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Metabolic syndrome: Intake of Camu-Camu (*Myrciaria dubia* (Kunth) McVaugh)

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Abstract
To verify the impact of the consumption of camu-camu, fruit native to the Amazon, with high content of ascorbic acid and phenolic compounds, in the treatment of Metabolic Syndrome (MS). A double-blind, documental, descriptive and analytical experimental study including 58 adult individuals overweight (BMI> 30) of both sexes. Two groups were formed: experimental (EG) (n=29) and control (CG) (n=29). The EG group received a capsule containing camu-camu, holding approximately 442 mg of vitamin C for 45 days, and CG received a capsule (placebo) for the same time period. Both groups received a balanced hypocaloric diet associated with regular physical activity and were followed up in individual consultations, inserting nutritional assessment data at the beginning and end of the study, as well as monthly anthropometric evaluations. The daily supplementation of camu-camu capsules in the diet associated with regular physical activity contributed to the improvement of the MS indicators. The research was registered at CEP under CAAE n. 32780814.7.0000.5020. There was a significant reduction in some indicators of MS diagnosis, such as: decreased blood pressure (p=0.012), triglycerides (p=0.011), abdominal circumference (p=0.038) and increased HDL-c (p=0.001), as well as the practice of physical activity (p=0.013). The daily supplementation of camu-camu capsules in the diet associated with regular physical activity contributed to the improvement of the MS indicators.

Keywords: metabolic syndrome, obesity, camu-camu, myrtaceae, Amazonia, chronic non-transmissible diseases

1. Introduction

The usual diet provides, in addition to the macro and essential micronutrients, some chemical compounds, mostly present in fruits and vegetables, which exert a potent biological activity already proven in studies. These compounds are called bioactive compounds and may play several roles for the benefit of human health, thus possessing extranutritional constituents, which typically occur in small amounts in food [1].

Population studies indicate that individuals with Metabolic Syndrome (MS) have a low serum concentration of these compounds [2, 3]. There is evidence that many micronutrients, such as vitamin C, are involved in important metabolic and endocrine processes with regard to the genesis and control of overweight. For this reason, dietary intake becomes fundamental as a protective factor for the occurrence of obesity and its comorbidities [4].

The high prevalence of overweight and obesity, which is no longer exclusive to developed countries, in Brazil, is a worldwide public health problem [5, 6, 9]. In general, chronic non-communicable diseases (NCDs) are long-term, multiple, require permanent multidisciplinary follow-up, continuous interventions and require large material and human resources to be expended, generating burdens on the public and social system [7, 37]. Data from the Ministry of Health reveal that the SUS (Unified Health System) spends annually R$ 490 million per year on the treatment of diseases associated with obesity [9].

In the last decades, the Ministry of Health has been working on changes in the health conditions of the population, with a worrying increase in the prevalence of chronic diseases, conferring high cardiovascular risks, due to changes in dietary patterns and undesirable lifestyles. Under this context, the importance of the implementation of studies that focus on the qualitative characteristics of the diet is recognized [5, 10, 37].

As a strategy to add values from Amazonian fruits ascorbic acid supplementation and bioactive compounds effects to individuals with obesity and MS, for dietary therapy and better control of associated comorbidities, it is pertinent to include camu-camu in this experimental study on this syndrome [11, 12].

2. Methods and Materials

2.1 Participants

This study was conducted by means of double-blind, experimental and analytical research, carried out with the users of public health services in the municipality of Boa Vista, capital of the state of Roraima, Brazil, in 2015.

Twenty to 59 years old adult participants of both sexes, obese (BMI> 30), were randomly divided into two groups: control group (CG) and experimental group (EG), each with 29 participants.

The participants were estimated by means of estimation according to the studies of Costa *et al*. [13] The initial sample (n) was estimated as a function of a confidence interval (95%) previously fixed in (α = 5%) that in the abscissa of the Standard Normal Distribution is equal to (Z (α / 2) = 1.96); tolerable sample error (e = 7.5%); proportion of sample participants (p = 10%), totalizing an initial sample (n = 62).
The sample size (n) was estimated by the sample as a function of the initial sample (n_0 = 62) and the total number of individuals with obesity, in both groups (N = 536), totaled a sample of at least 56 participants.

2.2 Study design

This study was submitted and approved by the Human Research Ethics Committee (REC) of the Federal University of Amazonas (FUA) under protocol CAAE 32780814.7.0000.5020. Individuals invited to participate in the study were formalized by signing the Free and Informed Consent Term (FICT), authorizing their evaluations. Excluded were adults in the postoperative period of bariatric surgery, diagnosis of hypothyroidism, mental disorders using psychiatric and neurological medications or individuals in chronic steroids, with hepatosplenomegaly, edema, ascites, renal diseases, pregnant women, infants and the indigenous population.
Nutritional follow-up was carried out with the groups (CG and EG), which were encouraged to consume balanced hypocaloric diet, perform moderate low impact 60 to 90 min / day physical activity (walking, water aerobics, swimming) as recommended by WHO [14] and a disincentive to alcohol consumption and smoking [5, 10].
Each individual in the respective groups received 60 n. 0 capsules per month to be consumed daily. In the experimental group the capsules were filled with lyophilized camu-camu holding approximately 442 mg of ascorbic acid and the control group they were just placebo. Capsule density was calculated according to Santos & Pessim [15].
The participants were instructed to consume the capsules for breakfast during the 45-day period, store them at refrigeration temperature (5° C), without the incidence of luminosity [16].
The study was carried out in a 45, day period, with anthropometric evaluation (weight) and diet follow - up in individualized consultation, and nutritional evaluation between the groups (CG and EG) performed at the beginning and end of the experiment (Figure 1).

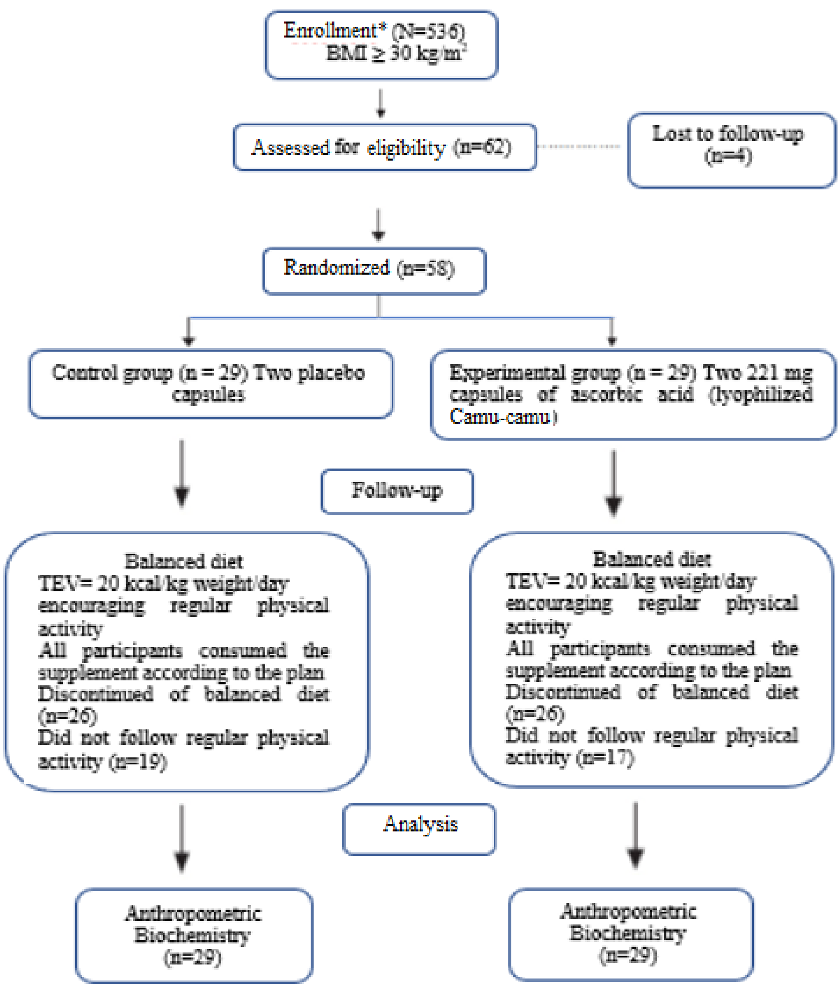

Fig 1: Flowchart of the study.

2.3 Dietary assessment and prescription

The nutritional composition of the participants consisted of a hypocaloric diet, the total energy value (TEV) of 20 kcal per kilogram of body weight per day[19], distributed in: 50-60% carbohydrate (HC) with sources of complex carbohydrates with low glycemic index, GI <55 [17], 20 to 30 g fibers per day, 5 to 10 grams of soluble fibers [18, 19], 1.0g protein per kg of body weight per day or 15% of TEV [19]; 25% of the TEV in the form of fats, having the following composition: saturated fatty acids <7% of TEV, with a cholesterol content of up to 200 mg / day; monounsaturated fatty acids <20% of TEV; no polyunsaturated fatty acids (omega-6 and omega-3) <10% [20], and the indication of 2 g sodium supply, tantamount to 5 g of salt (NaCl) per day [8].

Macro and micronutrients nutritional composition followed the recommended daily intake references (RDI) [21].

2.4 Anthropometric measurement

Anthropometry was used to evaluate weight in relation to height in order to assess the nutritional status of every participant.

In weighing, a mechanical platform scale with a maximum capacity of 300 kg, with two sensitivity levels, of 100 g and 10 kg respectively, was used. Before weighing, the scale was calibrated and after the participant, barefoot and wearing the least amount of clothing possible was placed on its center in a firm position, with his arms along the body and the reading checked in front of the scale [22].

The height determination was performed through a stadiometer coupled to the mechanical anthropometric scale with a field of use of 0.80 to 2.20 m. Weight and height data determined the body mass index (BMI), which was estimated from the weight expressed in kg and height in m², with the unit of measurement of this indicator per kg / m 2 proposed by the World Health Organization [23].

The cut-off points were used according to the reference standard recommended by the WHO [23]. And obesity is considered indicative of BMI equal to or greater than 30 kg / m^2 for men and women.

The measurement of abdominal circumference (AC) was performed in the thinner part, between the costal border and the iliac crest, using an inelastic and inextensible tape measure [24]. The cutoff points were considered as reference for men> 102 cm and for women> 88 cm, established by the Third Report of the National Cholesterol Education Program's Adult Panel [18], adopted by the I Brazilian Guideline on Diagnosis and Treatment of Metabolic syndrome [19].

2.5 Blood pressure, blood collection and biochemical indices measurement

The systemic arterial pressure was measured with a large-abounded automatic blood pressure monitor, according to instructions [25]. Thus, the normal pressure is the result below 135 mmHg for systolic blood pressure and below 85 mmHg for diastolic blood pressure.

The participants performed the biochemical exams in the clinical analysis laboratory of the Municipal Health Center. Blood was collected under local aseptic venous puncture of the peripheral vein of the arm with a 25 x 0.7 mm gauge disposable hypodermic needle after a 12-hour fast. After puncture, the subject was advised to do a compressive hemostasis at the puncture site for 3 to 5 minutes to avoid the possibility of a local hematoma.

Blood glucose determination was performed using the enzymatic colorimetric assay, using the semi-automatic spectrophotometer and Bioclin/Quibasa enzymatic glucose mono reagent.

The reference values adopted for serum fasting serum glucose in adults were in the range of 70 to 110 mg/dL as recommended by the American Diabetes Association [26].

The determinations of total cholesterol and fractions were performed by enzymatic and colorimetric test by using semi-automatic spectrophotometer with the aid of Bioclin/Quibasa enzymatic reagent.

The values adopted for cholesterol and its fractions (mg/dL) in adults were recommended according to the American Health Association and National Cholesterol Education Program [18], later classified in the following ranges: Acceptable <200, Borderline 200 to 239 and High> 240. The clinical analysis laboratory at the Health Center considers the cut-off point for HDL-c (high-intensity lipoprotein) cholesterol for men and women to range from 40 to 60 mg/dL. And LDL-c (low-intensity lipoprotein) cholesterol in the following ranges: Great <100, Acceptable 100 to 129, High borderline 130 to 159, High 160 to 189 and Very high> 190.

Triglycerides (TG) were also determined using the enzymatic and colorimetric assay, using the semi-automatic spectrophotometer and specific to Bioclin/Quibasa enzyme reagent. The reference values adopted in mg/dL for adults were TG> 150, following the recommendations of the Brazilian Society of Cardiology [20].

2.6 Statistical analyses

The analysis of the data of the groups (control and experimental) was conducted through analysis of variance (ANOVA) by the F test and test of comparison of means by Student's t test, both at the probability level of 5%, analyzed by the program Minitab, version14.

3. Results

3.1 Evaluation of the initial profile of participants

Participants ranged from 20 to 59 years old, with women (n = 31) averaging 37 years old (SD ± 8.83) in the age group of 20 to 54 years old, while males (n = 29) presented mean age 41 years old (SD ± 8.44) between 26 and 55 years old. Schooling prevailed between middle and higher education. The reported per capita income of the participants showed to distributed in amounts equal to or greater than 3 minimum wages. The reported self-reported racial identification was as follows: brown with 68.33%, 21 women (65.61%) and 20 men (71.43%); white with 25%, with 9 women (28.13%) and 6 men (21.43%); (3.13%) and yellow (1.67%) for only 1 female (3.13%), as described in the Table 1.

Table 1: Socio-demographic characteristics of the participants (n = 60) with MS followed at the Sílvio Botelho Health Center, Boa Vista-RR, Brazil, 2015.

Variables	20 to 29 anos n (%)		30 to 39 anos n (%)		40 to 49 anos n (%)		50 to 59 anos n (%)	
	F	M	F	M	F	M	F	M
Education								
Elementary School	1 (100.0)	0 (0.0)	1 (50.0)	1 (50.0)	0 (0.0)	1 (100.0)	0 (0.0)	0 (0.0)
High School	3 (75.0)	1 (25.0)	2 (33.3)	4 (66.7)	6 (54.5)	5 (45.45)	0 (0.0)	4(100.0)
Highter education	4 (57.1)	3 (42.9)	7 (87.5)	1 (12.5)	5 (62.5)	3 (37.5)	1 (33.3)	2 (66.7)
Pos graduation studies	0 (0.0)	0 (0.0)	0 (0.0)	1 (100.0)	1 (50.0)	1 (50.0)	1 (50.0)	1 (50.0)
Income per capita (Minimum wage-Mw)								
1 to 2 Mw	2 (100.0)	0 (0.0)	1 (100.0)	0 (0.0)	0 (0.0)	2 (100.0)	0 (0.0)	0 (0.0)
3 to 4 Mw	4 (66.7)	2 (33.3)	4 (50.0)	4 (50.0)	10 (66.7)	5 (33.3)	0 (0.0)	1(100.0)
> 5 Mw	2 (50.0)	2 (50.0)	5 (62.5)	3 (37.5)	2 (40.0)	3 (60.0)	2 (25.0)	6 (75.0)
Race								
White	4 (80.0)	1 (20.0)	2 (66.7)	1 (33.3)	3 (50.0)	3 (50.0)	0 (0.0)	1(100.0)
Black	1 (100.0)	0 (0.0)	0 (0.0)	1 (100.0)	0 (0.0)	0 (0.0)	0 (0.0)	1(100.0)
Yellow	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	1 (100.0)	0 (0.0)	0 (0.0)	0 (0.0)
Brown	3 (50.0)	3 (50.0)	8 (61.5)	5 (38.5)	8 (53.3)	7 (46.7)	2 (28.6)	5 (71.4)

At the beginning of the study, the participants' profiles (CG and EG) were homogeneous (p> 0.05), both in age and weight (p> 0.05). Age ranged from 20 to 59 years old, with the mean of 37 years old in the control group and 41 years old in the experimental group. The weight ranged from 65.5 to 186 kg, with a mean of 93 kg in the control group and 103 kg in the experimental group.

Regarding the lifestyle evaluation of the obese individuals in the study groups (CG and EG), there were no significant differences between the groups (p> 0.05) for the variables: sex, smoking, alcohol, soft drink consumption and practice of physical activity.

While in the anthropometric evaluation, they presented significant difference between the groups (p <0.05) in relation to the BMI. However, there was no significant difference (p> 0.05) in abdominal circumference (AC), with all participants being obese (BMI> 30).

On the other hand, in the evaluation of blood pressure and biochemistry, the groups also did not present significant differences (p> 0.05) in the following variables: blood pressure, total cholesterol, triglycerides, HDL-c, LDL-c and glucose.

3.2. Experimental group nutritional evaluation

The experimental group (EG) was evaluated at the beginning and the end of the study, with no significant difference (p> 0.05) in relation to weight loss. Furthermore, our findings showed there to be an increase on the number of participants doing physical exercises with a reduction on sedentary ones from 69.2% to 30.8% by the end of the study, significantly different from the beginning (p <0.05).

In the anthropometric evaluation there was no significant difference in BMI in relation to the beginning and end of the study in the EG (p> 0.05), but we found there to be a 10.3% decrease in people classified as obese becoming overweight (BMI <30). In the evaluation of abdominal circumference there was a significant difference at the end of the study (p <0.05), suggesting it to have been provided by the practice of physical activity.

In the evaluation of blood pressure (BP), there was a significant difference between them, from the beginning to the end of the study (p <0.05) in the EG participants. At the beginning of the study, 24.1% of the participants had high BP (> 140x90 mmHg), and at the end of the study participants had borderline blood pressure, ranging from 120x90 to 130x90 mmHg. Regarding normal BP (120x80mmHg), 13.8% of the participants present at the beginning of the study, comparing to 20.7% at the end of the study (Table 2).

Table 2: Assessment of blood pressure (mmHg) of the EG (before and after the study) at the Municipal Health Center, Boa Vista-RR, Brazil, 2015.

Variable		Before n (%)	After n (%)	p
BP				0.012*
Low	< 12x8	16 (55.2)	15 (51.7)	
Normal	12x8	4 (13.8)	6 (20.7)	
Bordering	12x9 a 13x9	2 (6.9)	8 (27.6)	
Hypertension	> 14x9	7 (24.1)	0 (0.0)	

* Significant value for p<0,05.

Regarding the biochemical evaluation for triglyceride levels (TG) and the HDL-c fraction, there was a significant difference between the beginning and the end of the study (p <0.05) in the EG participants. The mean TG of participants at the start of the study was 209 mg / dL going to 133 mg / dL at the end and, for the HDL-c at baseline, the participants averaged 42 mg / dL, rising to 53 mg / dL, by the end of the study.

Regarding the levels of total cholesterol, LDL-c and glucose, there was no significant difference among participants (p> 0.05).

When analyzing the statistical correlations between total cholesterol and TG, total cholesterol and LDL-c, as total cholesterol decreases, TG and LDL-c also decrease, as well, in relation to TG with LDL-c, we found that the lower the TG the lower the LDL-c (p <0.05) (Table 3).

Table 3: Statistical correlations (r) between the biochemical (mg / dL) and anthropometric parameters of the experimental group at the end of the study.

Correlations	Total Cholesterol	TG	WC (cm)
TG	0.413**		
HDL-c	-0.024ns	-0.283*	
LDL-c	0.565**	0.573**	
Weight (kg)	-0.280ns	-0.070ns	0.903**

*Significant probability value (p <0.05)
** Significant probability value (p <0.01)
NS: non-significant probability value (p> 0.05)

In the same table, we observed the weight to be related to the AC (p <0.05), that is, the weight loss also provides a decrease in abdominal circumference.

We also observed the statistical correlation between HDL-c and TG (p <0.05), confirming the results presented, when analyzing the increase in HDL-c levels and the decrease of TG in the study participants who consumed the capsules with the camu-camu.

The weight loss of the participants of the experimental group was not significant (p> 0.05) at the end of the study (Table 4), verified by the noncompliance of the hypocaloric diet, according to information collected (AIC) in the evaluation, 13.8% 75.8% reported noncompliance with diet, and only 10.4% followed dietary recommendations (Table 7).

Table 4: Evaluation of the weight of the experimental group (before and final) of the study at the Sílvio Botelho Health Center, Boa Vista-RR, Brazil, 2015.

Variable	Weight (kg)		p=0.681*
	Before	After	
Average	103.0	100.0	
Minimum	65.5	64.1	
Maximum	186.0	182.5	
Amplitude	120.5	118.4	
Standard deviation	30.3	30.0	
Inferior limit	91.7	88.6	
Upper limit	114.8	111.4	
n	29	29	

* Significant value for p<0.05.

As to physical activity, it has been reported to help with weight loss and preservation or gain of lean muscle mass, yet we know this type of activity is usually hard to keep on being performed as one gets fatter. Thus, it is essential that the prescribed physical exercise prioritizes activities of low impact and light to moderate intensity so as to reduce the risks of micro-injuries, potentiated by obesity, and uses mainly lipids as an energy source to help reduce body fat.[14,27] However, even though there was no significant difference (p> 0.05) in relation to weight loss, there was a small one (Table 4), and in relation to physical activity, there was an improvement in habits, increasing the number (p <0.05) in Relation to the beginning of the study (Table 5).

Table 5: Physical activity evaluation of the experimental group (before and after) the study at the Sílvio Botelho Health Center, Boa Vista-RR, Brazil, 2015.

Variable	Before	After	
Physical activity			p=0.013*
Frequent	9 (31%)	12 (41.4%)	
Irregular	2 (7%)	9 (31%)	
Sedentary lifestyle	18 (62%)	8 (47.6%)	
n	29	29	

* Significant value for p<0,05.

3.3 Control group final evaluation

When analyzing the statistical correlations of the biochemical parameters between total cholesterol and HDL-c, total cholesterol and LDL-c, and total cholesterol and weight, one finds that the lower the total cholesterol, the lower the HDL-c, LDL-c and weight (p <0.05), this is also true regarding AC and weight (p <0.05) (Table 6). Thus, weight loss also provides a decrease in abdominal circumference (Fig. 2), this high statistical correlation was also verified in the evaluation of EG (Table 2).

Table 6: Statistical correlations ® between biochemical (mg/dL) and anthropometric parameters of the control group at the end of the study.

Correlations	Total Cholesterol	TG	HDL-c	AC (cm)
Triglicerídeos	0.30ns			
HDL-c	0.50*	-0.08ns		
LDL-c	0.81*	-0.05ns	0.22ns	
Weight (kg)	0.36*	0.36ns	-0.04ns	0.86*

* Significant probability value (p <0.05)
Ns: non-significant probability value (p> 0.05)

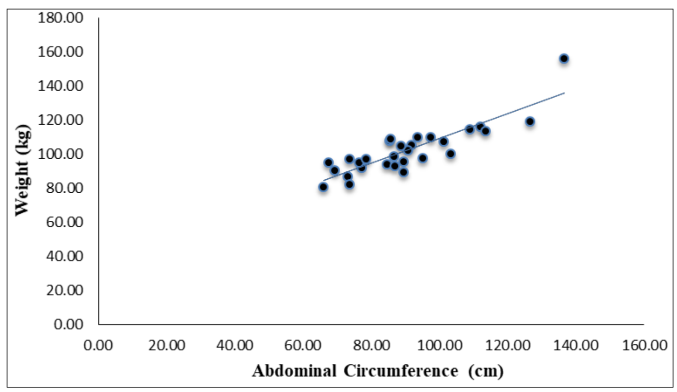

Fig 2: Statistical correlation (r = 0.86) between the anthropometric parameters, weight and AC, of the control group participants at the end of the study.

3.4 Control and experimental Groups final evaluation

As to the final dietary evaluation of control (CG) and experimental (EG) groups, the present study reports that most participants failed to comply with the hypocaloric diet as prescribed (Table 7).

Table 7: Evaluation of groups (CG and EG) showing on how they complied with diet therapy at the end of the study.

	Diet therapy	
Evaluation	**CG n (%)**	**EG n (%)**
Yes	3 (10.4)	3 (10.4)
No	5 (17.2)	4 (13.8)
Irregular*	21 (72.4)	22 (75.8)

* Dietary noncompliance 2 to 3 times per week (AIC).

The weight loss difference between the control and experimental groups in the final evaluation of the study (Table 8) showed there to be no significant difference between them (p> 0.05) (Figures 2 and 3), possibly due to both groups not having truly complied with their prescribed hypocaloric diet (Table 7).

Table 8: Pondered weight of the participants of the GC and EG groups at the beginning and end of the study.

Weight (kg)						
Evaluation	**Beginning**			**End**		
	GC	**GE**	**p**	**GC**	**GE**	**p**
Mean	93,0	103,0		90,5	100,0	
Minimum	68,0	65,5	0,116	66,0	64,1	0,145
Maximum	138,0	186,0	(ns)	136,6	182,5	(ns)
SD (+)	17,2	30,3		17,2	30,0	
n	29	29		29	29	

Probability value: not significant ns (p≥0, 05).

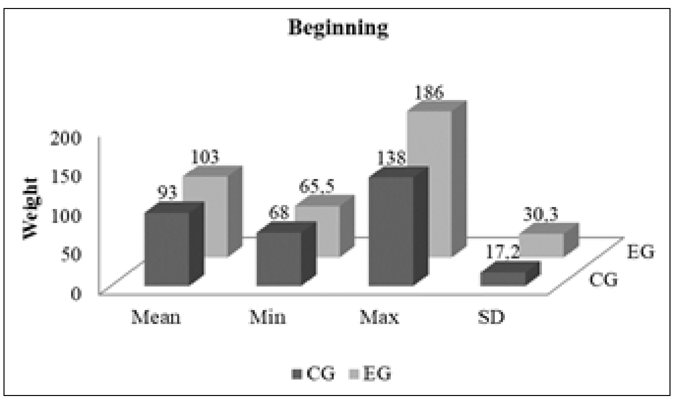

Fig 3: Statistical difference (p> 0.05) between the weight of the control and experimental groups (CG and EG) at the beginning of the study.

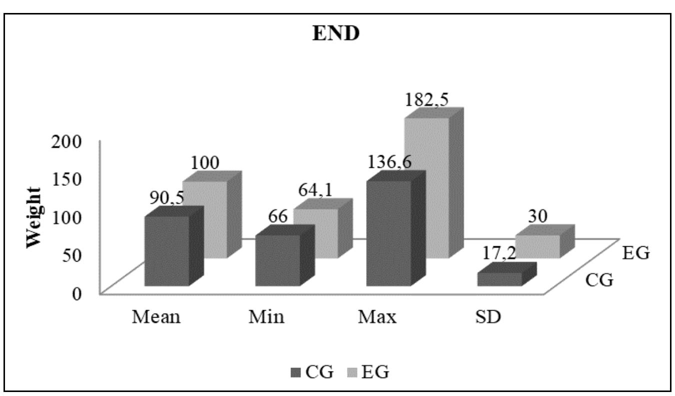

Fig 4: Statistical difference (p> 0.05) of the weight between the control and experimental groups (CG and EG) at the end of the study.

The physical and anthropometric activities undertaken by both CG and EG groups showed no significant difference (p> 0.05) between BMI and AC variables, respectively (Table 9). According to the evaluation of the participants of the experimental group, there was a significant difference (p <0.05) from the beginning up to the end of the study, increasing the number of participants doing physical activity

And decreasing the number of sedentary ones (Table 5). Therefore, since there was no significant difference between the groups evaluated (CG and EG), we can assert there to also have been an improvement on the physical activities being performed by the control group as well, as shown in the final evaluation.

Regarding the evaluation of abdominal circumference at the end of the study (Table 9), we found there to have been no significant difference (p> 0.05) between the groups (GC and GE), but in the abdominal circumference assessment with the participants of the EG, there was difference (p <0.05) at the end (Table 3), so we can observe there to also have been a decrease in C in the control group, considering that at the beginning of the study all participants presented a risk.

Table 9: CG and EG groups' physical and anthropometric evaluation at the end of the study.

Variables	**CG**	**EG**	**p**
	n (%)	**n (%)**	
Physical activity			0.809 (ns)
Frequent	10 (52.6)	12 (57.1)	
Irregular	14 (51.8)	9 (81.8)	
Sedentary lifestyle	5 (41.7)	8 (30.8)	
BMI			0.267 (ns)
Overweight	4 (13.8)	3 (10.3)	
Obesity I	16 (55.2)	11 (38.0)	
Obesity II	8 (27.6)	10 (34.5)	
Obesity III	1 (3.4)	5 (17.2)	
WC			0.640 (ns)
Without risk	2 (6,9)	3 (10.3)	
At risco	27 (93,1)	26 (89.7)	

Without risk: Female <88 cm and male <102 cm
At risk: Female> 88 cm and male> 102 cm
Probability value: non-significant ns (p> 0.05)

Regarding the final assessment of blood pressure (mmHg), between CG and EG, there was a significant difference (p <0.05) as seen in Table 10. The significant result (p <0.05) was also observed in the participants of the experimental group (before and after) the study, so we can infer that there was no significant difference (p> 0.05) in the final evaluation of the control group. We can attribute the improvement of the blood pressure of the participants of the experimental group to the action of the fruit's bioactive compounds as well as the practice of physical activity.

Regarding the CG and EG groups analyzed biochemical parameters, there was no significant difference (p> 0.05) between them (Table 10). However, the results of the biochemical evaluation of the experimental group (before and after) the study were observed, and there was a significant difference (p <0.05) in triglycerides and HDL-c, which are indicators for the diagnosis of MS [18].

Table 10: Assessment of blood (mmHg) and biochemical (mg / dL) pressure of the control and experimental groups at the end of the study.

Evaluation			
Variables	**CG**	**EG**	**p**
	n (%)	**n (%)**	
Blood Pressure			0.049*
Low	12 (41.4)	15 (51.7)	
Normal	9 (31.0)	6 (20.7)	
Bordering	4 (13.8)	8 (27.6)	
Hypertension	4 (13.8)	0 (0.0)	
Total cholesterol			0.753 (ns)
Normal	22 (75,9)	23 (79,3)	
Limit	7 (24.1)	6 (20.7)	
High	0 (0.0)	0 (0.0)	
TG			0.594 (ns)
Normal	16 (55.2)	18 (62.1)	
High	13 (44.8)	11 (37.9)	
HDL-c			0.517 (ns)
Normal	22 (75.9)	24 (82.8)	
Low	7 (24.1)	5 (17.2)	
LDL-c			0.396 (ns)
Great	17 (58.6)	18 (62.0)	
Acceptable	9 (31.0)	5 (17.2)	
High Limit	1 (3.4)	4 (13.8)	
High	2 (7.0)	2 (7.0)	
Glucose			0.553 (ns)
Normal	28 (96.5)	27 (93.0)	
High	1 (3.5)	2 (7.0)	

* Significant value for ($p < 0.05$).
Non-significant ns ($p > 0.05$).

4. Discussion

During the study, the participants reported noncompliance with the diet, due to several factors (AIC), such as anxiety (worries, expectations and frustrations), resistance to healthy eating habits, pleasure in eating a lot of caloric food, failure to organize schedules and low calories foods selection.

The same was observed regarding the use of hypotensive medications, irregulary, which can be the cause for the pressure levels improvement and the practice of physical activity associated with the camu-camu fruit's antioxidant effects.

According to Nascimento *et al*. [28] in animal studies (*Rattus norvegicus* var Albinus), with the ingestion of camu-camu from the nonflooded land ecosystem, the results demonstrated the efficiency of this fruit in weight reduction, lipid and glycemic profile, as well as the increased HDL-c levels.

However, the present study has found increased HDL-c and decreased TG. It should be pointed out that this study was evaluated with 45 days of camu-camu consumption, which in a longer experimental period might find a safer response as to preprandial glycaemia assessment, since it is a biochemical parameter for the diagnosis of SM.

Gonçalves [29] also conducted animal studies with young male Wistar rats. There was a significant reduction of both total cholesterol and triglycerides in the groups treated orally with camu-camu extract, with 3g/kg body weight for 44 days. The author also found a significant increase in HDL-c levels.

High HDL-c levels have shown to be directly related to reducing the risk of cardiovascular diseases by transporting excess cholesterol from the bloodstream to the liver where it is catabolized [30].

The reduction of plasma lipid levels is considered to be one of the main biological effects of catechins and procyanidins, since studies have pointed out these polyphenols present in tea, cocoa and also in camu-camu to be able to inhibit the activity of the enzyme lipase, responsible for the degradation of fats in the intestine, by reducing the lipid absorption, in addition to presenting high antioxidant potential, similarly to ellagic acid [31-33].

Fontes *et al*. [34] verified the influence of the psychological, psychosocial and environmental aspects in all spheres, systems and subsystems of human life in the chronic imbalance of obesity, by observing the etiological complexity of lifestyles and having the notion that it is necessary to intervene in all spheres of life of the individual to promote the adoption of healthy lifestyles or alteration of undesirable behaviors.

So as to improve the quality of life, it is necessary to investigate the population groups profile as related to obesity and its implications, in order to contribute to the support of public policies aimed at better quality of life [35].

According to WHO [36], promoting and maintaining health should be a general concern, because living and being able to enjoy it, is doubtlessly an aspiration and a right common to all human beings.

5. Conclusions

In conclusion, this study showed the consumption of camu-camu, associated with regular physical activity, to be able to improve blood pressure, abdominal circumference, HDL-c and triglycerides contents of participants with metabolic syndrome. The presence of high ascorbic acid content, as well as phenolic compounds has probably contributed to the results, suggesting that this Amazonian fruit can be inserted in the diet to improve indicators of the metabolic syndrome.

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