AAB BIOFLUX

Advances in Agriculture & Botanics-
International Journal of the Bioflux Society

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

[1,2]Jade G. Pahila, [1]Emeliza C. Lozada, [1]Jose Ali F. Bedano, [2]Leticia J. Ami

[1] School of Technology, University of the Philippines Visayas, Miagao 5023 Iloilo, Philippines; [2] Institute of Fish Processing Technology, University of the Philippines Visayas, Miagao 5023 Iloilo, Philippines. Corresponding author: J. G. Pahila, jadegopahila@gmail.com

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, shreded, 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^{o}C, until a terminal moisture content of 13%. Other dehydrated ingredients used were *M. oleifera* leaves and ripe squash fruit (C*ucurbita* 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^{o}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^{o}C for 18 minutes. All preparations of the different treatments were done in triplicate runs.

Table 1

Ingredients used in different treatments

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

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).

Table 2

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

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

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 *Cucurbita* 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 carotene 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 3

Sensory evaluation results for attribute profiling and acceptability

Sensory attributes	*Intensity scale score over 15*	*Acceptability score over 9*
Brown color	6.7±2.04	8±0.63
Crispness	7.1±3.16	7±1.51
Sweetness	5.7±1.74	7±0.82
Starchy flavor	5.4±2.24	7±1.33

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.

Acknowledgements. The authors would like to thank the UPV School of Technology, Department of Chemistry, and UPV-DOST-BDP for the provision of the chemicals and equipment used.

References

Adebayo O. R., Farombi A. G., Oyekanmi A. M., 2013 Proximate, mineral and anti-nutrient evaluation of pumpkin pulp (*Cucurbita pepo*). IOSR Journal of Applied Chemistry 4(5):25-28

AOAC, 1980 Official Methods of Analysis of the AOAC. 13th edition. Horwitz W. (ed), AOAC International, Arlington, VA, USA, 1018 pp.

Berk Z., 2013 Food process engineering and technology. 2nd edition. Academic Press, London, UK, 720 pp.

Bradford M. M., 1976 A rapid and sensitive for the quantitation of microgram quantitites of protein utilizing the principle of protein-dye binding. Analytical Biochemistry 72:248-254.

Caili F., Haijun T., Tongyi C., Yi L., Quanhong L., 2007 Some properties of an acidic protein-bound polysaccharide from the fruit of pumpkin. Food Chemistry 100:944-947.

De Leon S. Y., Bravo O. C., Martinez L. O., 1988 Fruits and vegetables dehydration manual. National Bookstore Inc., Quezon City, Philippines, 329 pp.

Englberger L., Schierle J., Kraemer K., Aalbersberg W., Dolodolotawake U., Humphries J., Graham R., Reid A. P., Lorens A., Albert K., Levendusky A., Johnson E., Paul Y., Sengebau F., 2008 Carotenoid and mineral content of Micronesian giant swamp taro (*Cyrtosperma*) cultivars. Journal of Food Composition and Analysis 21:93-106.

Fahey J. W., 2005 *Moringa oleifera*: a review of the medical evidence for its nutritional, therapeutic, and prophylactic properties. Part 1. Trees for Life Journal 1:5-20.
FAO, 1993 Preventing micronutrient deficiencies: food abundance and diversity are fundamental. Food, Nutrition and Agriculture version 7, pp. 8-17.
FAO/WHO, 2004 Vitamin and mineral requirements in human nutrition. 2nd edition, World Health Organization, Geneva, Switzerland, 341 pp.
Fuglie L. J., 1999 The miracle tree, *Moringa oleifera*: natural nutrition for the tropics. Church World Service, Dakar, Senegal, 68 pp.
Gardner G., Halweil B., 2000 Escaping hunger, escaping excess. World Watch 13(4):25-35.
Huang C., Chen W., Wang C., 2007 Comparison of Taiwan paddy- and upland-cultivated taro (*Colocasia esculenta* L.) cultivars for nutritive values. Food Chemistry 102:250-256.
Makkar H. P. S., Becker K., 1996 Nutrional value and antinutritional components of whole and ethanol extracted *Moringa oleifera* leaves. Animal Feed Science and Technology 63:211-228.
Nguimbou R. M., Njintang N. Y., Makhlouf H., Gaiani C., Scher J., Mbofung C. M. F., 2013 Effect of cross-section differences and drying temperature on the physicochemical, functional and antioxidant properties of giant taro flour. Food Bioprocess Technology 6:1809-1819.
Onwueme I., 1999 Taro cultivation in Asia and the Pacific. FAO, Bangkok, Thailand, pp. 50.
O'Sullivan A., Sheffrin S. M., 2003 Economics: principles in action. Prentice Hall, Upper Saddle River, N. J., USA, 592 pp.
Rattray D., 2006 The About.com guide to southern cooking. Adams Media, Avon, USA, 288 pp.
Sen A., 1981 Poverty and famines: an essay on entitlement and deprivation. Oxford University Press Inc., New York, 270 pp.
Staub P. T. A., 1982 The science of the Philippine foods. Abaniko Enterprise, Quezon City, Philippines, 370 pp.
Stoscheck C., 1990 Quantitation of protein. Methods in Enzymology 182:50-68.
Vaclavik V. A., Christian E. W., 2008 Essentials of food science. 3rd edition. Springer, New York, USA, 572 pp.
Walpole R. E., 1982 Introduction to statistics. 3rd edition. Macmillan Publishing, New York, USA, 340 pp.

Received: 05 October 2013. Accepted: 26 October 2013. Published online: 30 October 2013.
Authors:
Jade G. Pahila, School of Technology, University of the Philippines Visayas, 5023 Miagao, Iloilo, Philippines; Institute of Fish Processing Technology, College of Fisheries and Ocean Sciences, University of the Philippines Visayas, 5023 Miagao, Iloilo, Philippines, e-mail: jade_go_pahila@yahoo.com, jadegopahila@gmail.com
Emeliza C. Lozada, School of Technology, University of the Philippines Visayas, 5023 Miagao, Iloilo, Philippines, e-mail: lizaclozada@yahoo.com
Jose Ali F. Bedano, School of Technology, University of the Philippines Visayas, 5023 Miagao, Iloilo, Philippines, e-mail: jalibed@yahoo.com.ph
Leticia J. Ami, Institute of Fish Processing Technology, College of Fisheries and Ocean Sciences, University of the Philippines Visayas, 5023 Miagao, Iloilo, Philippines, e-mail: letty_ami@yahoo.com

How to cite this article:
Pahila J. G., Lozada E. C., Bedano J. A. F., Ami L. J., 2013 Flour substitution and nutrient fortification of butter cookies with underutilized agricultural products. AAB Bioflux 5(3):115-120.