*Philippine Journal of Arts, Sciences, and Technology* (2016) **1**:34–40

# Development and Process Optimization of Blended Beverage from Coconut Water and Sweetpotato

CHRISTY DIANNE Q. RAMOS *[1] and LORINA A. GALVEZ[2]

[1] *College of Agriculture and Forestry, Tarlac Agricultural University, Camiling, Tarlac 2306 Philippines*
[2] *College of Agriculture and Food Science, Visayas State University, Baybay City, Leyte, 6521 Philippines*

## Abstract

Combination of coconut water and sweetpotato are potential raw materials in making a nutritious and quality health drink. This study aimed to optimize the process and formulation of the product employing a Response Surface Methodology by Central Composite Design. Sugar (10,15, 20% w/w), calamansi (8,12,16% w/w), and sweetpotato (10,20,30% w/w) levels were identified as the significant variables. Sensory acceptability evaluation, cost analysis, and physico-chemical analysis were carried out on the different samples. Response surface regression analyses revealed that there is no significant effect on sensory acceptability except for general acceptability. Based on the superimposed contour plots, the optimum region is at 18% w/w sugar, 12% w/w calamansi, and 20% w/w sweetpotato at a cost of ₱16.51/ 330 mL. Even if independent variables had significant effect on total solids, pH and Vitamin C were not affected. Free radical scavenging activity was, however, affected by calamansi and sugar levels. Total soluble solids and titratable acidity significantly increased with increasing sugar and calamansi, respectively. Either stored at room or in refrigerated condition for a month, the optimum beverage had a satisfactory acceptability with tolerable level of microbial load.

***Keywords:*** health drinks, natural food products, product quality

## Introduction

The beverage industry is well aware of the complex diet, lifestyle, and health challenges facing the society. Thus, development of new and convenient products that offer good sensory acceptance, contain high nutritional value, with functional activity had been started. An interesting way to improve the nutritional quality of traditional products is through the mixture of two or more kinds of fruits.

Blended drinks combine new taste and sensory characteristics and can result in a new product with more vitamins and minerals (Carvalho et al., 2006). Furthermore, the development of new products such as these has been encouraged by the food industry and has been well accepted by consumers.

Coconut water, with its many applications, is one of the worlds most versatile natural products. Coconut water is the new trend beverage that everyone is talking about. According to new findings from global research organization Mintel, it has taken the global beverage industry by storm due to its growth of 540 percent between 2008 and 2012 (Langley, 2013). Besides its various traditional uses, coconut water has also drawn the attention of manufacturers as a natural functional drink (Prades et al., 2011). The wide applications of coconut water can be justified by its unique chemical composition of sugars, lipids, vitamins, minerals, amino acids, nitrogenous compounds, organic acids, enzymes, and phytohormones (Yong et al., 2009). Coconut water is produced in many coconut industries but most are still left unused as a by-product in copra processing. In addition, this coconut water can be used for the production of more value-added products. Coconut water is often marketed as the natural alternative for conventional carbonated drinks and is also used for types of products where fruit juices, mineral water, and energy drinks are combined to develop new and healthier

* Corresponding author.
*Email:* christydianneramos@yahoo.com; *Tel.:* +63 45 934-0216

© 2016 Tarlac Agricultural University

beverages.

Sweetpotato was alsoused in the study given its health benefits and its major role in the emerging market. Sweepotatoes are nutritious and are also moderately a good source of energy that are rich in dietary fiber, minerals, vitamins, and antioxidants such as phenolic acids, anthocyanins, tocopherol, and beta-carotene (Woolfe, 1992). Moreover, sweetpotato beverage is a viable option for processing coconut into a valuable product.

In this study, therefore, an optimization experiment using response surface methodology was applied to process and formulate a blended beverage based on coconut water and sweetpotato. Optimum formulation was determined through evaluation of its sensory, physico-chemical, and cost analysis. This method determined the best acceptable process and formulation for quality enhancement of the said product. Ultimately, the study also aimed to evaluate the shelf-life of the developed product.

## MATERIAL AND METHODS

### Preliminaries and Experimental Design for Optimization Experiment

A screening experiment using 7-variable, 8-runs Plackett-Burman Design with two levels for each variable was conducted to determine the main effects of individual variables on the quality of beverage. The different variables were sweetpotato variety, steamed sweetpotato level, sweetpotato leaves infusion level and sugar level, calamansis juice level, pasteurization time, and pasteurization temperature. On the other hand, the response variables included the products sensory qualities likecolor, aroma, flavor, sweetness, sourness, and general acceptability. The variables that gave the most significant effect on the beverage, based on the results of the screening experiment, were used as independent variables for the optimization experiment. A 33fractional factorial experiment following Central Composite Design (CCD) with 15 treatmentsfollowed and utilized as the experimental design.

### Procurement of Materials

Mature coconuts (9-11 months old) were procured from the Baybay Public Market. Sweetpotatoes (SP30 variety) were obtained from the experimental fields of the Philippine Root Crops Research and Training Center (PhilRootcrops) and the Visayas State University (VSU). Other ingredients such as the sweetpotato leaves, calamansi, and refined sugar purchased at the Baybay Public Market were also prepared.

### Processing of Cocowater-Sweetpotato Beverage

Coconuts were washed, sanitized, and opened. Moreover, water was filtered and collected in closed containers. Sweetpotatoes were also washed, sanitized, peeled, sliced, steam cooked for about 15 minutes, and cooled. Then, infusion was made with sweetpotato leaves by blanching equal amount of water and leaves for about 10 minutes. Afterwards these were cooled and filtered. All the ingredients based on the formulation were properly homogenized with the sugar and calamansi juice using an osterizer until there were no large sweetpotato particles visible. Finally, the beverage was transferred to sterile glass bottles and pasteurized at 90°C for 10 minutes. Beverages were cooled and stored for further analysis.

### Sensory Analysis and Cost Analysis

The prepared beverage samples were evaluated for their sensory acceptability by a panel of 35 judges composed of students and faculty of the DFST and (VSU) who evaluated each treatment per replicate. A 9-point Hedonic scale ranging from 'like extremely' to 'dislike extremely' was used for the evaluation. Production cost of the different experimental treatments was also calculated based on the prevailing market price of the raw materials, ingredients, labor, and other processing costs.

### Physico-Chemical Evaluation

Samples of all the experimental treatments were analyzed for their physico-chemical qualities that included the pH, total soluble solids

(TSS), titratable acidity (TA), total solids (TS), Vitamin C, and Free Radical Scavenging Activity (FRSA). pH was measured using a laboratory pH meter (pH 600 pocket-sized). Then TSS was determined using an American Optical 0-30 refractometer. On the other hand, total Solids were determined following the procedure adopted from Wireko-Manu (2010). Titratable Acidity expressed as % citric acid was measured following a titration method using 0.1N sodium hydroxide (NaOH). Free Radical Scavenging Activity of the samples was determined using the DPPH radical scavenging assay while the Vitamin C content was determined by redox titration with iodine solution.

### Statistical Analysis

Data obtained from the sensory and physicochemical analysis were subjected to Response Surface Regression (RSREG) analysis using the Statistical Computer Software (SAS 9.1.3 Portable) to determine the effect of the independent variables. Contour plots were generated using Statistica version 8. The optimum formulation of the beverage was identified by superimposing contour plots of sensory attributes and the production costs. A cut-off acceptability score of $\geq$ 6.75 (of the Hedonic scale) was set to establish region above which the product is considered acceptable.

### Shelf-life Studies of Optimum Product

Shelf-life of the beverage with optimum formulation was studied at two different temperature conditions:- room temperature and refrigerated temperature. The beverage was packed in glass bottles with plastic cover. Four bottles were stored in a dark drawer and another four in a refrigerator. Samples were examined weekly for 4 weeks for its sensory acceptability and microbial tests (Total Plate Count and detection of *Salmonella and Escherichia coli*).

## Results and Discussion

### Variable Screening Experiment

Based on the analysis of the effects of the different sensory attributes of the product, sweetpotato variety has a negative significant effect on the color acceptability which means the beverage is more acceptable when the orange variety is used. Calamansi level has a positive significant effect on the aroma acceptability while both sugar and calamansi levels have positive significant effect on the flavor, sweetness, sourness, and general acceptability. These positive effects estimates indicate that the higher the level of sugar and calamansi were used, the more acceptable the product is. Based on these results, levels of sweetpotato, sugar, and calamansi juice were chosen for the optimization experiment. Although sweetpotato level did not exhibit significant effect on the different responses, it was chosen as the third variable in order to maximize the utilization of the carotenoids present in the sweetpotato. Three levels of sugar (10, 15, 20% w/w), calamansi (8, 12, 16% w/w) and sweetpotato (20, 30, 40% w/w) were tested for their effects using a 33 fractional factorial design (CCD). All the other variables that were left constant were: sweetpotato variety(yellow-orange SP30), sweetpotato leaves infusion level (20%w/w), pasteurization time (10 minutes), and pasteurization temperature (9°C)

### Sensory Evaluation and Production Cost in Optimization Experiment

Table 2 summarizes the Analysis of Variance (ANOVA) F-ratios of the sensory acceptability and costing data of the optimization experiment. Based on the table, response surface regression analysis showed that there is no significant differences in the color, aroma, flavor, sweetness, and sourness acceptability between the different experimental treatments. However, general acceptability showed a lumped linear effect that means an interaction between the variables had a linear effect on the general acceptability even if individually, these have no significant effect. Furthermore, analysis on the results revealed that a linear significant effect is due to the interaction of the


© 2016 Tarlac Agricultural University

**Table 1.** Summary of Effects of the Different Sensory Attributes of Cocowater-Sweetpotato Beverage

| Variables | Color | Aroma | Flavor | Sweetness | Sourness | General Acceptability |
|---|---|---|---|---|---|---|
| Mean/Intercept | 7.30872 | 7.0906 | 6.929309 | 6.939894 | 6.827369 | 6.999874 |
| 1. SP Variety | **-1.1486** | -0.2437 | 0.032006 | 0.120212 | 0.064012 | -0.09349 |
| 2. Steamed SP level | 0.19556 | -0.10005 | 0.186744 | 0.098538 | 0.092238 | 0.109123 |
| 3. SP leaves level | -0.1638 | -0.10005 | 0.186744 | 0.067288 | 0.092238 | 0.077873 |
| 4. Sugar level | -0.0861 | 0.0063 | **0.672631** | **0.682712** | **0.626512** | **0.578377** |
| 5. Calamansi level | 0.19556 | **0.52495** | **0.405494** | **0.348538** | **0.717238** | **0.530998** |
| 6. Pasteurization Time | -0.0393 | 0.1313 | -0.04611 | 0.088962 | 0.157762 | 0.047127 |
| 7. Pasteurization Temperature | 0.05444 | 0.22505 | 0.172631 | 0.276462 | 0.095262 | 0.250252 |

*Note:* Values in bold represent significant effect on the attribute

variables. This implies that increasing the different levels would increase the cost and decreasing levels would also decrease the costs since cost is determined by the product yield.

### Optimum Formulation of the Beverage

Contour plots obtained using predicted models in terms of consumer acceptable ratings for the sensory attributes and cost tested provided the idea as to what levels of sugar, calamansi, and sweepotato result to a beverage with desirable acceptability level. These contour plots were generated using two independent variables at a time, with the third variables kept constant. Moreover, the location of the optimum region was determined by superimposing the contour plots of all the sensory attributes being evaluated that had the same constant variable evaluated. Figure 1 shows the superimposed contour plots of the cocowater-sweetpotato. Shaded region represents acceptability of $\geq$ 6.75 that corresponds to lslightly to like moderately of the Hedonic scale. It was also observed that aroma, flavor, sourness, and cost are the limiting attributes that defined the optimum region.

At constant sweetpotato, shaded region was found to be between 15-20% w/w sugar and between 12-16% w/w calamansi. Meanwhile, at constant calamansi, low levels of sweetpotato were at 20- 22% w/w and high level of sugar at 17-20%w/w that filled the acceptable region. Finally, at constant sugar, two shaded regions were identified. Sweetpotato level at 20-25 %w/w and 35-39 %w/w and calamansi at 12-16 %w/w filled the acceptable region. From the three superimposed plots, it appeared that the optimum region was found at 15-20 %w/w sugar, 12-16% w/w calamansi, and 20-25% w/w sweetpotato. Having considered a lower cost, optimum formulation was identified at 18% w/w sugar, 12% w/w calamansi, and 20% w/w sweetpotato that cost $\leq$ ₱16.51.

### Physico-chemical Evaluation

Beverage samples were evaluated for their physico-chemical qualities. pH ranged from 3.83 to 4.47; TSS from 12.8 to 17.2 °Brix; TA ranged from 0.4074 to 0.7727% citric acid; FRSA ranged from 107.93 to 3875.31 µmol TE/100 g; and Vitamin C ranged from 2.012 to 3.018 mg/ 100 mL. Results of the response surface regression on the physico-chemical properties of the beverage revealed a lumped linear effect on pH and Vitamin C content. In addition, sugar had a highly significant linear effect on Total Soluble Solids and Total Solids; while calamansi had a highly significant linear effect on Titratable Acidity. On the other hand, sweetpotato had a highly significant effect also on Total Solids of the product. The crossproduct of calamansi and sugar significantly affect the FRSA.

### Shelf-life Studies of the Optimum Formulation

Shelf-life of the developed cocowater-sweetpotato beverage at optimum formulation

© 2016 Tarlac Agricultural University 

**Table 2.** Summary of ANOVA F-ratios for the Sensory Acceptability and Cost of Cocowater-Sweetpotato Beverage

| Regression | Color | Aroma | Flavor | Sweetness | Sourness | General Accept-ability | Cost |
|---|---|---|---|---|---|---|---|
| Linear | 1.32 $^{ns}$ | 1.08 $^{ns}$ | 1.48 $^{ns}$ | 1.57 $^{ns}$ | 1.91 $^{ns}$ | 3.32* | 57.99** |
| Quadratic | 0.98 $^{ns}$ | 0.39 $^{ns}$ | 0.62 $^{ns}$ | 0.30 $^{ns}$ | 0.82 $^{ns}$ | 0.95 $^{ns}$ | 0.4961 $^{ns}$ |
| Cross-Product | 0.69 $^{ns}$ | 0.15 $^{ns}$ | 0.16 $^{ns}$ | 1.22 $^{ns}$ | 0.68 $^{ns}$ | 1.10 $^{ns}$ | 0.2372 $^{ns}$ |
| Total Regression | 1.00 $^{ns}$ | 0.54 $^{ns}$ | 0.75 $^{ns}$ | 1.03 $^{ns}$ | 1.14 $^{ns}$ | 1.79 $^{ns}$ | 0.200** |

ns – not significant; * – significant at 5%; ** – significant at 1%

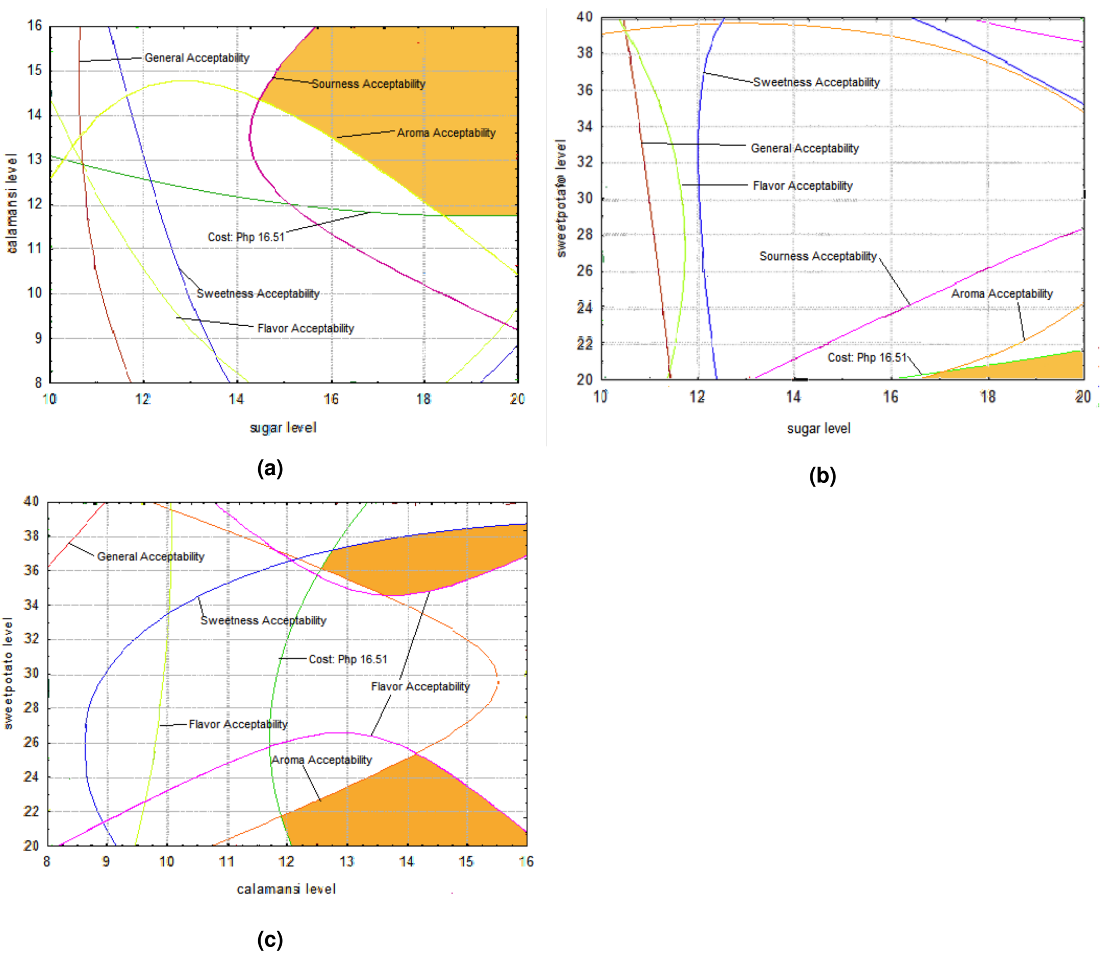


**Figure 1.** Optimum region for cocowater-sweetpotato beverage (acceptability >6.75) at constant **(a)** sweetpotato level (30%w/w) **(b)** calamansi level(12%w/w) **(c)** sugar level(15% w/w)


© 2016 Tarlac Agricultural University

**Table 3.** Summary of ANOVA F-ratios for the Physico-Chemical Attributes of Cocowater-Sweetpotato Beverage

| Regression | pH | TSS | TA | TS | FRSA | Vit C |
|---|---|---|---|---|---|---|
| Linear | 23.54 ** | 130.54 ** | 125.25 ** | 272.18 ** | 1.13 $^{ns}$ | 6.02 * |
| Quadratic | 0.48 $^{ns}$ | 1.47 $^{ns}$ | 2.00 $^{ns}$ | 5.70 ** | 0.54 $^{ns}$ | 1.36 $^{ns}$ |
| Cross-Product | 0.58 $^{ns}$ | 2.95 $^{ns}$ | 1.96 $^{ns}$ | 5.45 ** | 3.28 * | 2.24 $^{ns}$ |
| Total Regression | 8.20 ** | 44.98 ** | 43.07 ** | 94.44 ** | 1.65 $^{ns}$ | 3.20 $^{ns}$ |

ns – not significant; * – significant at 5%; ** – significant at 1%

was studied from February to March 2014. Beverage samples were processed and stored at room temperature (27-29°C) and at refrigerated temperature (10-14°C). Table 4 shows the attributes mean acceptability scores on the sensory evaluation of the cocowater-sweetpotato beverage that were stored at room and refrigerated conditions. The acceptability of all evaluated attributes ranged from 7.44 to 8.08 corresponding to like moderately to like very much in the Hedonic scale. Results also indicate that whether stored at room or refrigerated temperature, the acceptability of the optimum formulation of the cocowater-sweetpotato beverage is still satisfactory.

Meanwhile, results of the standard plate count (SPC) and detection for pathogens of the optimum formulation at different storage conditions is presented in Table 5. These said results indicate that either stored at room or refrigerated condition, pathogens were not detected from the samples during the 4-week storage. The acidity of the beverage, pasteurization process, and the packaging in a hermetically sealed container was also efficient in inhibiting the growth of the pathogenic microorganism.

The total plate count of the different samples of the beverage shows that during storage there is a high increase of microbial count during the second week and that this,however, decreased in the following weeks. Furthermore, the colony forming units per ml (cfu/ml) determined from the samples suggest that the processed beverage was still microbiologically safe after a month of storage. It can also be observed that beverages stored at refrigerated temperature has lower count on the 3rd and 4th week indicating that low temperature storage can inhibit the growth of microorganisms and any enzymatic activity. Refrigeration slows down the chemical and biological processes in the beverage that resuls to deterioration and ultimately, to loss of quality.

## Conclusions

Based on the results of the 7-variable, 8-run screening experiment, the study revealed that calamansi level and sugar level appear to be the most significant variables in f processing the cocowater-sweetpotato beverage.. Moreover, sweetpotato level was considered as variable for the optimization of the experiment to maximize sweetpotato utilization. On the other hand, color, aroma, flavor, sweetness, and sourness acceptability were not significantly affected by the different levels of sweetpotato, calamansi, and sugar. Furtherore, interaction of the different variables has a significant effect on the general acceptability but individually has no significant effects. Physico-chemical qualities were also significantly affected by the different levels of the independent variables.

Results of this study indicated that optimum formulation for developing the cocowater-sweetpotato beverage is 20% w/w sweetpotato, 18% w/w sugar, and 12% w/w calamansi. And that this would be acceptable to a smaller number of panelists. The said beverage still received satisfactory acceptability and is free from pathogens after a month of storage either at room temperature or in refrigerated conditions.

A further study regarding the purchasing intensions of the developed product is recommended sinces the product may have the potential for commercialization. Optimization studies using other varieties of sweetpotato, especially on those

© 2016 Tarlac Agricultural University 

**Table 4.** Mean Sensory Acceptability of Cocowater-Sweetpotato Beverage stored at Room and Refrigerated Conditions

| | | Color | Aroma | Flavor | Sweetness | Sourness | Aftertaste | General Acceptability |
|---|---|---|---|---|---|---|---|---|
| Room Temperature | Wk1 | 7.96 | 7.96 | 7.76 | 7.76 | 7.84 | 7.68 | 7.96 |
| | Wk2 | 8.04 | 7.68 | 7.84 | 7.92 | 7.6 | 7.8 | 7.84 |
| | Wk3 | 7.92 | 7.56 | 7.72 | 7.88 | 7.68 | 7.6 | 7.88 |
| Refrigerated Temperature | Wk1 | 7.76 | 7.52 | 7.52 | 7.68 | 7.68 | 7.44 | 7.76 |
| | Wk2 | 7.8 | 7.44 | 7.72 | 7.92 | 7.6 | 7.68 | 7.76 |
| | Wk3 | 8.08 | 7.96 | 7.88 | 8 | 7.8 | 7.76 | 7.8 |

**Table 5.** Microbial Analysis and Detection of the Presence of Pathogens in the optimum formulation of Cocowater-Sweetpotato Beverage During Storage at Different Conditions

| Analysis | Room Temp storage | | | | Refrigerated storage | | | |
|---|---|---|---|---|---|---|---|---|
| | Wk1 | Wk2 | Wk3 | Wk4 | Wk1 | Wk2 | Wk3 | Wk4 |
| SPC (cfu/ml) | 2x10 | 3x104 | 1.5x104 | 5.7x103 | 2x10 | 4.8x104 | 6x103 | 2.2x103 |
| A. *Salmonella* | - | - | - | - | - | - | - | - |
| BGA/BSA/XLD/SSA | - | - | - | - | - | - | - | - |
| B. *E. coli* | - | - | - | - | - | - | - | - |
| EMB/ MacConkey | - | - | - | - | - | - | - | - |

(-) negative; SPC – Standard Plate Count; BGA – Brilliant green agar; BSA – Bismuth sulfite agar; XLD – Xylose-lysine deoxycholate; SSA – Salmonella-Shigella agar; EMB – Eosin-methylene blue agar

known to have functional properties is also recommended.


## Acknowledgements

Financial support for this research study was provided by the Department of Science and Technology- Accelerated Science and Technology Human Resource Development Program (DOST-ASTHRDP), Philippines.


## References


Carvalho, J. M. D., Maia, G. A., Figueuredo, R. W. D., Brito, E. S. D., and Rodrigues, S. (2006). Storage stability of a stimulant coconut water-cashew apple juice beverage. *International Journal of Food Science and Technology*, 42:1195–1200.

Langley, S. (2013). New coconut water products quintuple globally over past five years. *Australian Food News – Thought for Food*.

Prades, A., Dornier, M., Diop, N., and Pain, J. (2011). Coconut water uses, composition and properties: A review. *Fruits Journal*, 62(2):87–107.

Wireku-Manu, F. D., Ellis, W. O., and Oduru, I. (2010). Production of a non-alcoholic beverage from sweetpotato. *African Journal of Food Science*, 4(4):180–183.

Woolfe, J. (1992). *Sweetpotato: An Untapped Source*. Cambridge University Press.

Yong, J. W. H., Ge, L., Ng, Y. F., and Tan, S. N. (2009). The chemical composition and biological properties of coconut (cocos nucifera l.) water – a review. *Molecules Journal*, 14:5144.



© 2016 Tarlac Agricultural University