Village-level Processing of Pangi (*Pangium edule* Reinw.) Seeds by the Obu Manuvu Improves the Edibility and Level of Some Nutritional Factors

Rovi Gem E. Villame-Gayagas¹, Jennifer P. Fronteras¹*, Mara Christna D. Nacar¹, Aaron P. Lorilla¹, and Pedro A. Alviola IV²

¹College of Science and Mathematics, University of the Philippines Mindanao, Tugbok District, Mintal, Davao City, Philippines 8000
²School of Management, University of the Philippines Mindanao, Tugbok District, Mintal, Davao City, Philippines 8000

*Author for correspondence: Email: jpfronteras@up.edu.ph; Telefax: 082-293-0302

Received: September 08, 2022/ Revised: July 28, 2023/ Accepted: August 07, 2023

Pangi (*Pangium edule* Reinw.) seed is known to be a poisonous material. However, it becomes safe for consumption after processing. This study determined the effect of village-level processing by the Obu Manuvu community of Marilog District, Davao City, Philippines on the antinutrient and nutritional composition of Pangi seeds. Processing methods involved washing with running water for about 15 s, boiling in water for 30 min, and soaking in flowing water in a nearby river overnight. Results showed that after processing, the levels of antinutrients such as cyanogenic glycosides and oxalates were reduced significantly (*p* < 0.05) by 99.15% and 78.23%, respectively. Further, the tannin content was also significantly reduced by 96.15%. The crude fat content significantly increased (*p* < 0.05) by about 54%. Crude ash and fiber decreased, while protein did not change significantly (*p* < 0.05). Minerals such as calcium and zinc increased (*p* < 0.05) by 221.43% and 64.39%, respectively while the iron and manganese levels remained unaffected. Findings of the study suggested that the processing method by the Obu Manuvu effectively reduces the level of antinutrients, thereby improving the edibility and safety of Pangi seeds. Further, the processing method improves the level of some nutrients, specifically crude fat, calcium, and zinc.

Keywords: antinutrients, indigenous processing, minerals, *Pangium edule* Reinw., Obu Manuvu

INTRODUCTION

Pangi (*Pangium edule* Reinw.), commonly known as "Football Fruit," is a tropical tree that grows in Southeast Asia and the Southern Pacific islands. In Asian countries, it is commonly called "Pangi," "Kepayang," or "Picung." The main product of this plant is the endosperm of its fruit seed which is usually consumed as a spice or an added ingredient to several local dishes. However, its consumption is compromised by its relatively high amount of cyanogen, making it poisonous and unsafe to eat (Deshpande et al. 2000; Sailah et al. 2021). Cyanogen is an antinutrient that limits the optimum utilization of plant food sources because of its adverse effects on human health. Antinutrients, also called antinutritional factors, interfere with nutrient intake, digestion, and absorption, thus preventing optimal utilization of nutrients. Plants naturally contain antinutrients such as alkaloids, trypsin inhibitors, oxalates, phytates, hemagglutinin, cyanogenic glycosides, cardiac glycosides, saponins, and some phenolic substances which include tannins (Emmanuel and Deborah 2018). These substances induce detrimental effects on humans and animals when consumed in specific amounts (Gemede and Ratta 2014; Minatel et al. 2016).

Nevertheless, several studies showed that specific processing methods could reduce or eliminate the levels of antinutrients in food (Ertop and Bektaş 2018). These include thermal and mechanical processing, soaking, fermentation, and germination. For instance, there is evidence that boiling, steaming, and dry roasting of sweet and bitter cassava leaves induce significant reduction of
phytate (Ekpo and Baridia 2020). Santoso et al. (2014) reported the removal of cyanogens in Pangi endosperm by soaking and soaking in water followed by pit fermentation for about 40 d. Similarly, drying bamboo shoots showed 92.95% – 95.05% reduction in cyanogenic glycosides by volatilization of hydrogen cyanide due to heat (Singhal et al. 2022). In another study, Ismaila et al. (2018) reported that boiling and frying was effective in reducing phytate, oxalate, and saponins in cassava. In the case of Pangi, boiling the seeds coupled with rinsing in running water for a prolonged period can eliminate hydrogen cyanide (Hoe and Siong 1999), thus making it fit for human consumption.

The Philippines is a pluralistic society and a melting pot of various ethnolinguistic groups such as Tagalog, Ilokano, Cebuano, Hiligaynon, Muslim Filipinos, and the Indigenous Peoples (IPs), also called Lumads (Tomaquin 2013). In particular, the Obu Manuvu—an IP sub-group of the Manobos—has several traditional food processing methods that can potentially change the concentration of antinutrients and improve the bioavailability of nutrients in food. Preliminary talks with the community leaders revealed that Pangi is one of the many plant sources eaten in their community and is therefore processed in a particular way to make it safe for consumption. Thus, this study aimed to investigate the effect of indigenous processing by the Obu Manuvu on the antinutrient levels and nutrient profile of Pangi seeds. This can provide the chemical basis as to how Pangi seeds become edible and safe for consumption after processing. Although review of literature does not reveal records on food poisoning cases from Pangi seeds in the Philippine setting, there are references stating that fresh Pangi fruit and seeds are high in hydrogen cyanide which is a deadly poison (Deshpande et al. 2000; Etoh 2001; Sailah et al. 2021). Furthermore, interviews with the Obu Manuvu community revealed that consuming unprocessed Pangi seeds results in poisoning for both humans and animals.

The results of this study provided baseline data that can be used in intervention efforts to help alleviate the incidences of malnutrition and food poisoning in the community. Marilog District, where most of the Obu Manuvu reside, has the second highest prevalence rate of malnutrition cases in Davao City in 2017 (Salveron 2017). In 2019, the Davao City Health Office identified Marilog District as one of the 10 nutrition depressed areas in Davao City (Llemit 2019). Moreover, the processing method of the Obu Manuvu, once communicated, has the potential to be adapted as a good practice in reducing the level of hydrogen cyanide in plant-based commodities which was associated with numerous cases of food poisoning.

**MATERIALS AND METHODS**

Prior to the conduct of the study, the research team obtained a permit from the National Commission on Indigenous Peoples (NCIP) Provincial Office in Davao City and from the chieftain of the Obu Manuvu community in Marilog District, Davao City. Moreover, an informed consent was also obtained from the respondents (http://bit.ly/RvFK).

The research team visited the site to conduct interviews and observe the process demonstration as well as obtain samples for chemical analyses.

**Processing of Pangi Seeds by the Obu Manuvu**

The observed village-level processing method by the Obu Manuvu to render Pangi seeds edible and suitable for human consumption was outlined in Fig. 1.

The whole fruit was harvested and cut open to obtain the seeds. Seeds were washed thoroughly and boiled in a pot of water for 30 min. The outer seed layer softens during boiling, making it easier to remove the shell. After this, the seeds were cooled, drained, and sliced into halves to remove the embryos. The seeds were placed in a net bag and fastened to a makeshift pipe with flowing water from a nearby river—this step allowed for the rinsing and soaking of the seeds in running water overnight. The next day, the seeds were collected for sampling and processing.

![Process flow chart to produce edible Pangi seeds.](https://pas.cafs.uplb.edu.ph)

**Fig. 1.** Process flow chart to produce edible Pangi seeds.
Sample Collection

Fifty percent of the collected seeds were placed in a clean plastic bag and kept at 4°C in an ice chest. The remaining seeds were subjected to further processing by some representatives of the Obu Manuvu under the supervision of the research team. The processed material was collected and cooled in clean plastic bags. These were stored at 4°C in an ice chest for transport to the laboratory.

Chemical Analyses

The effect of processing raw Pangi seeds on their antinutrient content was analyzed in terms of cyanogenic glycosides, oxalates, and tannin content. The effect on the proximate composition as well as on the levels of selected minerals was also determined. All samples were analyzed in triplicates. Dried samples were used for all analyses hence, all results were expressed on dry basis.

Upon arrival at the laboratory, composite samples of the raw and processed Pangi seeds for antinutrient analyses were lyophilized using a freeze dryer (Christ BPT Alpha 1-4 LD Plus) and stored at -20°C. On the other hand, samples for proximate composition analysis were stored in a refrigerator at 4°C until use.

Antinutrient Content Analysis

Cyanogenic Glycosides

Cyanogenic glycoside content was determined using the alkaline picrate method (Eleazu and Eleazu 2012). One gram of the sample was weighed and dissolved in 25 mL of distilled water and was allowed to stand at ambient temperature for 12 h, followed by filtration. One milliliter of the filtrate was collected and added with 4 mL alkaline picrate solution (1 g picric acid [Sigma-Aldrich, USA], in 5 g Na2CO3 [Himedia, India] in 200 mL distilled water). While the standard solutions were prepared by diluting KCN (Univar, USA) with distilled water, 500 µL of 0.05 N Folin-Ciocalteu reagent (Univar, USA) and 1000 µL of 35% NaOH (Univar, USA) solutions with final concentrations of 0.1, 0.2, 0.5, 0.8, and 1 mg mL−1 concentrations. The standard solutions and the alkaline picrate-treated sample were heated in a water bath at 50°C for 5 min until a color change was observed. Absorbance was read at 490 nm using a spectrophotometer (UV-Vis 1700, Shimadzu, Japan) against a blank. Cyanide content was calculated using a linear regression method.

Oxalates

The oxalate content was determined using the method developed by Iwuhoa and Kalu (1995). Digestion was performed by suspending 2 g of the sample in 190 mL distilled water in a 250 mL volumetric flask. Ten milliliters of 6 M HCl (Labscan, Thailand) were added, and the suspension was digested for 1 h at 100°C. The sample was cooled and diluted to 250 mL with distilled water, followed by filtration. The supernatant was collected in a 125 mL flask. To this, four drops of methyl red were added. Concentrated NH4OH (Univar, USA) was added dropwise until the test solution changed from salmon pink to a faint yellow color (equivalent to pH 4 to 4.5). The solution was heated to 90°C, cooled, and filtered to remove the precipitate containing ferrous ions. The resulting filtrate was heated to 90°C, to which 10 mL of 5% CaCl2 (Scharlau, Spain) was added with continuous stirring. After heating, the sample was cooled and kept overnight at 5°C, followed by centrifugation at 2500 rpm for 5 min. The precipitate was collected and dissolved in 10 mL of 20% H2SO4 (Scharlau, Spain), then diluted to 200 mL with distilled water. The resulting solution was heated until near-boiling. The sample was titrated against a 0.1027 N KMnO4 (Univar, USA) solution to a faint pink color, which persisted for 30 s. Oxalate content was calculated on a dry basis based on the relationship:

\[ \text{Equivalence of KmnO}_4 = \text{Equivalence of C}_2\text{O}_4^{2-} \quad [2] \]

\[ \text{Mass of oxalate} = (N \times \text{vol in L}) \times (\text{MM of C}_2\text{O}_4^{2-}/n) \quad [3] \]

where \( n \) = number of equivalents of C2O42-, N = Normality, MM = Molar Mass, and

\[ \% \text{ Oxalate} = (g \text{ oxalate}/g \text{ sample}) \times 100 \quad [4] \]

Tannin Content

The tannin content of Pangi seeds was analyzed using the modified Folin-Ciocalteu method based on the procedures of Chye and Sim (2009) and Mohammed and Manan (2015). The sample was prepared by dissolving 1 g in 25 mL of 80% aqueous methanol (Scharlau, Spain) followed by heating in a water bath at 60°C for 1 h. The heating step at elevated temperature for 1 h aimed to degrade the phenolics except the tannins (Setyaningsih et al. 2016; Das et al. 2020; Zubia et al. 2023). The homogenate was centrifuged (NovaFuge B115-20R, Senova, China) at 7000 rpm for 5 min at 4°C. The supernatant was collected while the precipitate was discarded. The standard gallic acid (Spectrum Chemical, USA) solutions with final concentrations of 0.1, 0.2, 0.5, 0.8, and 1 mg mL−1 were also prepared using distilled water. A 100 µL from each sample and standard solution concentration was aspirated and added separately into 10 mL volumetric flasks containing a mixture of 750 µL of distilled water, 500 µL of 0.05 N Folin-Ciocalteu reagent (Sigma-Aldrich, USA) and 1000 µL of 35% Na2CO3 (Himedia, India). These were diluted to 10 mL with distilled water followed by incubation for 30 min at ambient temperature. Absorbance was read at 725 nm.
Pangi (Pangium edule Reinw.) Seeds Edibility and Level of Nutrition

Rovi Gem E. Villame-Gayagas et al.

against a blank. The amount of tannin was expressed in percentage in terms of Gallic Acid Equivalent or GAE as computed from the prepared standard curve:

\[
\% \text{ tannin} = \left( \frac{g \text{ GAE}}{g \text{ sample}} \right) \times 100 \quad [5]
\]

**Proximate Composition Analysis**

Moisture, crude ash, crude fat, crude fiber, and crude protein content of raw and processed Pangi seeds were analyzed following the Association of Official Chemists (AOAC 2005) methods. Moisture content was determined using the oven-drying method (AOAC Method 925.10). Crude ash was determined employing high-temperature incineration (AOAC Method 923.09). Crude fat was determined following the Soxhlet Method (AOAC Method 920.39). The crude fiber was analyzed employing the Wendee method (AOAC Method 984.04). The crude protein analysis was outsourced to the Davao Analytical Laboratories, Inc. (Davao City, Philippines), following the Kjeldahl method (AOAC Method No. 978.04). About 500 g of oven-dried raw and processed Pangi seed samples in sealed containers was submitted to the third-party laboratory for the protein analysis. Results were presented on dry basis.

**Mineral Content Analysis**

Five hundred grams of freeze-dried raw and processed Pangi seed samples in sealed containers were sent to the Davao Analytical Laboratories, Inc. for the determination of the following specific minerals employing atomic absorption spectrophotometry (AAS): calcium, iron, zinc, and manganese. Results were reported on dry basis.

**Statistical Analysis**

The Independent *t*-test at a 5% level of significance (*p* ≤ 0.05) was used to compare the means in antinutrient content, proximate composition analysis, and mineral content of Pangi seeds before and after processing. The GNU PSPP version 1.2.0-g0f8d4 software (GNU Project 2019) was used to perform statistical analysis. All analyses were performed in three trials with three replicates each.

**RESULTS AND DISCUSSION**

The Obu Manuvu in Marilog District, Davao City practices indigenous processing method for Pangi to render it safe for consumption. This study documented the process using open-ended questionnaires. Questions were asked on the general description, local name, culinary use, safety, and food poisoning issues related to the consumption of Pangi seeds, harvesting procedure, and the indigenous processing method performed by the community to render the seeds edible. Moreover, the respondents were asked to conduct a demonstration of the process.

Based on the interview, Pangi is a non-cultivated but widely distributed crop in Marilog District. It produces fruits in cluster that are generally round or oblong. The mature and ripened fruit is characterized by a brown exterior with a rough texture. It has a thick rind (about an inch thick) with a pale yellow-to-white colored pulp when opened or sliced. The pulp where the seeds are embedded is aromatic and sweet (Farida-Hanum 1996; Useful Tropical Plants Database 2014). The seed coat has a distinct raised webbed appearance (Fig. 2).

Furthermore, the Obu Manuvu community stated that consumption of unprocessed Pangi seeds results in poisoning of both humans and animals. Hence, it is important to properly handle and process Pangi seeds to make them edible and safe for consumption. Processed Pangi is usually eaten as is or added as an ingredient to other local dishes of the community.

**Antinutrients**

Antinutrients in food negatively affect human nutrition, especially in children (Roos et al. 2013; Popova and Mihaylova 2019; Nath et al. 2022). One type of antinutrient is cyanogenic glycoside and is found to be high in Pangi seeds amounting to 11.82 ± 0.14% (Fig 3A). This value is significantly higher than that of raw corn (0.11% cyanide), taro (0.52% cyanide), cassava leaves, peels, and roots (0.09% – 0.2% cyanide) and bamboo shoots (0.1% – 0.8% cyanide) (Fronteras et al. 2019; Nyirenda 2020; Lorilla et al. 2022). This may explain the reported high toxicity of Pangi seeds by the Obu Manuvu community. However, after processing, the level of cyanogenic glycoside was significantly reduced by 99.15% (*p* ≤ 0.05). The most abundant cyanogenic glycoside in Pangi is gynocardin (Aronson 2014) which produces cyanide acid, a highly toxic compound. This explains why unprocessed Pangi seeds are poisonous for human and animal consumption. However, cyanide acid can be easily removed due to its high solubility in water (Kasim and Wahyudi 2013; Kuliahari et al. 2021). The combined effect of washing, boiling, and soaking in...
running water done by the Obu Manuvu on Pangi seeds resulted in a significant reduction of the cyanogenic glycoside level in the seeds. Results from this study agree with those of Omoruyi et al. (2007), wherein boiling reduced the levels of cyanogenic glycosides in sweet potato (60.5% reduction) and cocoyam (98.8% reduction). Also, a similar declining trend was observed for yellow yam. Furthermore, Kasaye et al. (2018) also reported that boiling cassava tubers in water decreased their total cyanide content by 98.23%. It was also found that endogenous $\beta$-glucosidase activity caused significant degradation of amygdalin—a cyanogenic glycoside common in apricot kernels, after soaking in water at 20°C (Bolarinwa et al. 2016). This implied that the indigenous

\[ \text{Fig. 3. Effect of indigenous processing on the proximate composition, antinutrients, and minerals of Pangi seeds. Bars with different letters indicate a significant difference at } \alpha = 0.05 \text{ level of significance.} \]
processing method of the Obu Manuvu was effective in reducing the cyanide content of Pangi seeds.

Moreover, when cell structures of plants are damaged during processing such as pounding and soaking, cyanogenic glycosides are brought together with the corresponding β-glucosidase enzyme to release cyanide (Bolarinwa et al. 2016). Cyanide is a potent and rapidly acting poison. Animals are commonly found dead due to acute poisoning by cyanide (Talcott 2018). Other symptoms include sudden onset of vomiting, lethargy, coma, colic, headache, dizziness, weakness, and diarrhea (Stegelmeier et al. 2013). However, in Pangi seeds, multiple processes can volatilize cyanide to low levels and alleviate its toxicity. The acceptable intake of hydrogen cyanide for an adult human ranges from 0.5 mg to 3.5 mg per kg body weight (Nwokolo and Smartt 1996). Therefore, a 50 kg person can only take an acceptable dose of 25 mg – 175 mg of the cyanogenic glycoside. The % cyanide in gynocardin (the most common cyanogenic glycoside in Pangi) is 8.6 (Webber and Miller 2008). Thus, for a 100 g serving of processed seeds containing 100 mg of gynocardin, the amount of cyanide is 8.6 mg. This value falls below the toxic dose for cyanide. Hence, the processed seeds are safe for human and animal consumption.

Another antinutrient considered in this study is oxalate which is known to bind minerals like calcium and magnesium. Excess oxalate in the body prevents absorption of such minerals and tends to form kidney stones (Adeniyi et al. 2009; Soetan and Oywol 2009; Alelign and Petros 2018). Most urinary stones formed in humans are calcium oxalate stones. The tolerable dose of oxalate for human consumption is 15 g – 30 g per d (Silberhorn 2005). The oxalate level in Pangi seeds was significantly reduced from 1.24 ± 0.05% to 0.27 ± 0.04% (Fig. 3A) after processing. The oxalate content of processed seeds (0.27 g) falls below the tolerable dose. This reduction in the oxalate content may likely be attributed to the boiling step during processing. The significant reduction in oxalate during boiling results from the high solubility of oxalate in water. Boiling causes considerable skin rupture and facilitates the leakage of soluble oxalate into the cooking water (Arias-Rico et al. 2020). Results agree with that of Lewu et al. (2009) on boiled C. esculenta leaves and Maqbool et al. (2021) on boiled kale. Boiling is a more effective way to eliminate oxalate compared to pressure cooking and baking (Bhandari and Kawabata 2004).

Tannin is considered another antinutrient because it can complex with minerals and proteins, thus affecting their absorption and bioavailability (Ashok and Upadhyaya 2012; Uraku et al. 2015; Samtiya et al. 2020). Hence, in this study, the levels of tannin before and after processing were compared as changes in tannin content may affect the levels of other nutrients (i.e., minerals and proximate composition) in the sample.

The Folin-Ciocalteau (FC) method is used to quantify the total phenolic content (TPC). However, a modification (heating at 60°C for 1 h) during extraction has been incorporated in the standard FC method for the purpose of degrading the other phenolic compounds while retaining the tannins. In the study of Zubia et al. (2023), the total phenolic content of bignay pomace significantly decreased when the sample was dried at 45°C for 48 h; however, tannin content was not affected. Further, in the study of Setyaningsih et al. (2016), it was established that 36 out of 40 phenolic compounds (tannin not included in the study) were stable up to 50°C only. Presumably, because of the complexity of the structure of tannins, they are relatively more stable at higher temperatures than the simpler phenolic compounds. Das et al. (2020) validated that optimum extraction of tannins using methanol/ethanol is achieved at 60°C – 120°C.

Findings from this study suggest that the combined effect of boiling and soaking followed by dehulling significantly reduced the tannin levels in Pangi seeds by 96.15% (Fig. 3A). Rehman et al. (2005) also reported a 20.8% – 26.8% reduction of tannins in legumes after boiling. Further, loss in tannin can also result from leaching during washing and soaking (Vijayakumari et al. 2007; Thakur et al. 2021) as some tannins are readily hydrolyzable (Das et al. 2020). Additionally, a significant reduction of tannin may be attributed to the loss of the compound after exposure to high temperature (Nithya et al. 2007). Dehulling was also previously reported to substantially reduce tannins in beans (Olika et al. 2019). According to Akalu and Geleta (2017), the maximum allowable daily tannic acid intake in humans is 560 mg. The tannin level of processed Pangi seeds is 40 mg/100g serving and is therefore not considered a potential health hazard.

**Proximate Composition**

On another note, the effect of the indigenous processing method of the Obu Manuvu on the proximate composition of Pangi seeds was also investigated (Fig. 3B). As shown, the moisture content increased significantly (p ≤ 0.05) by 18.38%. This may be attributed to the combined effect of soaking and boiling on Pangi seeds as plant cells and fibers can absorb moisture during boiling (Alcantara et al. 2013). An increase in moisture content after boiling and/or soaking was also observed in other seeds such as fluted pumpkin (Telfairia...
While the crude ash and crude fiber contents significantly decreased, crude fat increased, and crude protein content remained unaffected. A 13.49% reduction of ash content in processed samples (1.86 ± 0.20%) was observed compared to the raw sample (2.15 ± 0.16%). This can be attributed to the leaching of the minerals into the cooking medium. Results from the study of Garcia-Herrera et al. (2020) involving boiled wild edible plants support these findings. The same occurrence was observed in melon husks (ash content reduced from 6.79 ± 0.105% to 5.93 ± 0.088%) after boiling (Idoko et al. 2014). High ash content indicates high nutritional levels in terms of mineral content. However, in this study, the crude ash content of processed Pangi seeds decreased significantly, which could influence its mineral levels.

Crude fat, on the other hand, exhibited a significant increase (p ≤ 0.05) after processing. Fat is a storage form of energy. Pangi kernels have a very high energy level of 227 kcal per 100 g (Hoe and Siong 1999), more than half of which consists of oil fraction (Santoso et al. 2014) which was evident in the result obtained by this study. However, the results contrasted with some studies (Farinde et al. 2018; Chauhan et al. 2022), wherein a declining trend in crude fat was observed after processing. Nevertheless, studies by Arinola and Adesina (2014) and Djikeng et al. (2018) also reported an increase in the crude fat content of seeds and walnuts after boiling. An increase in crude fat content with processing time may be attributed to the application of heat disrupting the cell partitions of the seeds. This causes the fat to melt, facilitating further extraction (Onyeike et al. 2015).

Furthermore, the processing method applied caused a significant reduction (p ≤ 0.05) in the crude fiber content of the samples by 57.93%. Haruna and Bichi (2015) observed similar results on the crude fiber of boiled and roasted legume seeds. The fiber in the diet enhances digestibility, slows down the release of glucose into the bloodstream, aids bowel movement, and prevents bowel cancers (Arinola and Adesina 2014). This implies that the application of indigenous processing methods reduced the availability of fiber. This reduction may be attributed to solubilization as an increase in temperature leads to the breakage of weak bonds between polysaccharide chains and glycosidic linkages in dietary fiber polysaccharides (Căpriță et al. 2011).

Finally, there was no significant change observed in the crude protein content of Pangi seeds after processing. This contrasts with the study of Obiakor-Okeke and Chimdinma (2014), wherein the cooking and roasting of African breadfruit increased the protein content. Nevertheless, the protein content (20.35 g per 100 g) of processed Pangi seed still falls within the Recommended Dietary Allowance (RDA) for protein in children ages 1 – 12 yr old (17 g – 46 g) (FNRI 2018). However, for adults ages ≥ 19 years old, consumption of other protein-rich food sources was recommended to supplement the RDA for protein which is 71 g – 62 g (FNRI 2018).

Mineral Composition

The effect of processing Pangi seeds on specific minerals (calcium, iron, zinc, and manganese) was also investigated. Results showed that calcium, zinc, and manganese levels were significantly increased, while no significant difference was observed in iron levels (Fig. 3C).

The calcium content of the seeds significantly increased (p ≤ 0.05) by 221.43%. This agrees with Adebayo (2014), wherein an increase in calcium content is associated with soaking lima beans in water. A study by Karkle and Beleia (2010) also reported that some varieties of soybeans showed an increase in calcium content after soaking and cooking in water. Apparently, the water treatment improves the availability of calcium presumably through dissociation from binding with other metabolites. The increase in calcium may be attributed to the substantial reduction of oxalate levels in the processed Pangi seeds since oxalates bind and precipitate calcium (Savage and Klunklin 2018). Further, the increase in calcium may also be due to the reduction of tannin in processed Pangi seeds. Like oxalate, tannin also binds with calcium (Amalraj and Pius 2017). Several studies reported on the negative correlation between bioavailable calcium and tannin in selected legumes samples (Savelkoul et al. 1992; Hussein and Ghanem 1999; Ghavidel and Prakash 2007) which supports the findings found in Fig. 3B.

The RDA of calcium for children and adolescents ranges from 500 mg – 1000 mg (FNRI 2018). The processed Pangi seeds could provide up to 398.2 mg per 100 g consumption of edible portions.

For the level of iron, boiling and soaking appeared to have no significant effect. This finding agrees with Lewu et al. (2009) concerning boiled C. esculenta leaves. A similar trend was also observed by Omoruyi et al. (2007). In the study of Towo et al. (2003), it was found that phenolic compounds such as tannin could negatively influence the bioavailability of iron. However, in this...
study, the decrease in tannin of processed seeds did not make up for any significant increase in the iron level after processing.

The RDA of iron for children (1 – 12 yr old) is 8 mg – 28 mg per d (FNRI 2018). With the iron content (3.77 mg per 100 g) of processed Pangi seeds falling below the recommended daily intake, it could contribute up to 13.46% of the RDA. Thus, the intake of iron-rich and iron-fortified food, as well as the use of other supplements, is recommended.

The zinc level in Pangi seeds significantly increased by 64.39% after processing (p ≤ 0.05). Findings agree with Feitosa et al. (2018), who observed that zinc concentration increased in black beans after applying household cooking methods. On the contrary, Lestienne et al. (2005) showed that solely soaking bean cultivars were not efficient for improving mineral bioavailability. However, their results also showed that zinc levels could be increased in combination with other treatments or with optimized soaking conditions. Moreover, like iron, a strong inverse correlations of tannin content with zinc extractability have been reported (Nakitto et al. 2015). Therefore, it can be implied that reduction in tannin content could have led to an increase in zinc levels of processed Pangi seeds.

In this study, the zinc levels in processed Pangi seeds were only 1.68 mg per 100g, whereas its RDA ranges from 4 mg – 9 mg in children (FNRI 2018). Although there was a notable increase in zinc, it did not fall within the recommended intake values. Hence, it is suggested to consume zinc-rich and zinc-fortified foods or other supplements.

No significant change was observed in the manganese levels of raw and processed Pangi samples. Manganese is a critical component of some enzymes and part of the bone structure. It also supports brain function and reproduction and is required for blood sugar regulation (Vincente et al. 2014). The RDA for manganese in children and adolescents ranges from 1.2 mg – 2.2 mg (Institute of Medicine 2001). The processed Pangi seed contained 1.47 mg of Mn per 100 g of edible portion, implying that Pangi seed is a good source of manganese.

CONCLUSION

The processing method of the Obu Manuvu for Pangi seeds effectively reduces the levels of antinutrients namely cyanogenic glycoside, oxalate, and tannin. The indigenous processing can mitigate incidences of food poisoning in the community. Consumption of processed Pangi seeds may serve as an additional dietary source of minerals (such as calcium and zinc) and crude fat to alleviate malnutrition among children.

The results of this study are valuable to the community as these can create a general awareness on the nutritional potential of processed Pangi seeds. The indigenous processing, once communicated, has the potential to be adapted as a good practice in reducing the level of hydrogen cyanide in plant-based commodities which is associated with numerous cases of food poisoning. Moreover, these can be of help to government agencies in crafting policies concerning food safety and nutrition in the community. Future work is necessary to study further the characteristics of Pangi seeds to maximize their use and utilization. Further, chemical analysis on a per step basis can also be explored to determine which processing step could largely contribute to the changes in the levels of antinutrients and nutritional factors of Pangi seeds.

ACKNOWLEDGMENT

The study was supported by the Center for the Advancement of Research, Development and Engagement in Mindanao or CARIM of the University of the Philippines Mindanao.

REFERENCES CITED


AKALU ZK, GELETA SH. 2017. Antinutritional levels of tubers of Colocasia esculenta, L. Schott (Taro) and Dioscorea alata (Yam) cultivated in Ethiopia. J Nutr Food Sci. 7(2). doi:10.4172/2155-9600.1000585.

ALCANTARA RM, HURTADA WA, DIZON E. 2013. The nutritional value and phytochemical components of taro [Colocasia esculenta (L.) Schott] powder and its...
Pangi (Pangium edule Reinw.) Seeds Edibility and Level of Nutrition


Rovi Gem E. Villame-Gayagas et al.


Phaseolus vulgaris Colocasia Phaseolus lunatus Manihot esculenta

GHAVIDEL RA, PRAKASH J. 2007. The impact of


THAKUR P, KUMAR K, AHMED N, CHAUHAN D, EAIN HYDER RIZVI QU, JAN S, SINGH TP, DHALIwal HS. 2021. Effect of soaking and germination treatments on nutritional, anti-


