

# The Nutritional Value and Phytochemical Components of Taro [*Colocasia esculenta* (L.) Schott] Powder and its Selected Processed Foods

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## Abstract

The nutritional value, phytochemical components and antinutrient contents of taro corm and its products were studied. Processing taro corm significantly affected its proximate composition, mineral content, phytochemical components and antinutrient (oxalate and phytate) contents. There was a significant reduction ( $p < 0.05$ ) in the proximate composition, mineral content, phytochemical components and antinutrient contents when taro corms were made into powder and were further decreased when processed into taro noodles and cookies. Exposure to high temperature during processing could have greatly affected the reduction in nutrient and phytochemical as well as antinutrient contents of raw taro.

**Keywords:** Taro; Nutritional value; Phytochemical components; Antinutrients; Processing; Noodles; Cookies

## Introduction

When a crop is being considered for food, nutritional value and consumer acceptance must be taken into consideration. The nutritional value of a food depends upon its nutritional contents and their digestibility and the presence or absence of antinutrients and toxic factors. As far as consumer acceptance is concerned, *Colocasia esculenta*, commonly known as taro or cocoyam, is an important food staple of developing countries in Africa, West Indies, Pacific region and Asia. For supplying nutrients, the corms may be considered as a good source of carbohydrates and potassium. Large servings of taro corms can become a significant source of dietary protein, especially if taken more than once a day. Taro is also a good source of thiamin, riboflavin, iron, phosphorus and zinc and a very good source of vitamin B6, vitamin C, niacin, potassium, copper and manganese. Taro also contains greater amounts of vitamin B-complex than whole milk [1].

In addition, taro is especially useful to persons allergic to cereals and can be consumed by children who are sensitive to milk [2]. Taro is also a tuber that is very rich in carbohydrates, ranging between 73 to 80% which is mainly starch at 77.9% and 1.4% crude fiber, Dry Matter (DM) basis. Because of its high carbohydrate content, this tuber represents one of the main sources of energy in many parts of the tropics and sub-tropics providing about a third of the food intake of more than 400 million people in these areas [1].

Nowadays, zinc deficiency is widespread and affects the health and well-being of populations worldwide [3] and since taro is one of the few non-animal sources of zinc [4], its utilization should therefore be pursued to help in the alleviation of zinc deficiency which is associated to stunting. However, despite the wide application and great potential of taro as a chief dietary source of carbohydrate and other essential nutrients, its usage is often limited by its antinutrient contents which are either potentially toxic or may limit the bioavailability of nutrients.

This study specifically determined the nutritional value, phytochemical components and antinutrient contents of raw taro and when processed into powder, noodles and cookies to determine the effect of processing. The results of this study may provide opportunities to promote and support the use of taro into processed foods like noodles and cookies to reduce its antinutrient contents which can help improve its production and utilization potentials.

## Materials and Methods

### Raw materials

Two varieties (NSIC G-9 and VG-2) of taro corms were obtained from Philippine Root Crop Research and Training Center, Visayas State University, Visca, Baybay City, Leyte. *Gabing Tagalog*, the native variety was purchased from a vegetable dealer in Calamba City and was authenticated at the Museum of Natural History, University of the Philippines Los Baños. The samples used were fresh and in their raw form. The two varieties (NSIC G-9 and VG-2) from Leyte were 3-4 cm in diameter and have purple flesh while the other variety (*Gabing Tagalog*) was 1-2 cm in diameter and has white flesh.

### Screening of taro varieties

Preliminary study was conducted on the three varieties of taro to identify the variety that was used in this study with the highest zinc and lowest antinutrient (oxalate and phytate) contents. Variety NSIC G-9 showed the highest zinc and lowest antinutrient (oxalate and phytate) contents and was used in the development of taro powder.

### Processing of taro corms

The raw taro corms underwent different physical treatments such as washing, peeling, dicing, soaking, drying and milling before they were processed into taro powder to reduce their antinutrient contents based on the study of Blasé [5]. The taro powder was then used in the preparation of noodles and cookies. The raw taro corms, powdered taro and taro-based noodles and cookies were also analyzed for their proximate composition, mineral, phytochemical and antinutrient contents. All the analyses were done at the Institute of Plant Breeding, University of the Philippines Los Baños.

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## Chemical analysis

Chemical analyses were done in the raw taro corms, after it was processed into powder and when used in the preparation of noodles and cookies.

## Nutritional value

Moisture, crude protein, ash, fiber and fat were analyzed as described in AOAC methods (1990). Carbohydrate (expressed as nitrogen free extract, NFE) was computed by subtracting the moisture, crude protein, ash, fiber and fat from 100. Zinc was analyzed following the AOAC (1990) dry ashing procedure and standard analytical method for atomic absorption spectrophotometry. Also, iron content was analyzed following the AOAC [6] wet digestion method and standard analytical method for atomic absorption spectrophotometry while calcium content followed the EDTA Method.

## Phytochemical contents

The total phenolic content was determined by the Folin-Ciocalteu Assay while the total tannin analysis was conducted using the modified vanillin method. The total flavonoid concentration was measured using a colorimetric assay developed by Zhishen et al. [7] while the method of Hostettman and Marsto [8] for the analysis of saponins was used. For the alkaloids contents, the method developed by Hultin and Torsell [9] was used in the analysis.

## Antinutrient contents

Oxalate content was determined by the method of Munro and Bassir [10] while the analysis of phytate content followed the method developed by Latta and Eskin [11].

## Preparation of taro powder

NSIC G-9 variety, the sample with the highest zinc and lowest antinutrient (oxalate and phytates) contents was used in the preparation of taro powder. The raw taro was washed in running water for two hours and then peeled. The samples were diced into one cm size, washed again then were soaked in water overnight. The samples were blanched for five minutes then were dried at 60°C for 24 hours in the following day. The dried samples were milled (100 mesh) and were analyzed for its proximate composition, minerals, phytochemicals and antinutrients contents before packing.

## Preparation of noodles and cookies

The taro powder was used in the preparation of taro-based food products such as noodles and cookies. For both products, recipes were standardized to determine the proportion of the ingredients that yielded the most acceptable product. This was based on a preliminary sensory evaluation done on the different proportions of taro powder and all purpose flour in making noodles and cookies.

For the preparation of noodles, the ingredients used were taro powder (75%), all purpose flour (25%), salt, egg and water. On the other hand, for the preparation of cookies, the ingredients used were taro powder (50%), all purpose flour (50%), baking powder, salt, sugar, butter, egg and vanilla.

## Statistical analysis

Results of the chemical tests were analyzed using Analysis of Variance (ANOVA), Fisher's Least Significant Difference (LSD) and Pearson Correlation Analysis. All the statistical tests were performed

at 5% level of significance using SAS version 6.12. The results were expressed as mean values  $\pm$  standard deviation.

## Results

### Preliminary screening of taro varieties

The three varieties of taro (NSIC G-9, VG-2 and *Gabing Tagalog*) were analyzed for their zinc, oxalate and phytate contents to determine the variety to be made into powder and used in making noodles and cookies. The results showed that NSIC G-9 had the highest zinc content at 1.67 mg/100 g while VG-2 had the lowest at 1.28 mg/100 g. For their antinutrient contents, VG-2 had the lowest oxalate (146.62 mg/100 g) and phytate (48.42 mg/100 g) contents while *Gabing Tagalog* had the highest oxalate (1,348.48 mg/100 g) and phytate (96.58 mg/100 g) contents. All the results were significantly different (Table 1).

### Proximate composition of taro

**Moisture content:** Table 2 summarizes the proximate composition of raw taro, powdered taro, taro noodles and taro cookies. Raw taro had the highest moisture content at 6.54% while taro cookies had the lowest at 1.07%. The results also showed that the moisture content of taro powder in noodles and cookies had decreased significantly while the decreased in the moisture content from raw taro to powdered taro were not significant. Figure 1 shows that there was a 5.05% reduction in moisture content from raw taro to taro powder, 5.08% reduction from taro powder to noodles and 82.77% reduction from taro powder to cookies.

**Crude ash:** The crude ash of raw taro increased when processed into powder then decreased when boiled and baked. Taro cookies had the lowest ash content at 0.24% while taro powder had the highest at 2.78% (Table 2). Results showed that there was a significant difference in the ash content of raw taro and its processed products. Figure 1 shows that there was a 13.93% increase in ash content from raw taro to taro powder.

**Crude fiber:** The crude fiber of raw taro increased when processed into powder then decreased when made into noodles and cookies. Taro powder had the highest fiber content at 3.10% while taro cookies had the lowest at 0.27% (Table 2). The results also showed significant differences in the crude fiber of raw taro and its processed products. Figure 1 shows

VARIETY	ZINC (mg/100g)	OXALATE (mg/100g)	PHYTATE (mg/100g)
<i>Gabing Tagalog</i>	1.45 $\pm$ 0.03 b	1,348.48 $\pm$ 8.51 a	96.58 $\pm$ 1.66 a
NSIC G-9	1.67 $\pm$ 0.17 a	156.33 $\pm$ 2.50 b	85.47 $\pm$ 1.40 b
VG-2	1.28 $\pm$ 0.05 c	146.62 $\pm$ 2.52 b	48.42 $\pm$ 3.47 c

\* Means having the same letter within column are not significantly different at  $p < 0.05$ . Data were mean of three determinations (n=3).

**Table 1:** Mean zinc, oxalate and phytate contents of the different varieties of taro.

COMPONENTS	RAW TARO	TARO POWDER	TARO NOODLES**	TARO COOKIES**
Moisture (%)	6.54 $\pm$ 0.16 a	6.21 $\pm$ 0.03 a	3.10 $\pm$ 0.28 b	1.07 $\pm$ 0.10 c
Crude Ash (%)	2.44 $\pm$ 0.03 b	2.78 $\pm$ 0.07 a	1.39 $\pm$ 0.13 c	0.24 $\pm$ 0.02 d
Crude Fiber (%)	3.01 $\pm$ 0.03 a	3.10 $\pm$ 0.04 a	1.24 $\pm$ 0.06 b	0.27 $\pm$ 0.02 c
Crude Protein (%)	7.79 $\pm$ 0.03 b	8.07 $\pm$ 0.07 a	3.23 $\pm$ 0.14 c	0.69 $\pm$ 0.03 d
Crude Fat (%)	0.65 $\pm$ 0.02 a	0.45 $\pm$ 0.03 b	0.19 $\pm$ 0.03 b	0.13 $\pm$ 0.01 c
Carbohydrate (%)	86.11 $\pm$ 0.06 a	85.60 $\pm$ 0.06 a	59.92 $\pm$ 0.21 b	36.69 $\pm$ 0.20 c

\* Means having the same letter within rows are not significantly different at  $p < 0.05$ . Data were mean of three determinations (n=3).

\*\* Excluding other ingredients.

**Table 2:** Mean proximate composition of raw taro, taro powder and taro-based noodles and cookies (dry weight basis).\*

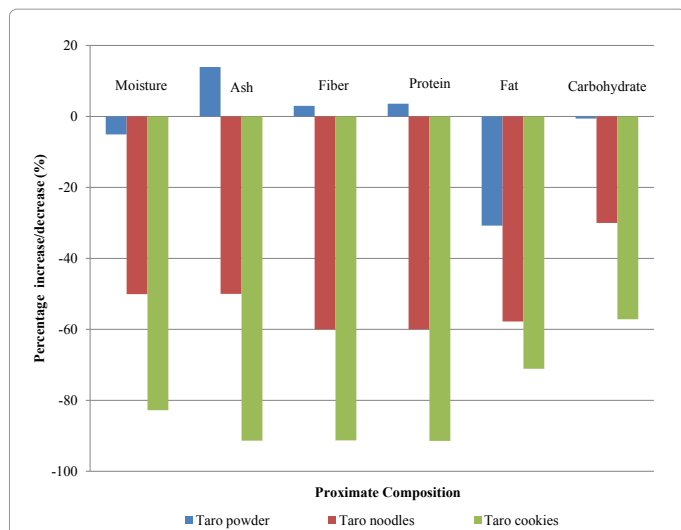


Figure 1: Changes in the proximate composition of raw taro, taro powder and taro-based noodles and cookies.

SAMPLES	ZINC (mg/100g)	IRON (mg/100g)	CALCIUM (mg/100g)
Raw Taro	1.67 ± 0.06 b	2.95 ± 0.19 b	55.00 ± 1.64 b
Taro Powder	1.84 ± 0.06 a	4.06 ± 0.13 a	64.84 ± 0.44 a
Taro Noodles**	1.29 ± 0.04 c	2.84 ± 0.21 d	32.41 ± 0.35 c
Taro Cookies**	0.87 ± 0.01 d	3.47 ± 0.11 c	13.90 ± 0.11 d

\* Means having the same letter within column are not significantly different at  $p < 0.05$ .  
 \*\* Excluding other ingredients

Table 3: Mean mineral contents of raw taro, taro powder and taro-based noodles and cookies.

that there was a 2.99% increase in the fiber content of raw taro to taro powder while the significant reduction in fiber content of taro powder in noodles and cookies were 60% and 91.29%, respectively.

**Crude protein:** Taro powder (8.07%) had the highest protein content and taro cookies (0.69%) had the lowest (Table 2). Results showed that there was a significant difference in the crude protein of raw taro and its processed products. There was a noticeable reduction in the protein content of taro powder when made into taro noodles and cookies at 59.98% and 91.45%, respectively (Figure 1).

**Crude fat:** Raw taro had the highest fat content at 0.65% while taro cookies had the lowest at 0.13% (Table 2). Figure 1 shows that there was a decrease in fat content from raw taro to powdered taro at 30.77%, from taro powder to noodles at 57.78% and cookies at 71.11%.

**Carbohydrate:** The carbohydrate content of raw taro decreased significantly when processed into powder, noodles and cookies. Raw taro had the highest carbohydrate content at 86.11% while taro cookies had the lowest at 36.69% (Table 2). As shown in figure 1, there was a significant decrease in the carbohydrate content of taro powder when made into taro noodles and cookies at 30% and 57.14%, respectively.

**Mineral content of taro:** There were significant differences in the zinc, iron and calcium content of raw taro, taro powder, noodles and cookies (Table 3). In general, there was an increase in the mineral content from raw taro to taro powder at 10.18% in zinc, 37.63% in iron and 17.89% in calcium (Figure 2). On the other hand, there was a reduction in the mineral contents of taro powder into noodles at 29.89% for zinc, 30.05% for iron and 50.02% for calcium while cookies at 52.72% for zinc, 14.53% for iron and 78.10% for calcium (Figure 2).

### Antinutrient content of taro:

**Oxalate :** Raw taro (156.33 mg/100 g) had the highest oxalate content while taro noodles (29.96 mg/100 g) had the lowest (Table 4). It was also observed that there was a reduction in the oxalate content from raw taro into powdered taro at 77.18%, from taro powder into noodles at 16.01% and from taro powder into cookies at 9.7% (Figure 3).

**Phytate:** Raw taro (85.47 mg/100g) had the highest phytate content which significantly decreased when processed into powder, noodles and cookies (Table 4). It was observed that there was a reduction in the phytate content of raw taro into taro powder at 15.80% and taro powder into taro noodles at 70% and taro cookies at 82.85% (Figure 3).

### Antioxidant activity and phytochemical components of taro: The

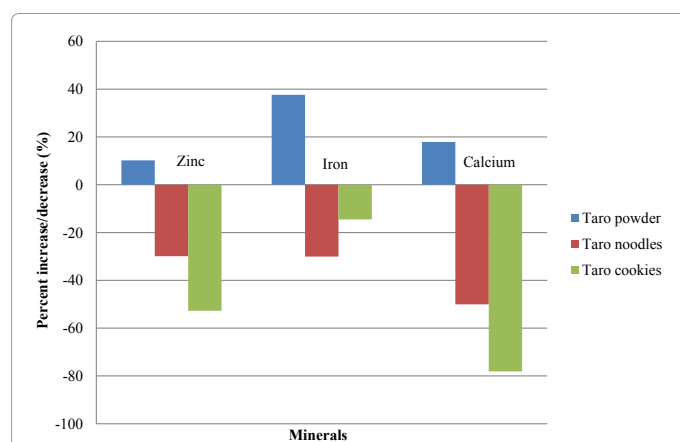


Figure 2: Changes in the mineral contents of raw taro, taro powder and taro-based noodles and cookies.

SAMPLES	OXALATE CONTENT (mg/100g)	PHYTATE CONTENT (mg/100g)
Raw Taro	156.33 ± 5.13 a	85.47 ± 0.83 a
Taro Powder	35.67 ± 0.58 b	71.97 ± 0.57 b
Taro Noodles**	29.96 ± 0.57 d	21.59 ± 0.34 c
Taro Cookies**	32.21 ± 0.32 c	12.34 ± 0.18 d

\* Means having the same letter within column are not significantly different at  $p < 0.05$ .

Data were mean of three determinations (n=3).

\*\* Excluding other ingredients.

Table 4: Mean antinutrient contents of raw taro, taro powder and taro-based noodles and cookies.\*

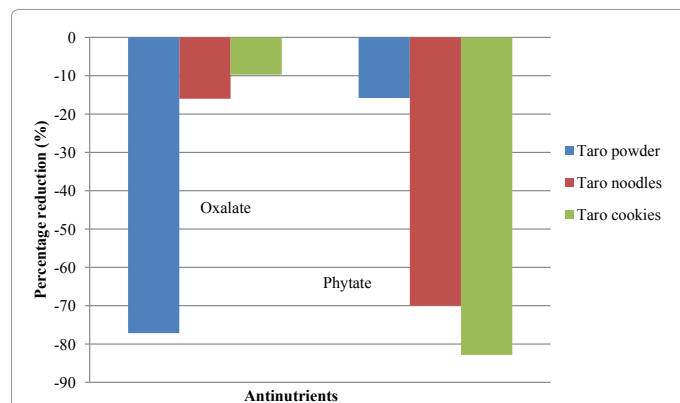


Figure 3: Changes in the antinutrient contents of raw taro, taro powder and taro-based noodles and cookies.

COMPONENTS	RAW TARO	TARO POWDER	TARO NOODLES**	TARO COOKIES**
Antioxidant Activity (% LP) <sup>1</sup>	74.68 ± 0.44 b	81.77 ± 0.47 a	65.91 ± 0.27 c	28.00 ± 0.12 d
Phenols (mg/100g expressed as g catechin eq/g )	34.83 ± 0.28 b	78.33 ± 0.66 a	16.27 ± 0.90 c	3.68 ± 0.10 d
Tannins (mg/100g expressed as vanillin eq/g)	32.24 ± 0.35 a	32.24 ± 0.35 a	Negative	Negative
Flavonoids (mg/100g expressed as mg gallic acid eq/g)	28.56 ± 0.23 b	64.23 ± 0.54 a	2.96 ± 0.32 c	0.90 ± 0.16 d
Saponins (mg/100g saponins)	14.22 ± 0.36 b	26.96 ± 0.61 a	5.01 ± 0.61 c	2.73 ± 0.18 d
Alkaloids (rating)	Negative	Negative	Negative	Negative

\* Means having the same letter within column are not significantly different at p<0.05.

Data were mean of three determinations (n=3).

\*\* Excluding other ingredients.

<sup>1</sup>The higher the % lipid peroxidation, the lower the antioxidative activity

**Table 5:** Mean antioxidant activity and phytochemicals present in raw, powdered and processed taro.\*

phytochemical components of taro are shown in table 5. Taro powder had the highest antioxidant activity value at 81.77% lipid peroxidation while taro cookies had the lowest at 28% lipid peroxidation. The higher the % lipid peroxidation, the lower is the antioxidative activity therefore taro powder has a lower antioxidant activity. On the other hand, taro powder had the highest total phenolic content at 78.33 mg/100 g while taro cookies had the lowest at 3.68 mg/100g expressed as g catechin equivalent/g. The tannin content was highest in raw taro and powdered taro at 32.24 mg/100 g expressed as vanillin equivalent/g and there were no traces in taro noodles and cookies. For the flavonoids content, taro powder had the highest at 64.23 mg/100 g while taro cookies had the lowest at 0.90 mg/100 g expressed as mg gallic acid equivalent/g. The saponins content were highest in taro powder at 26.96 mg/100 g and lowest in taro cookies at 2.73 mg/100 g saponins. Lastly, alkaloids were not present in all samples. The results showed that all the mean values for antioxidant activity, phenols, tannins, flavonoids and saponins were significantly different from raw taro to powdered taro to noodles and cookies.

## Discussion

### Preliminary screening of taro varieties

Based on the results, the variety that was best to be utilized was NSIC G-9 since it had the highest zinc content and had low phytate and oxalate contents compared to the other varieties.

### Proximate composition of taro

**Moisture content:** The reduction in moisture content was due to the application of heat which caused the loss of water from food as a result of evaporation. The higher reduction in moisture content of taro cookies was due to the higher temperature used in baking which is 190°C compared to the 60°C used in drying which resulted in the rapid evaporation of water. When a food is placed in a hot oven, the low humidity of air in the oven creates a moisture vapor pressure gradient, which causes moisture at the surface of the food to evaporate and this in turn creates movement of moisture from the interior of the food to the surface [12].

**Crude ash:** The increase in the ash content resulted from the removal of moisture during drying which increased the concentration of ash in taro powder. On the other hand, the significant reduction in the ash content of taro powder into noodles at 50% and cookies at 91.37% implies that the potential ability of taro to supply essential minerals has been reduced. This may be due to water absorption during boiling of the taro noodles leading to dilution [13], or it may be due to leaching of the mineral compounds into the boiling water [14]. Also, it could have been lost during baking of the taro cookies due to higher temperature (190°C) either by degradation as a result of destruction

or chemical changes like oxidation [15]. As heating continued, some of the mineral elements may be partly loss as volatile compounds [16] contributing to the reduction in the ash content.

**Crude fiber:** The increase in the fiber content observed in taro powder resulted from the removal of moisture during drying which increase the concentration of fiber [17]. Since boiling and baking require higher temperatures, 100°C and 190°C, respectively, it is possible that these caused the decrease in fiber content of taro powder when used in making noodles and cookies. Boiling reduces the crude fiber content due to increased temperature that leads to breakage of weak bonds between polysaccharide chains and glycosidic linkages in the dietary fiber polysaccharides [14]. According to FAO (1990), the depolymerization of the fiber results in the solubilization of the fiber. Other reactions during boiling that may affect the dietary fiber content and its properties are leakage into the boiling water, formation of Maillard reaction products thus adding to the lignin content and formation of resistant starch fractions. Also, baking may decrease the amount of pectin in roots and the degree of esterification, thereby decreasing their dietary fiber content, but this is not nutritionally significant [18].

**Crude protein:** Agoreyo et al. [17] reported that the protein content of raw taro decreases after drying and processing, from 4.5 to 2.3%. The low crude protein content of taro noodles and cookies was due to the effect of heat from boiling and baking which could have denatured the secondary and tertiary structures of the protein. The observed decrease in protein content by the boiling process was due to the denaturation of protein wherein the hydrogen bonds and non-polar hydrophobic interactions of the secondary and tertiary structures of proteins are disrupted by heat [15] and the soluble amino acids leached out in the cooking medium [18].

**Crude fat:** The decrease in fat content may be due to blanching done prior to drying which may have melted the fat into the boiling water thus causing a reduction in the fat content [14]. Also, heating triggers polymerization, decomposition and oxidation of fat contributing to its loss during drying, boiling and baking [19].

**Carbohydrate:** The high level of carbohydrate content observed in raw taro, taro powder, noodles and cookies agrees with the findings reported by FAO [18] that the main nutrient supplied by taro, as with other roots and tubers, is dietary energy provided by the carbohydrates [20]. Moreover, the lower carbohydrate content of taro noodles and cookies compared to taro powder was due to the other ingredients added like all purpose flour and egg thus decreasing the amount contributed by taro powder.

**Mineral content of taro:** The increase in the mineral contents observed in this study could be a result of the removal of moisture



during drying which tends to increase the concentration of minerals [17]. Minerals are generally not sensitive to heat during processing, but are susceptible to leaching into the processing or cooking water. The decrease in mineral contents were due to water absorption during boiling of the noodles leading to dilution or it may be due to leaching of the mineral compounds into the boiling water, and hence, low amount of the ash and mineral content [14]. Also, the reduction in mineral contents during baking of the taro cookies were due to higher temperature (190°C) which causes mineral degradation as a result of destruction or chemical changes like oxidation [15]. Moreover, as heating continued, some of the mineral elements such as zinc, iron and calcium may be partly loss as volatile compounds [16] contributing to the reduction in the mineral content.

**Antinutrient content of taro oxalate:** The reduction in oxalate content may be due to the different treatments done to raw taro prior to drying like washing, peeling, dicing, soaking overnight and blanching as well as the boiling of noodles and baking done in making cookies. Washing according to the studies of Huang *et al.* [2] reduced the concentration of oxalate by 9.2%, while Akpan and Umoh [21] stated in their study that the peel of tubers contains more oxalate than the peeled tubers. Buntha *et al.* [22] also reported that the acidity of high oxalate cultivars of taro can be reduced by peeling, grating, soaking and fermentation during processing. Thus, dicing of the tubers makes the tissues finer and smaller resulting in greater surface area exposed to soaking medium so that leaching process is faster. Huang *et al.* (2010) also found out in their studies that soaking reduced the concentration of oxalates by 23.5% and cooking by 56.7% [2]. Shanthakumari *et al.* [23] further confirmed that the decrease in the anti-nutritional factors like oxalates during soaking may be due to leaching out of these substances in soaking medium. Boiling may cause considerable cell rupture and facilitate leakage of soluble oxalate into cooking water [24].

**Phytate:** Because phytate is heat-stable, significant heat destruction of phytate during cooking is not expected to occur. Therefore, the reduction in phytate content during boiling only takes place either by discarding the boiling water or by enzymatic phytate hydrolysis due to the action of the intrinsic plant phytases during the early part of the cooking phase. Heating for prolonged times at elevated temperatures lead to a progressive inactivation of the endogenous enzymes. The decrease in phytate content during boiling of the taro noodles may be partly due to the formation of insoluble complexes between phytate and other components, such as phytate-protein or phytate-protein-mineral [25]. Moreover, phytates may be soluble under very high temperatures like during boiling (100°C) and baking (190°C) as evident by the significant reduction of phytate content in taro noodles and cookies.

#### Antioxidant activity and phytochemical components of taro

Generally, the phytochemical components of raw taro increased when it was made into powder and decreased when used in making noodles and cookies (Figure 4). It is well known that heat can destroy the quality of food attributes, such as color, texture, nutrients and phytochemicals beneficial to health. The natural antioxidants contained in foods can be lost to a significant degree during processing using boiling, drying or handling such as peeling and slicing, as well as during storage, because most bioactive compounds are relatively unstable when subjected to heat. However, recent studies have shown that heat processing does not necessarily result in a loss of quality and health properties. In some cases, heat treatment produces no change or has an improved effect on the content and activity of naturally occurring antioxidants as evident in the increase in phytochemical components of taro powder after drying (60°C) at 124.89% for phenols, 89.59%

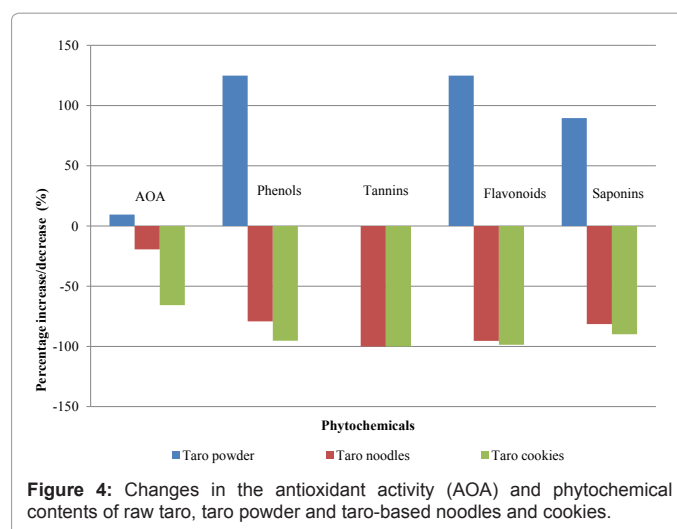


Figure 4: Changes in the antioxidant activity (AOA) and phytochemical contents of raw taro, taro powder and taro-based noodles and cookies.

for saponins and 124.89% for flavonoids (Figure 4). This might be attributed to the increased extractability of phenolic compounds due to the disruption of plant cell walls during drying [26] as observed in the increase phenolic content of powdered taro. When taro noodles were boiled, there was a reduction in the phytochemical components at 79.23% for phenols, 95.39% for flavonoids and 81.42% for saponins while 100% for tannins since it was no longer detected (Figure 4). According to Tomas-Barberan and Espin (2001), with increasing temperature, the polyphenol oxidase (PPO) activity which degrades phenolic compounds may have been increased or activated from latent to active PPO [27] and thus decreasing the total phenolic content in taro noodles. The decreased in the total antioxidant activity and in other phytochemicals may also be due to the leaching out of the water soluble antioxidants. Also, heat tends to degrade certain compounds such as phenols, flavonoids, tannins and saponins with antioxidant properties [28]. Most losses are due to the leaching of antioxidant compounds from the vegetables into the cooking water during the prolonged exposure to water and heat [29].

On the other hand, baking caused the significant reduction in phytochemical components at 95.30% for phenols, 98.60% for flavonoids, 89.87% for saponins while tannins were no longer detected in taro cookies (Figure 4). Baking at 190°C functions to inactivate the enzymes polyphenol oxidases due to the high temperature applied. The results was in accordance with the work of Chism and Haard [30], wherein the total phenolic content decreased significantly due to the non-inactivation of the oxidative enzymes as a result of high temperatures which may released more bound phenolic acids from the breakdown of cellular constituents through the disruption of cell walls that could have released the oxidative and hydrolytic enzymes that can destroy the antioxidants. According to Hakkinen and Torroren [31], the polyphenol oxidase could have been denatured at high temperature which may have prevented the oxidation of phenolic compounds. Exposure of polyphenol oxidases to temperatures higher than 70°C results in the destruction of their catalytic activity. Given that the taro cookies were baked for 190°C for 10-13 minutes, the higher temperature and longer cooking time promotes further cell disruption and decompartmentalization of phenolic compounds and polyphenol oxidase can be denatured with high temperatures. The denaturation of PPO could have occurred immediately upon its release and have prevented any activation. It has also been reported by Tomaino *et al.* [32] that increase and/or prolonged thermal treatment such as in boiling and

baking may be responsible for a significant loss of natural antioxidants, as most of these compounds are relatively unstable as against some compounds which are heat stable. However, other causes of depletion of antioxidants could also be due to operations such as peeling, cutting and slicing which were done to raw taro before drying as they induce a rapid enzymatic oxidation of natural antioxidants as reported by Oboh et al. [33]. Soaking was also effective in reducing the levels of tannins and flavonoids [15]. Shanthakumari et al. [23] further confirmed that the decrease in saponins, tannins, flavonoids and phenolics during soaking may be due to leaching out of these substances in soaking medium under the influence of concentration gradient. Generally, these processes (drying, boiling, baking, soaking, peeling and slicing) may cause negative attribute to the final food product as evident in the decreased phytochemical contents of taro noodles and cookies.

## Conclusion

The results of the study revealed that the proximate composition, mineral content, phytochemical components and antinutrient (oxalate and phytates) contents of raw taro significantly decreased when made into taro powder and when used as an ingredient in the preparation of noodles and cookies. Boiling the taro noodles and baking the taro cookies significantly decreased the proximate composition, mineral content, phytochemical components and antinutrient (oxalate and phytates) contents of taro powder.

## Recommendation

Studies on the shelf life and effect of storage to taro powder as well as to its products like noodles and cookies must be done. Another area of interest would be the characterization of taro powder for its use as an ingredient in baked products and other processed foods to improve palatability especially for children. Also, further studies on possible ways of minimizing its antinutrient content to improve its mineral content should be pursued. Lastly, the use of taro-based food products in feeding programs should be tested to know whether it can help improve nutritional status, thus preventing malnutrition.

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