Effect of consumption of cocoa paste (*Theobroma cacao* L.) on anthropometric and clinical indicators in university students

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University students are vulnerable to developing metabolic syndrome, due to the low consumption of foods with bioactive properties. Cocoa paste containing phenols (CPCP) may prevent it. The objective of the study was to evaluate the effect of consuming 1 g of cocoa paste for 4 weeks on anthropometric indicators, body composition, blood pressure and heart rate in university students. The population consisted of 7 men and 13 women. In the post-test measurement, students had the best result in weight (74.4-72.3 kg), BMI (26.0-25.2 kg/m$^2$) and WC (85.5-83.5 cm), and in the body composition, only in the percentage of fat mass (62.3-60.9 %) there were significant differences (p>0.05). CPCP consumption in females decreased systolic and diastolic blood pressure (107.0 vs 100.0, p=0.023) and (76.0 vs 71.0, p=0.007) respectively. CPCP has a protective effect and may exert a preventive function.

Keywords: anthropometry, BOD POD, blood pressure, heart rate, *Theobroma cacao* L., university students.

1 INTRODUCTION

Most university students are healthy, but a lack of interest in their daily organization will have repercussions in the future in disorders of metabolic syndrome (Lorenzini et al., 2015).

Moreover, the environment in which the university population is developing, they can be influenced and copy unhealthy lifestyles, such as physical inactivity, tobacco smoking, alcohol consumption and generally their diet is replaced by foods with a high energy density, and most of them are unaware of the different ingredients that constitute the diversity of dishes that constitute traditional Mexican cuisine, which is considered Intangible Cultural Heritage of Humanity by the United Nations Educational, Scientific and Cultural Organization (Lorenzini et al., 2015; Montagna et al., 2019).

One of these ingredients is cocoa beans (*Theobroma cacao* L.), which for two thousand years, Mesoamerican cultures have used it to make cocoa paste and beverages, and currently the same process is followed for its production, which is a roasting of the seeds, addition of spices, grinding, melting, and molding, does not contain additives (unlike commercial chocolates) and represents 100 % of its nutritional composition, and one of the main bioactive compounds, are polyphenols (flavanols, flavonols, flavones, flavonones, flavonones, stilbenes, methylxanthines and phenolic acids), which are secondary metabolites, and are believed to be responsible for the bitter taste, the astringency of cocoa beans and their derivatives, and exert health benefits, such as the reduction of adipose tissue and dyslipidemia, hyperglycemia and insulin resistance, which are induced by a frequent excess in the diet, of foods with high energy density and ultra-processed foods (Montagna et al., 2019; Ariza et al., 2021). Therefore, the aim of this work was
to evaluate the effect of consuming 1 g for 4 weeks of cocoa paste (*Theobroma cacao* L.) on anthropometric indicators, body composition, blood pressure and heart rate in university students.

**2 MATERIALS AND METHODS**

**2.1 STUDY AND SAMPLE**

We conducted the study as a randomized controlled clinical trial, with the participation of 20 students from the Autonomous University of the State of Hidalgo (UAEH), Mexico, of the Bachelor's Degree in Nutrition of the Institute of Health Sciences (ICSa). The inclusion criteria were participants aged 18-25 years (women and men), who studied from the third to the eighth semester of the Bachelor's degree. The exclusion criteria were pregnant women, students with a pharmacological or dietary treatment or with a dietary supplement consumption. The criteria for elimination were voluntary withdrawal of participants. Finally, this work was assessed and approved by the Research Ethics Committee of the ICSa of the UAEH (CEI-2020-005), in addition to having informed consent from each participant.

**2.2 INTERVENTION WITH THE COCOA PASTE**

The participation with the cocoa paste intervention was carried out with the consumption of 1 g daily per person for 4 weeks. The cocoa paste was previously elaborated by the working group and its total phenol content was 1300 mg of gallic acid equivalents (GAE) per gram (Ariza *et al*., 2021).

**2.3 ANTHROPOMETRIC ASSESSMENT**

The anthropometric assessment was carried out by determining the height of the students, which was measured using a SECA® 217 portable rigid stadiometer (Seca Deutschland, Hamburg, Germany). The body weight was measured with the TANITA® SC 331 S analyzer (Arlington Heights, IL, USA). The body mass index was calculated by weighing and measuring each participant, and was classified using the values recommended by the World Health Organization (2022). The waist circumference (for abdominal adiposity) was measured at the end of normal expiration to the nearest 0.1 cm at the midpoint between the last floating rib and the top of the iliac crest, and the cut-off points for women and men proposed by the World Health Organization (2022) were used. The anthropometric measurements were standardized by an expert certified by the International Society for the Advancement of Kinanthropometry (ISAK) level 1. The students were asked to come fasting, with light clothing and without accessories, so as not to affect the measurements.
2.4 BODY COMPOSITION ASSESSMENT (BOD POD)

The body composition assessment was carried out using the whole body air displacement plestimography system BOD POD (Life Measurement Inc, Concord, CA, USA), which is a method considered the gold standard for this assessment. For the measurements, the students wore only tight-fitting clothing (swimsuit or underwear), an acrylic swim cap, sports bra (no underwire or padding material) and outside of menstrual period, pregnancy or lactation. Each student was introduced inside the BOD POD equipment, which is a computerized fiberglass egg-shaped chamber or capsule, following the protocol of the anthropometrist, who follows the guidelines of the equipment's computer. The students were evaluated twice. To calculate body density (Siri's equation was used) to estimate body composition. The BOD POD was calibrated on the morning of the test session as well as between each intervention.

2.5 BLOOD PRESSURE AND HEART RATE MEASUREMENT

Blood pressure and heart rate measurement was performed using NOM (2009). Each measurement was performed in duplicate.

2.6 STATISTICAL ANALYSIS

For the initial analysis of the results, the Levene test was performed to identify equality of variances (homoscedasticity), and normality through the Shapiro-Wilk test, where the numerical variables were established according to the difference in medians. The Wilcoxon test for related samples was used for comparison of two different times (pretest and posttest) at $p<0.05$. All results were analyzed using IBM 2013 statistical software (SPSS Statistics for Windows; version 22.0 Chicago, USA).

3 RESULTS

3.1 ANTHROPOMETRIC ASSESSMENT

The results of the overall mean age was 22.54 ($\pm$ 3.5) in men and 20.77 years ($\pm$ 1.57) in women. The following are the results of the anthropometric evaluation and body composition, and its effect during the consumption of cocoa paste.
Table 1. Pretest and posttest results.

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Men (n=7)</th>
<th>Woman (n=13)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pretest measurement</td>
<td>Post-test measurement</td>
</tr>
<tr>
<td>Sex (%)</td>
<td>35</td>
<td>-</td>
</tr>
<tr>
<td>Age (years)</td>
<td>22.54 ± 3.5</td>
<td>-</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Men (n=7)</th>
<th>Woman (n=13)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pretest measurement</td>
<td>Post-test measurement</td>
</tr>
<tr>
<td>Height (m)</td>
<td>1.71 ± 0.9</td>
<td>-</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>74.45 ± 14.27</td>
<td>72.30 ± 13.96</td>
</tr>
<tr>
<td>aBMI (kg/m²)</td>
<td>26.06 ± 3.03</td>
<td>25.20 ± 2.95</td>
</tr>
<tr>
<td>WC (cm)</td>
<td>85.50 ± 8.08</td>
<td>83.55 ± 7.74</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Men (n=7)</th>
<th>Woman (n=13)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pretest measurement</td>
<td>Post-test measurement</td>
</tr>
<tr>
<td>Body fat (%)</td>
<td>16.00 ± 3.31</td>
<td>17.15 ± 4.49</td>
</tr>
<tr>
<td>Body fat (kg)</td>
<td>13.62 ± 3.66</td>
<td>12.37 ± 4.50</td>
</tr>
<tr>
<td>Muscle (%)</td>
<td>83.87 ± 3.26</td>
<td>82.70 ± 4.54</td>
</tr>
<tr>
<td>Lean mass (%)</td>
<td>62.39 ± 12.17</td>
<td>60.69 ± 11.65</td>
</tr>
</tbody>
</table>

aBMI: Body Mass Index, bWC: Waist circumference. The results were expressed as means ± SD. PV: p-value identified with an asterisk in the column indicates a significant difference (p<0.05) between the pretest and posttest measurements.

Source: The authors

According to the results of the anthropometric indicators in the pretest measurement, the students who participated in this study were overweight, since their BMI was greater than 25.

In terms of body composition, in the indicators of body fat percentage and kilograms, there were no significant differences in the study groups (p<0.05), but there were variations in the results (Table 1).

A decrease was determined for the results of the percentages of muscle and lean mass indicators. However, this was not statistically significant (p<0.05), except, in the students in the measurement of the percentage of lean mass in the posttest group (p>0.05).

Table 2 shows that the men and women who participated in this study are within the classification of optimal in these indicators, where women have a better condition. In addition, a significant decrease (p<0.05) in SBP (107.00 ± 14.77 vs 100.00 ± 10.37, p=0.023) and DBP (76.00 ± 8.23 vs 71.00 ± 9.31, p=0.023).
Table 2. Results of the consumption of 1 g daily for 4 weeks of cocoa paste on Systolic Blood Pressure (SBP), Diastolic Blood Pressure (DBP), Heart rate (HR).

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Pretest</th>
<th>Posttest</th>
<th>PV*</th>
<th>Pretest</th>
<th>Posttest</th>
<th>PV*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Man (N=7)</td>
<td>118.00 ± 12.62</td>
<td>120.00 ± 9.45</td>
<td>0.249</td>
<td></td>
<td>107.00 ± 14.77</td>
<td>100.00 ± 10.37</td>
</tr>
<tr>
<td>Women (N=13)</td>
<td></td>
<td></td>
<td></td>
<td>72.00 ± 7.32</td>
<td>75.00 ± 8.65</td>
<td>1.000</td>
</tr>
<tr>
<td></td>
<td>126.00 ± 8.65</td>
<td>132.00 ± 9.45</td>
<td>0.017</td>
<td>85.00 ± 10.59</td>
<td>88.00 ± 11.37</td>
<td>0.045</td>
</tr>
</tbody>
</table>

The results are expressed as means ± SD. PV: p-value identified with an asterisk in the column indicates a significant difference (p<0.05) between the pretest and posttest measurements.

Source: The authors

4 DISCUSSION

The female students are within the BMI parameter classified as normal (World Health Organization, 2022). Bauce and Moya-Sifontes (2020) carried out a study with male and female students (n=97) of the Central University of Venezuela, and their values of the means in age, height, weight, BMI and CC (20.93 years and 21.16 years, 1.72 m and 1.59 m, 74.10 kg and 57.46 kg, 24.97 kg/cm² and 22.42 kg/cm² and 82.43 cm and 67.49 cm respectively) were similar to the results obtained in this work, except for the BMI for the students. It has been indicated that the results in anthropometric variables, depend on epigenetics and can be modified, if lifestyle is changed (Mase et al., 2022). However, when the posttest measurement was determined, the university students, a decrease in adipose tissue was quantified, presumably because they improved their lifestyle, and the consumption of 1 g of cocoa paste, which contains 1300 mg AGES per gram of phenols. Whereas in women, the difference was only in the CC indicator (Table 1). In studies conducted with the daily intake of 2 g up to 100 g of cocoa or dark chocolate (with 50-90 % and 13 % flavonoids) for 15 days up to 6 months, a decrease in adipose tissue was quantified, in healthy, overweight or obese population, determined by the indicators of body weight, BMI, CC and the ratio of waist hip index (Nour-Rahman et al., 2019) and it has been reported that this effect is attributed to the content of polyphenols present in cocoa, so its daily intake, improves the expression of peroxisome proliferator-activated receptor (PPARγ) levels, decreasing serum levels of triglycerides and free fatty acids, the latter are coactivators of 1 α peroxisome proliferator-activated receptor-activated receptor (PGC1α), which can bind and coactivate PPARγ, and increase transport and metabolize to fatty acids (Leyva-Soto et al., 2018; Rahman et al., 2018). In addition, PGC1α interact with sirtuin 1 (SIRT1), regulating energy homeostasis, which increase energy expenditure, and energy storage in white adipose tissue, thus decreasing adipose tissue and dyslipidemia (Leyva-Soto et al., 2018; Rahman et al., 2018; Coronado-Cáceres et al., 2019).

On the other hand, according to the American Council on Exercise (2009) the students who participated in this work, are within the classification, fitness body fat percentage (14-17 %) and average (25-31 %) respectively. From the above, cocoa and its polyphenol content, although they can modulate the expression of PGC1α, SIRT1 and PPARγ in white adipose tissue [8], it is suggested that students, increase
the energy expenditure of their metabolism, to balance the percentage and kilograms of body fat, and
decrease the risk of obesity, which will influence alterations in lipid profile, arterial hypertension and
diabetes mellitus in the future (Leyva-Soto et al., 2018; Rahman et al., 2018; Coronado-Cáceres et al., 2019).

Due a decrease was determined in the results of the percentages of muscle and lean mass indicators,
is recommended to perform strength exercise, to increase or maintain skeletal muscle mass (Kim et al.,
2021). Likewise, a higher daily protein intake (1.2-1.6 g/kg per body weight/day) to improve lean body
mass gain or maintain muscle mass, in young and older healthy adults, as muscle has been reported to
have several functions in health, and reduced skeletal muscle mass and function has been linked to chronic
diseases, poor quality of life, disability, increased risk of fractures, and risk of frailty (Kim et al., 2021;
Mase et al., 2022), so that in adulthood, college students may have these disorders.

The men and women who participated in this study are within the classification of optimal systolic
blood pressure (<120 mmHg), optimal diastolic blood pressure (<80 mmHg) and optimal heart rate (60
and 100 beats per minute) (NOM, 2009). Moreover, the consumption of cocoa paste and its total phenol
content (1300.00 mg EAG/g), improve the values of these indicators, because they increase the
bioavailability of nitric oxide in the vascular endothelium, regulating vasodilation and the wall of blood
vessels (Leyva-Soto et al., 2018; Montagna et al., 2019).

5 CONCLUSIONS

With regard to anthropometric indicators, the students had the best results after the consuming 1 g
of cocoa paste (daily for 4 weeks). Regarding the body composition in the post-test measurement, the
students decreased the percentage of fat mass, decreased SBP and DBP in women. However, lifestyle
changes are needed.

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