, and combined salt-vinegar treatments. The findings indicate that soaking in salt, vinegar, and combined salt-vinegar solutions effectively reduced oxalate levels compared to untreated samples, while soaking in plain water was less effective. The reduction in oxalate content may be attributed to the leaching of soluble oxalates and other cellular components into the soaking medium, particularly in acetic acid and salt solutions (Rozali et al. 2021). These results suggest that salt-based and acidic immersion treatments may serve as practical household methods for reducing oxalate content in Galyang.

4. Conclusion & Recommendations

The study revealed that oxalate content varied among the different plant parts of the locally known Galyang, with the leaves containing the highest oxalate levels and the corms having the lowest, showing a significant difference between them. Among the immersion treatments tested, soaking in salt solution and salt with vinegar solution were the most effective in reducing total oxalate content, while soaking in plain water showed the least effectiveness. The findings indicate that simple household processing methods may help improve the safety and potential utilization of Galyang as a food source and for possible product development.

Future studies are recommended to further investigate other processing techniques that may effectively reduce oxalate content in Galyang. Additional research may also focus on nutrient retention, sensory properties, and the identification of specific oxalate forms present in the crop to support its safe utilization and product development potential.

The study was limited to selected household immersion treatments and focused only on the total oxalate content of the locally known Galyang sourced from Cauayan City, Isabela. Other processing techniques, nutrient retention, sensory characteristics, and specific oxalate forms were not included in the scope of the study.

Compliance with ethical standards

This study complied with applicable ethical standards for laboratory-based research. The study did not involve human participants or animal subjects and was limited to the collection and laboratory analysis of plant materials locally known as Galyang obtained from Barangay Marabulig I, Cauayan City, Isabela.

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