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Changes in Glucose and Lipid Profile after Consumption of Malunggay (*Moringa oleifera*) Leaves Products in Humans with Moderately Raised Serum Glucose and Cholesterol Levels

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Abstract ***Background***: Malunggay (*Moringa oleifera*) was considered a promising functional food because of the many nutrients, minerals and vitamins present in its leaves, seeds and bark. ***Objective***: To determine the changes in glucose, lipid profile and antioxidant capacity in humans with moderately raised serum glucose and cholesterol levels after consumption of malunggay leaves supplemented-food products. ***Materials and Methods***: Test foods are buns, fish sausage and veggie soup with and without malunggay leaves powder. Thirty-eight participants were randomly grouped into control and experimental, given foods without and with malunggay. The total amount of dietary fiber containing malunggay leaves powder was 14.4 g while without malunggay was 9.3 g. ***Results***: Serum blood glucose from baseline to endline for the control group was still considered moderately raised (6.2 to 5.6 mmol/L) while in the experimental group resulted from moderately raised (5.8 mmol/L) to normal serum glucose (5.0 mmol/L; $P<0.05$). Hemoglobin A1C measurements were within the normal limits for both groups. A decreasing trend in TC and LDL-C, and an increasing trend in HDL-C and antioxidant capacity were observed in the experimental group. ***Conclusion***: Malunggay leaves supplemented-food products decreased fasting blood sugar and may have a promising effect for cholesterol-lowering.

Keywords *Moringa oleifera*, Glucose and lipid profile

1. Introduction

Malunggay is widely cultivated in the Philippines. It is a promising food source in the country because the tree is in full leaf at the end of the dry season when other foods are made typically scarce. Almost all year round, malunggay leaves are present and readily available for consumption [1].

Moringa Oleifera leaves is used as a traditional medicine in many cultures. Because of its high vitamins A and C, calcium, iron and protein content, it has attracted interest in the modern scientific community. However, most of the studies done are either nutrient analysis or laboratory studies in animals [2]. Also, there is a wide array of malunggay products manufactured in the Philippines and being sold in local and international markets — *malunggay* tea, *malunggay pan de sal*, *malunggay polvoron*, m*alunggay* oil (for cooking and cosmetic purposes), *malunggay* noodles, *malunggay* food powder, *malunggay* supplement capsules, *malunggay* shampoo and conditioner, and *malunggay* ice cream [2].

While much of the information appears to be justified, it is critical to separate rigorous scientific evidences from anectodes and testimonials. The many reports on its nutritional or medicinal value will raise questions on the amount, safety assessment, bioavailability, effectiveness and efficacy of these nutrients and non-nutrients, which will depend on the source, harvesting season, maturity and processing of leaves used and consumed, as well as the products developed from malunggay. The purpose of the study is to critically evaluate the anecdotes/testimonials and scientific evidences on the nutritional and health benefits of malunggay in the Philippine situation, and specifically study the developed products for human consumption to maintain good health. The probable marketability and abundant supply of the known "miracle tree" offers a challenge to our country to produce and develop malunggay and its products for human consumption and in the improvement of our health and economy.

The objective of the study is to determine the changes in

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glucose, lipid profile and antioxidant capacity in humans with moderately raised serum glucose and cholesterol levels after feeding of malunggay leaves products, specifically: 1) to determine the changes in blood serum glucose and hemoglobin A1C; 2) to determine the changes in total cholesterol, HDL-cholesterol, LDL-cholesterol and triglyceride; and 3) to determine the changes in antioxidant capacity.

2. Materials and Methods

Test Foods

Food products with malunggay leaves powder was developed at the Food and Nutrition Research Institute-Department of Science and Technology (FNRI-DOST). The total amount of dietary fiber/100 g in the products containing malunggay leaves powder were as follows: buns, 4 g; fish sausage, 10.6 g; and veggie soup, 2.2 g. The buns were purchased from the company recipient of FNRI technology transfer while the fish sausage and veggie soup were prepared at the Nutritional Product Development Section, FNRI-DOST. Similar test foods were given to the control group but without malunggay leaves powder. All of the above food products underwent sensory evaluation conducted at FNRI-DOST.

Analytical Methods

Malunggay leaves and products were analyzed for proximate composition and dietary fiber using AOAC methods [3-6] and phytonutrients [7-9] as well as antioxidant activity [10]. Fasting blood glucose (FBS), total cholesterol and HDL-C were read in a Clinical Chemistry Analyzer. Hemoglobin A1 C (HbA1C) was analyzed by High Precision Laboratory, an ISO-Laboratory.

Study Participants

Forty (40) apparently healthy human participants were included in the study. The inclusion criteria are: 30-59 years old; moderately raised serum cholesterol 200 – 250 mg/dL total cholesterol and moderately raised serum glucose of 5.6-6.9 mmol/L following the WHO and American Diabetic Association (ADA) criteria; no medication; no vitamin / mineral supplements; non-smoker; no complications, ambulatory, consuming usual diet and must have a medical clearance. Three- day dietary intake were collected to test for homogeneity of food intake among study participants before the study and another three-day food intake were collected after the study to determine if there were changes in caloric intake and dietary pattern before and after the intervention. The study participants were physically examined by a medical doctor and evaluated by an endocrinologist before the start of the study.

Protocol of the Study

The forty (40) study participants were randomly grouped into two: the control group and the experimental group. The experimental group was fed with foods containing malunggay leaves powder while the control group was fed with the same foods without malunggay leaves powder during AM or PM snacks including weekends for a period of three (3) months. The total amount of dietary fiber present in foods fed to the experimental group containing malunggay leaves powder was 14.4 g while for the control group, 9.3 g.

Ten mL blood sample was extracted from the study participants at baseline, and 3 months after intervention, and analyzed for serum glucose, and lipid profile determined against standard glucose and lipids, and read in a clinical chemistry analyzer. Hemoglobin A1C was also determined. In addition, serum was also analyzed for antioxidant capacity using Ferric Reducing Antioxidant Power (FRAP). Physical activity of study participants were also monitored using the International Physical Activity Questionnaire (IPAQ). IPAQ assessed the physical activity undertaken across a comprehensive set of domains including leisure time physical activity, domestic and gardening activities, work-related physical activity and transport-related physical activity. Anthropometric measurements were also done at baseline and endline. Data were encoded using SPSS. Analysis of variance and Tukey's test were done to determine significant differences between treatments and groups at $P<0.05$.

The protocol of the study was approved by the FNRI Institutional Human Ethics Committee following Helsinski Declaration.

3. Results

The characteristics of the study participants are shown in Table 1. Thirty-eight study participants passed the inclusion criteria, 30 females and 8 males, grouped into control and experimental group.

Table 1. Characteristics of Study Participants, Mean±SEM

	Control	Experimental
Participants	19(14F, 5M)	19(16F 3M)
Age, yrs	42±2	44±2
Height, cm	157.1±1.6	154.6±1.6
Weight, kg	66.5±3.1	59.8±2.2
BMI kg/m	26.8±0.9	25.0±0.8

There were no significant differences between age, height, weight and BMI of the two groups suggesting that the characteristics of the study participants approached homogeneity. Also, daily caloric intake based on carbohydrates, fats and protein intake did not differ significantly between groups ($P<0.05$). All study participants has moderately raised serum cholesterol level (200-250 mg/dL) and serum glucose (5.6-6.9 mmol/L) according to WHO/ADA cut off standards (Table 2). We did not compare the glucose and lipid profile of participants by gender because the females outnumbered the males. Comparisons were made between groups.

There was a significant decrease in serum glucose for both

control and experimental group (Table 2; P<0.05). However, the decrease in serum blood glucose for the control group although significant, was still considered moderately raised (6.2 to 5.6 mmol/L) while the decreased in the experimental group from baseline to endline resulted from moderately

Table 2. Changes in Serum Glucose and Lipid Profile, and Antioxidant Activity after Consumption of Test Foods, Mean±SEM

Biomarkers	Control		Experimental	
	Base	End	Base	End
Glu, mmol/dL	6.2±0.3[a]	5.6±0.2[b]	5.8±0.1[a]	5.0±0.1[b]
HbA1c, %	5.8±0.2[a]	5.6±0.1[a]	5.6±0.1[a]	5.4±0.1[a]
Total-C, mg/dL	221±3[a]	224±6[a]	228±3[a]	223±5[a]
LDL-C, mg/dL	104±8[a]	112±7[a]	124±4[a]	114 ±6[a]
HDL-C, mg/dL	60±6[a]	56±2[a]	52±3[a]	53±4[a]
Trigly, mg/dL	125±16[a]	123±14[a]	114±12[a]	122±13[a]
FRAP, mg/L	119±6[a]	110±6[a]	111±4[a]	116±5[a]

[ab]Denotes significant differences between baseline and endline at P<0.05.
raised (5.8 mmol/L) to normal serum glucose (5.0 mmol/L; Table 2,; P<0.05)

Hemoglobin A1C measurements were within the normal limits for both groups.

No significant results were observed in the lipid profile of both the control and experimental group before and after the intervention. However, a decreasing trend in total and LDL-cholesterol, and an increasing trend in antioxidant capacity was observed in the experimental group (Table 2).

Classifying the physical activity of study participants into low, medium and high from the physical activity questionnaires did not correlate well with biochemical markers used in the study.

4. Discussion

Malunggay leaves powder-supplemented food products consumed for 3-months significantly decreased fasting blood sugar from 5.8 (moderately raised) to 5.0 (normal) in the experimental group (P<0.05). This may be due to the higher dietary fiber content present in the malunggay leaves powder-supplemented foods given per day. Dietary fiber contributes in the slow release of glucose with time because it resists digestion in the stomach and small intestine, and is metabolized in the colon.

An acute study on untreated diabetic participants given a standard meal with *Moringa oleifera* leaves showed a low glycemic response as compared to the participants given a meal with no *Moringa oleifera* leaves [11]. The hopoglycemic effect of *Moringa oleifera* leaf (8 g/day) dietary consumption in a 40-day period in type 2 diabetic patients 30-60 years of age with no medication was studied and showed a significantly reduced glucose response as compared to the patients not given *Moringa oleifera* leaf [12]. More recently, a study group of type 2 diabetic patients , age 40-58 years given *Moringa oleifera* leaf tablets/day for 90 days showed that the blood glucose response progressed downwardly with time while HbA1C showed decreasing trend but not significant [13]. All of the above results were similar to the results obtained from this study.

Epidemiological data suggested that high intakes of dietary fiber reduced risk of coronary heart disease [14]. It is also predicted that for every 1% decrease in serum cholesterol concentration, there is a 2% decreased risk of coronary heart disease [15]. Studies showed that 3 g of ß-glucan from oats caused a clinical reduction of 0.13-0.16 mmol of serum cholesterol/L [16]. Our previous study on the cholesterol lowering effect of 15% and 25% coconut flakes containing 60 g dietary fiber/100 g revealed that for every gram of dietary fiber from oat bran, 2-3 gram of dietary fiber from coconut flakes reduced serum cholesterol by 6-12% in humans [17].

Previous work also showed that the dietary fiber present in dried malunggay leaves, when fermented in the colon *in vitro* produced short chain fatty acids with propionate > acetate > butyrate [18]. Propionate has been shown to inhibit the limiting enzyme HMG co-enzyme reductase for cholesterol synthesis [19].

The non-significant results between control and experimental groups for total cholesterol (TC), LDL-cholesterol (LDL-C), and HDL-cholesterol (HDL-C) may be due to the dietary fiber content of meals given to both the control (9 g) and experimental group (14 g) per day are considered very good sources of dietary fiber as classified by Codex Alimentarius (6-8 g dietary fiber). However, a decreasing trend was observed for TC and LDL-C, and increasing trend for HDL-C, and antioxidant activity in the participants given *Moringa oleifera* leaves supplemented foods.

A study in hyperlipidemic participants given 4.6 g dehydrated *Moringa oleifera* tablets twice a day for 50 days showed a 1.6% fall in triglycerides and a 6.3% increased in HDL-C with non-significant trends in LDL-C [20]. Another study on type 2 diabetic patients given 8 g *Moringa oleifera* leaf for 40 days showed a decreasing trend in plasma triglycerides and LDL-C and an increasing trend in HDL-C [12].

The therapeutic potential of *Moringa oleifera* leaves in hyperglycemia and dyslipedemia was reviewed in several studies [21]. However, it was advised that before advocating any formulation for treatment of the above metabolic disorders in humans, clinical studies must be conducted to establish its consistency with medicinal efficacy.

This study suggested that malunggay leaves powder-supplemented foods may be promising in the prevention for risk of diabetes mellitus and cardiovascular diseases, and may be more effective when given in longer period of time.

5. Conclusions

Malunggay leaves supplemented-food products decreased fasting blood sugar and may have a promising effect for cholesterol-lowering when given for a longer period of time.

Daily intake of malunggay leaves and malunggay leaves powder-supplemented food products is recommended for proper control and management of chronic diseases such as diabetes mellitus and cardiovascular diseases.

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