Flour substitution and nutrient fortification of butter cookies with underutilized agricultural products

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Abstract. A fortified cookie from dehydrated swamp taro (Cyrtosperma merkusii) combined with all-purpose enriched wheat flour was developed. The study was performed in a Randomized Complete Block Design with three treatments: unfortified swamp taro (ST) cookie, ST cookie with dehydrated moringa (Moringa oleifera) leaves, ST cookie with dehydrated moringa leaves and squash (Cucurbita moschata). The response variables included nutritional profiling of the finished products of the three treatments through proximate analysis of total crude protein, total crude lipid, total crude fiber, total moisture, mineral, water activity, and vitamin A content. The sensory characterization of the fortified cookies was performed in a Complete Randomized Design, and the response variables were the quality attribute descriptions and acceptability of the products. The moisture, protein, crude fiber, and soluble carbohydrate contents of the cookies with fortifications did not significantly differ from the unfortified cookies (p > 0.05), but the fat, total mineral content and the vitamin A content of the fortified cookies were significantly higher than the unfortified cookies (p < 0.05). The cookies developed using dehydrated swamp taro with moringa and squash can be described as nutritious in terms of protein content (11%) with high calorie value from crude fat (16.5–18%) and high soluble carbohydrate (61.5–63.2%). Based on the proximate composition of the cookies, 15 cookies at 13.3 g/cookie could provide about 22 g protein equivalent to one third of the recommended dietary allowance (RDA) for protein, 34–36 g fat and 122–126 g carbohydrate equivalent to one half of the RDA for fat and carbohydrate and >100% of the vitamin A daily requirement in accordance with the estimated 2000-calorie RDA of a 50-kg normal adult. After sensory evaluation using the 9-point hedonic scale, panellists described the fortified cookies to be highly acceptable in terms of appearance and moderately acceptable in terms of texture and flavour.

Key Words: swamp taro, proximate composition, cookies, vitamin A.

Introduction. Malnutrition is the insufficient, excessive or imbalanced consumption of nutrients. A number of different nutritional disorders may arise, depending on which nutrients are under or overabundant in the diet. The World Health Organization cites malnutrition as the gravest single threat to the world's public health (O'Sullivan & Sheffrin 2003).

In the Philippines, reports indicate that there is enough food to feed the country; however, many Filipinos continue to go hungry and become malnourished due to inadequate intake of nutritious food or imbalanced nutrients (Sen 1981). People from far flung areas and those from the poverty-stricken areas usually suffer from malnutrition due to insufficient intake of nutrients because of inaccessible terminal markets or of very high commodity costs. On the other hand, urban sedentary lifestyle can also cause malnutrition, due to inadequate consumption of unhealthy foods and lack of exercise, in which most cases lead to obesity (Gardner & Halweil 2000). The production and utilization of fortified processed foods is therefore one potential way for providing adequate nutritional needs. Although the actual processing of food may add to its costs, the use of cheap yet nutrient-rich raw materials could make them economically viable nutritional sources.
Some examples of relatively cheap yet underutilized agricultural products in the Philippines are swamp taro (*Cyrtosperma merkusii*), moringa (*Moringa oleifera*), and squash (*Cucurbuta moschata*). Swamp taro is widely consumed in the tropics and is considered as a valuable crop because of its low maintenance cultivation; however it is still underutilized because of the low acceptability of some known product preparations. Despite this, the relatively high carbohydrate content of dehydrated swamp taro preparations (Nguimbou et al 2013) makes it a potential alternative in some carbohydrate-based products which can thus add value to the crop and at the same time enhance its economic potential. Moringa leaves contain nutritional features that could help in providing enough nutrients for the body. Being rich in components for energy and nutrients such as calcium, magnesium, potassium, phosphorous, zinc, and iron, *M. oleifera* leaves become a valuable source in both urban and rural settings. Because of its fast growth and resistance to drought, it has the potential for year round cultivation and utilization (Fahey 2005). Squash is a common crop easily grown in the relatively hot and humid weather conditions of the Philippines. It is an excellent source of *β*-carotene, which is a precursor for vitamin A production. As an essential nutrient, vitamin A plays a significant role in eye health and can help in warding off several diseases (FAO/WHO 2004). The incorporation of these cheap yet underutilized crops as substitutes and fortifications in a processed food commodity, in this case butter cookies, provides a more acceptable preparation in delivering adequate nutrients needed for daily consumption.

**Materials and Method**

**Raw material selection and preparation.** Good quality swamp taro tubers were washed with clean water, pat dried, peeled, shredded, washed in clean running water for 30 minutes, and drained. Partially drained material was soaked in 0.1% sodium metabisulfite solution (De Leon et al 1988) for another 30 minutes. After soaking, the material was placed in a clean cheese cloth sack, tied, and spin-dried to remove excess water. Spin-dried material was spread onto screen trays and was further dried inside a cabinet dryer at 60-70°C, until a terminal moisture content of 13%. Other dehydrated ingredients used were *M. oleifera* leaves and ripe squash fruit (*Cucurbita* sp.). Prior to dehydration, materials were washed clean and pat dried, peeled (for squash) and shredded. *M. oleifera* leaves were dehydrated at ambient temperature for approximately 72 hours or until terminal moisture content of 7%. Squash fruit was dehydrated at 65°C for 3 hours or until a terminal moisture content of 5%. Dehydrated materials were packed and sealed in a polyethylene bag and stored in a clean dry cabinet.

**Cookie preparation and fortification.** This study was done from November 2010 to March 2011 at School of Technology laboratories, University of the Philippines Visayas, Miagao, Iloilo campus. Butter cookie recipe used was modified from Rattray (2006) with 50% of all-purpose flour (123 g) substituted with the prepared dehydrated swamp taro (80 g). Three different treatments were prepared in the fortification phase: plain swamp taro cookie [lot A], swamp taro cookie with dehydrated *M. oleifera* leaves (5 g) [lot B], and swamp taro with dehydrated *M. oleifera* leaves and squash fruit (25 g) [lot C]. Other ingredients of the base cookie preparations are shown in Table 1. Formulation of the different treatments was based on the aggregation property of the cookie dough.

In the preparation of the cookies, butter was creamed with the addition of sugar, and followed by all other ingredients. Cookie dough weighing approximately 13 g were flattened in a cookie sheet, and baked at 125°C for 18 minutes. All preparations of the different treatments were done in triplicate runs.
Ingredients used in different treatments

<table>
<thead>
<tr>
<th>Ingredients</th>
<th>Culinary measurement</th>
<th>Lot A (g)</th>
<th>Lot B (g)</th>
<th>Lot C (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dehydrated swamp taro</td>
<td>1 cup</td>
<td>80</td>
<td>80</td>
<td>80</td>
</tr>
<tr>
<td>All-purpose wheat flour</td>
<td>1 cup</td>
<td>123</td>
<td>123</td>
<td>123</td>
</tr>
<tr>
<td>Egg</td>
<td>½ cup</td>
<td>118</td>
<td>118</td>
<td>118</td>
</tr>
<tr>
<td>Butter</td>
<td>½ cup</td>
<td>112.5</td>
<td>112.5</td>
<td>112.5</td>
</tr>
<tr>
<td>Sugar</td>
<td>1 cup</td>
<td>184</td>
<td>184</td>
<td>184</td>
</tr>
<tr>
<td>Vanilla extract</td>
<td>1 tsp</td>
<td>4.4</td>
<td>4.4</td>
<td>4.4</td>
</tr>
<tr>
<td>Baking powder</td>
<td>½ tsp</td>
<td>1.9</td>
<td>1.9</td>
<td>1.9</td>
</tr>
<tr>
<td>Salt</td>
<td>1/8 tsp</td>
<td>0.9</td>
<td>0.9</td>
<td>0.9</td>
</tr>
<tr>
<td>Dehydrated M. oleifera leaves</td>
<td>¼ cup</td>
<td>-</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Dehydrated squash fruit</td>
<td>¼ cup</td>
<td>-</td>
<td>-</td>
<td>25</td>
</tr>
</tbody>
</table>

Product evaluation. Cooked cookies were set aside to cool and were prepared for product evaluation test. Proximate analysis (AOAC 1998) including moisture, ash, crude fiber, and crude fat content were analysed in each replicate per treatment. Protein content was determined using the Bradford Protein Assay (Bradford 1976; Stoscheck 1990). Water activities were determined using Hygro Palm AW1 Portable Water Activity Indicator (Rotronic, USA). Vitamin A determination was done using the AOAC (1998) spectrophotometric method.

A sensory evaluation test was done to characterize the different attributes of the finished cookie product, and to assess for acceptability. The finished product of Lot C was subjected to sensory evaluation wherein 30 panellists were invited to assess some given attributes like the color, crispness, sweetness, and starchy flavor. A 15 cm intensity scale was used to evaluate each with two anchor descriptive points at both ends, where color was evaluated from “light brown” to “dark brown”; crispness from “not crispy” to “very crispy”; sweetness from “not sweet” to “very sweet”; and starchy flavor from “not starchy flavour” to “very starchy flavour”.

Statistical analysis. One-way analysis of variance was performed on the data derived from the proximate analysis in order to compare the nutritional value of the finished products. Duncan’s Multiple Range Test was done to determine significant differences among treatments. Sensory evaluation results were treated with non-parametric statistical test using Kruskal-Wallis One Way Analysis of Variance (Walpole 1982).

Results and Discussion

Proximate analysis. Results of the proximate analysis (Table 2) show no significant difference between treatments, except for the lipid and the ash content. The addition of dehydrated vegetables (M. oleifera and squash) did not affect the moisture, protein and crude fiber profile of the cookies. Lipid and ash content significantly differ among treatments with the addition of dehydrated vegetables. With the given values of the moisture content of the different treatments of cookies it can be classified as a dry food commodity. The low moisture content of the final products is mainly due to the use of raw materials that were dehydrated prior to mixing and the use of butter and eggs instead of water as the medium for cohesion of the cookie dough. Maintaining low moisture content for a food commodity can help lengthen its shelf life and improve its safety since this inhibits the growth of potential spoilage and pathogenic microorganisms (Vaclavik & Christian 2008).

Although there was no significant difference in the protein content of the different treatments (Table 2), the protein content of the finished products still provided a considerable amount given that other ingredients such as butter and eggs could have also contributed to the overall protein content. Nguimbou et al (2013) determined that dehydrated swamp taro flour averagely has 9-10% protein, while Staub (1982) showed that all-purpose enriched wheat flour has approximately 10-12% protein. A single 13 gram cookie has approximately 1.45 grams of protein, which could offer a substantial amount of essential amino acids from the alternative raw materials used in this study.
Swamp taro, although low in histidine, lysine, isoleucine, tryptophan, and methionine, has relatively high amounts of other essential amino acids (EAA) (Onwueme 1999) and overall have higher EAA scores than other root crops (Huang et al 2006). M. oleifera, considered an important protein source in many developing countries, is also an excellent source of EAA. All EAA were found to be present in moringa leaves and were in amounts more than the recommended amino acid requirements of FAO and WHO for a 2-5 year old child (Makkar & Becker 1996). Squash (Curcubita sp.) was also found to contain a total of 18 amino acids as constituents of some acidic protein-bound polysaccharides (Caili et al 2007).

### General composition, water activity and Vitamin A content of the different treatments of fortified cookies

<table>
<thead>
<tr>
<th>Proximate composition (%) dry weight</th>
<th>Lot A</th>
<th>Lot B</th>
<th>Lot C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture, %</td>
<td>2.29±0.21a</td>
<td>2.80±0.65a</td>
<td>2.16±0.27a</td>
</tr>
<tr>
<td>Protein, %</td>
<td>10.90±0.16a</td>
<td>11.30±0.11a</td>
<td>11.12±0.52a</td>
</tr>
<tr>
<td>Lipid, %</td>
<td>17.11±0.42ab</td>
<td>16.49±0.12b</td>
<td>18.04±0.75a</td>
</tr>
<tr>
<td>Crude fiber, %</td>
<td>4.63±0.31a</td>
<td>4.17±1.03a</td>
<td>5.27±0.16a</td>
</tr>
<tr>
<td>Ash, %</td>
<td>1.81±0.01a</td>
<td>1.87±0.02b</td>
<td>1.97±0.00c</td>
</tr>
<tr>
<td>Water activity</td>
<td>0.39±0.01ab</td>
<td>0.44±0.06a</td>
<td>0.32±0.03b</td>
</tr>
<tr>
<td>Vitamin A, IU/g</td>
<td>7432.73±1531.1b</td>
<td>20375.50±5456.0a</td>
<td>27105.50±5259.9a</td>
</tr>
</tbody>
</table>

Results as mean (n = 3) ± SD. Different letters in the same row denote significant differences (p < 0.05).

The lipid content of the cookie significantly increased from 17.11±0.42 to 18.04±0.75, while the crude fiber content did not significantly differ upon the addition of dehydrated vegetables.

The addition of the dehydrated vegetables significantly increased the mineral content of the product, from 1.81±0.01 to 1.87±0.02 to 1.97±0.00 for lot A, lot B and lot C respectively (Table 2). The method of ashing represents the total mineral content of a food. Based on the data from FAO (1993), the possible minerals present in swamp taro are calcium-0.23%, phosphorus-0.01%, and iron-0.01%. Moringa leaves contain minerals such as calcium-0.44%, magnesium-0.024%, phosphorus-0.07%, potassium-0.259%, copper-0.0011%, iron-0.007%, and sulfur-0.137% (Fuglie 2010) while Curcubita sp. contains calcium-0.18%, iron-0.001%, magnesium-0.19% and potassium-0.16% (Adebayo et al 2013). The cookie developed contained some of the minerals which are essential to human health and the utilization of crops such as taro, moringa, and squash as substitutes and fortificants provide a practical way to deliver these nutrients in a palatable and safe product with a considerable shelf life.

**Vitamin A.** Beta-carotene is an antioxidant precursor to vitamin A. In the human body, it is important in human eye light reception. The addition of dehydrated vegetables shows that it could significantly increase the carotenoid content of the cookie product from 7432.73±1531.1 IU g⁻¹ to 27105.50±5259.9 IU g⁻¹ (Table 2). It was reported that swamp taro contains considerable levels of carotenoid (1000 µg/100 g), such that consuming four cups a day of swamp taro could satisfy more than half of the estimated vitamin A requirement of adult per day of 8000-10000 IU or 800–1000 retinal equivalents (Englberger et al 2008). Moreover, adding M. oleifera and squash to the cookie formulation resulted to a significant increase in the levels of vitamin A as well. M. oleifera leaves contain 4 times the Vitamin A in carrot which is needed to prevent night blindness, promote healthy skin, and fight infections (Fuglie 2010).

**Water activity.** Water activity values of all treatments were considerably low (Table 2), which allows the classification of the cookies as relatively stable food products. With proper packaging and storage, a product with this water activity value can have a lengthy shelf life (Berk 2013).
**Sensory evaluation.** Panellists in the sensory evaluation described the finished swamp taro cookie with dehydrated vegetables (lot C) to have moderately brown color (6.7 out of 15 points) and moderate crispness (7.1 out of 15 points) (Table 3). The low moisture content of the finished product was responsible for the crispy texture; and the color was the browning effect of baking as the reaction of food components such as lipid, carbohydrate and proteins. The sweetness and the starchy flavor were evaluated to be 5.7 and 5.4 points (out of 15), respectively, as shown in Table 3. These characteristics contributed to an overall acceptability score of 7.2 out of 9 points for the finished product indicating a generally positive response to the product.

<table>
<thead>
<tr>
<th>Sensory attributes</th>
<th>Intensity scale score over 15</th>
<th>Acceptability score over 9</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brown color</td>
<td>6.7±2.04</td>
<td>8±0.63</td>
</tr>
<tr>
<td>Crispness</td>
<td>7.1±3.16</td>
<td>7±1.51</td>
</tr>
<tr>
<td>Sweetness</td>
<td>5.7±1.74</td>
<td>7±0.82</td>
</tr>
<tr>
<td>Starchy flavor</td>
<td>5.4±2.24</td>
<td>7±1.33</td>
</tr>
</tbody>
</table>

Results as mean (n = 30) ± SD.

**Conclusions.** This study was done to develop a cookie formulation by substituting a portion of all-purpose flour in a conventional butter cookie with dehydrated swamp taro (*Cyrtosperma merkusii*); and by fortifying it through the addition of other constituents like dehydrated *Moringa oleifera* leaves and squash fruit.

The addition of the dehydrated vegetables was noted to have significantly increased the lipid, total mineral, and vitamin A content of the finished products. Sensory evaluation results also show that the finished product has good market potential. The incorporation of underutilized agricultural products such as swamp taro, moringa, and squash as both substitute and fortification ingredients in cookies thus presents considerable potential in providing necessary nutrients in a stable and palatable food product.

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