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EFFECT OF GREEN BANANA FLOUR ON THE METABOLIC PROFILE OF WISTAR RATS

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ABSTRACT

Changes in diet and physical activity practice lead to a reduction in chronic-degenerative diseases, such as diabetes, obesity, metabolic syndrome, and cardiovascular complications. The intake of green banana flour may result in health benefits. Some authors have shown it can reduce appetite and weight loss, and may improve glycemia, lipids, intestinal function, aging process, may reduce the incidence of cancer and cardiovascular diseases. The aim of this study is to evaluate the effects of green banana flour on the anthropometric and biochemical parameters of Wistar rats. We evaluated two groups: G1 (control group): animals received water and food *ad libitum* and G2 (treated group): animals received water and food supplemented with green banana flour (20%) *ad libitum* for 45 days. Our results show that the green banana flour promoted a significantreduction in the body weight, glycemia and triglycerides levels in the Wistar rats. Although not significant, the animals of G2 also presented a reduction in the LDL-c levels, non-HDL-c and in the atherogenic indices. Green banana flour can be easily incorporated in preparations like beverages, cakes, cookies and cereal bars. For this reason, more studies should be performed in new products formulation once green banana flour may bring beneficial on the metabolic profile of Wistar rats, and could be used as an alternative to prevent risk factors of developing chronic degenerative diseases. Furthermore, this product possesses high nutritional value and the reduced cost of its production promise to be used as a nonconventional food resource with elevated nutraceutical value.

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INTRODUCTION

The incidence of metabolic diseases in the world population has been growing and has attracted the attention of health professionals and researchers in the area. Changes in diet and physical activity practice lead to a reduction in chronic-degenerative diseases, such as diabetes, obesity, metabolic syndrome and cardiovascular complications (Bhardwaj *et al*, 2018; Jehan *et al*, 2018; Arena *et al*, 2018).

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Many foods or natural compounds have been included in the diet in order to reduce the risks of the occurrence of the diseases mentioned above. The intake of green banana flour may result in health benefits. Some authors have shown it can reduce appetite and weight loss, and may improve glycemia, lipids, intestinal function, aging process, may reduce the incidence of cancer and cardiovascular diseases (Tavares da Silva *et al*, 2014). The flour produced with green bananas results from dehydrated green banana and the benefits produced by the consumption of this flour can occur due to the presence of numerous compounds. The most important is the elevated concentration of starch (73.45%), resistant starch (17.5%) and fibers (14.5%). Furthermore, it is rich in vitamins

B and C, calcium, potassium, phosphorous, iron and magnesium. When added to food preparations, the green banana flour may augment the amount of these elements and also proteins and fiber levels (Apostolopoulos *et al*, 2017; Tavares-Silva, 2016; Galvão Cândido *et al*, 2015). It is also worthy to the point that this flour contains phytosterols, phenolic compounds and can exert antioxidant capacity (Campuzano, Rosell, Cornejo, 2018; Anyasi, Jideani, Mchau, 2018; Sib-Sankat *et al*, 2016). Due to the reduced number of studies showing the effects of banana flour, the aim of our study is to evaluate the effects of green banana flour on the anthropometric and biochemical parameters of Wistar rats.

After this pelletization, air circulation oven was used at 65°C for approximately 6 hours for drying. We evaluated the weight of the animals three times a week,andat the end of the experimental protocol the animals were anesthetized with thiopental overdose (200mg/kg) to evaluate the anthropometric parameters. Immediately after death, blood samples were taken from the inferior vena cava to delineate the biochemical (glycemia, total cholesterol (TC), and triglycerides (TG) and anthropometric profile (body weight, Lee Index, abdominal circumference, thoracic circumference; and visceral fat weight). Atherogenic Index (AI), Atherogenic Coefficient (AC), and Cardiac Risk Ratio 1 (CRR1) were analyzed

Table 1. Anthropometric parametersof G1 (control group) and G2 (group treated with banana flour)

Parameters	G1	G2	*p*-value
Weight	290±37.63	287±17.10	0.861
Lee index	29.30±0.60	28.40±0.96	0.012*
Bodymass index	0.57±0.05	0.53±0.04	0.001*
Thoracic circumference	9.13±0.65	13.50±1.09	0.000*
Abdominal circumference	10.80±0.71	14.80±1.14	0.001*
Visceral fat	2.11±0.95	2.62±0.77	0.201

*Significative difference.

Table 2. Biochemical parameters of G1 (control group) and G2 (group treated with banana flour)

Parameters (mg/dL)	G1	G2	*p*-value
Glycaemia	200.10±51.87	151.60±18.42	0.010*
Triglycerides	120.80±33.32	96.10±15.20	0.040*
Cholesterol	163.00±0.17	157.70±5.32	0.181
HDL-c	41.01±6.16	38.80±3.97	0.362
LDL-c	101.92±17.17	99.05±5.919	0.673

*Significant difference.

Table 3. Atherogenic indices of G1 (control group) and G2 (group treated with banana flour)

Parameters	G1	G2	*p*-value*
Non-HDL-c	126.10±9.72	118.6±5.08	0.33
AC	1.94±1.08	1.51±0.56	0.27
AI	1.21±0.40	1.07±0.19	0.23
CCR1	4.02±0.58	4.10±0.38	0.75
CCR2	2.43±0.40	2.48±0.30	0.47

AI: Atherogenic Index; AC: Atherogenic Coefficient; CRR1:Cardiac Risk Ratio 1; CRR2: Cardiac Risk Ratio2.

MATERIALS AND METHODS

Animal groups

Sixteen male Wistar rats weighing approximately 180-220g were obtained from the Center for Experimentation in Animal Models of the University of Marília / UNIMAR. The animals underwent an adaptation period of seven days before the start of the experiment and were kept in a 12-h light/dark cycleenvironment, temperature 22 ± 2° C and relative humidity of 60 ± 5% until the end of the experimental protocol. The animals were divided into two groups randomly (n=8):

- **G1 (control group):** animals received water and food *ad libitum;*
- **G2 (treated group):** animals received water and food supplemented with green banana flour (20%) *ad libitum* for 45 days.

Commercial feed supplemented with green banana flour in the ratio 20:80 was prepared as follows: the commercial feed was ground in an electric mill (4500 rpm) and then the green banana flour was added. The blend was manually patterned so that the final shape is similar to the commercial rat food.

according to: AI = log (TG/HDL-c); AC = (TC – HDL-c)/HDL-c; non-HDL-c = Total cholesterol – HDL-c; CCR1 = TC/HDL-c, and CCR2 = LDL-c/HDL-c (Munshi, Joshi, Rane (2015) and Ahmadvand *et al*. (2016).

Statistical analysis

Our data were expressed as mean ± standard deviation and we used T-test and Mann-Whitney. The results were analyzed using the software BioEstat 5.3, and the level of significance was 5%.

RESULTS

In Table 1 it is possible to see that the green banana flour promoted significantreduction in the body weight, Thoracic circumference and in the Abdominal circumference; Table 2 shows that the animals of G2 presented a significant reduction in glycemia and triglycerides levels. In table 3 it is possible to see that the intake of banana flour did not interfere with the atherogenic indices. Table 4 shows that there isa significant correlation between weight and visceral fat, abdominal and thoracic circumference.

Table 4. Correlation Analyses for parameters evaluated in G1 and G2

	Visceral fat		ACir		TCir		LEE	
	G1	G2	G1	G2	G1	G2	G1	G2
Weight	0.95	0.00	0.75	0.22	0.87	0.05	0.48	0.51
p-value	0.00*	0.49	0.00*	0.28	0.00*	0.44	0.07	0.06
HD L-c	-0.19	-0.56	0.24	-0.10	-0.34	-0.22	0.10	-0.70
p-value	0.30	0.04*	0.26	0.38	0.18	0.26	0.39	0.01*
LDL-c	-0.46	0.43	-0.60	0.17	-0.44	0.52	-0.08	-0.28
p-value	0.10	0.16	0.04*	0.35	0.11	0.11	0.41	0.26
Glycaemia	0.18	0.42	-0.07	-0.45	0.26	-0.47	-0.21	0.06
p-value	0.30	0.38	0.42	0.09	0.23	0.08	0.27	0.43
Triglycerides	0.59	0.15	0.65	0.02	0.68	-0.03	0.02	-0.03
p-value	0.03*	0.33	0.02*	0.48	0.01*	0.46	0.47	0.46
Cholesterol	-0.18	-0.59	0.02	-0.79	-0.11	-0.83	0.02	0.05
p-value	0.30	0.08	0.47	0.01*	0.37	0.00*	0.48	0.45
Visceral fat	___	___	0.83	0.42	0.91	0.63	0.34	0.25
p-value			0.00*	0.11	0.00*	0.02*	0.16	0.24
Non-HDL-c	-0.08	0.51	-0.16	0.25	0.01	0.53	-0.09	0.00
	0.41	0.11	0.33	0.29	0.48	0.10	0.40	0.49
AC	0.62	0.05	0.41	-0.12	0.72	-0.10	-0.17	0.59
	0.03*	0.43	0.13	0.37	0.01*	0.38	0.32	0.03*
AI	0.69	-0.07	0.69	0.02	0.62	-0.23	0.00	0.62
	0.01*	0.43	0.02*	0.48	0.02	0.30	0.19	0.06
CCR1	0.17	0.79	-0.20	0.04	0.32	0.29	-0.16	0.49
	0.32	0.01*	0.29	0.46	0.20	0.25	0.33	0.12
CCR2	-0.07	0.79	-0.43	0.04	0.06	0.29	-0.12	0.49
	0.42	0.01*	0.11	0.46	0.43	0.25	0.37	0.10

AI: Atherogenic Index; AC: Atherogenic Coefficient; CRR1: Cardiac Risk Ratio 1; CRR2: Cardiac Risk Ratio2.

DISCUSSION

Our results show that the green banana flour promoted essential results in the metabolic parameters of Wistar rats. Contradicting our results, Tavares-Silva *et al.* (2014) studied the effects of the use of 20g/day of green banana flour during 45 days in overweight women and did found weight loss or modifications in body composition in these patients. These authors also evaluated the effects of this compound in other parameters and observed a reduction in the hip circumference, glycemia and in systolic blood pressure. Ble-Castillo *et al*, 2017 studied the effects of banana starch on the appetite and did not found positive effects on the appetite or in the gut hormones. On the other hand, they showed that this compound was able to reduce the size of the meal. Other authors also showed that the supplementation with resistant starch is associated with the reduction of body mass index (Si *et al*., 2017; Barczynska *et al.,* 2016). Similarly to our results, some authors also showed a reduction of glycemia after treatment with resistant starch (Matsuda *et al*., 2016). Increase in the levels of glucose in plasma may be related to alterations in the insulin response, and this condition may lead to insulin resistance and diabetes mellitus that is also related to the cardiovascular diseases (Arnold *et al*., 2018; Navarro-Pérez *et al*., 2018). Famakin *et al.,* (2016) performed a study about the nutritional properties, glycemic index, and antidiabetic properties of plantain (*Musa paradisiaca*) based functional dough meals and found significantly reduction in the glucose levels compared to metformin (an antidiabetic drug) and concluded it could be used in the prevention or the management of diabetes mellitus. Green bananas may also exhibit hypolipidemic effects possibly to the presence of flavonoids. This effect was shown by Vijayakumar *et al* (2009) in their study with flavonoids form *Banana paradisiaca* in rats. They observed a reduction in the levels of triglycerides, cholesterol, phospholipids and free fatty acids in the blood, kidney, liver, and brain. Usha, Vijayammal, Kurup (1991) and Verma, Singh, Jaggi (2014) showed that green banana flour might play a role as anti-atherosclerotic activity in rats. These last authors showed that the alkaloidal fractions extract from banana may have potent inhibitory activity in sodium-hydrogen exchangers that have been described in the pathophysiology of several diseases such as cardiomyopathy, ischemic heart and brain diseases, and congestive heart failure. Resistant starch present in banana flour can produce several health benefits, such as an increase in the ratio of *Firmicutes: Bacteroidetes* (Maier *et al*., 2017) and its fermentation in colon results in the synthesis of acids and derivatives of organic acids that are associatedwith the reduction of lipids in the plasma. The reduction of lipids helps in the prevention of chronic degenerative diseases (Reshmi, Sudha, Shashirekha, 2017). The risk of developing cardiovascular diseases can be measured with atherogenic indices, and they can be used in the clinical practice as a tool of stratification of these diseases. Non-HDL-c has emerged as a new target of preventing or treating cardiovascular diseases in several guidelines. It reflects the cholesterol associated with atherogenic lipoproteins, and it is relevant to the assessment of cardiovascular risk prediction and is related with the progression of the atheroma plaque (Kurkowska-Jastrzebska *et al*., 2016; Ruan *et al*., 2016; Razali *et al*., 2015; Ikewuchi, 2012). Our results did not show improvement of atherogenic indices and non-HDL-c values. We did not find studies using green banana flour in the atherogenic indices and in the evaluation of non-HDL-c. Green banana flour could be easily incorporated in preparations like beverages, cakes, cookies and cereal bars (Ramith Ramu *et al*., 2017). For this reason, more studies should be performed in new products formulation once green banana flour may bring beneficial on the metabolic profile of Wistar rats, and could be used as an alternative to prevent risk factors of developing chronic degenerative diseases. Furthermore, this product possesses high nutritional value and the reduced cost of its production promise to be used as a nonconventional food resource with high nutraceutical value.

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