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Juice from leaves of cacti of the genus *Pereskia*: effect on the physiological parameters of Wistar rats

Suco das folhas de cactáceas do gênero *Pereskia*: efeito sobre os parâmetros fisiológicos de ratos wistar

Débora Cristina Mariano Brasil[1], Rafaela Marchiori Mariano do Val[1], José Antônio de Souza Cruz Ramos[2], Martha Elisa Ferreira de Almeida[1*]

[1]Universidade Federal de Viçosa, Campus Rio Paranaíba, Rio Paranaíba, MG, Brazil.
[2]Technician in Epidemiological Surveillance, Rio Paranaíba, MG, Brazil.
*Correspondent- martha.almeida@ufv.br

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Abstract

The objective was to evaluate whether the juice from the leaves of cacti of three species of the genus *Pereskia* promotes changes in the physiological parameters of Wistar rats. The study was divided into stage 1 (obesity induction with a hypercaloric diet, monosodium glutamate, and sucrose solution), and stage 2 (use of cactus juice). The data of body weight, Body Mass and Lee Indexes, feed intake, adipose tissue mass, and Visceral and Epididymal Fat Indexes were compared by the Tukey test at 5%. Monosodium glutamate and sucrose in association with the hypercaloric diet did not increase adipose tissues. No statistical difference was found between the means of body weight, Body Mass Index and Lee Index, liver weight, and Hepatosomatic Index. *Pereskia grandifolia* juice promoted a lower total weight gain due to the low feed intake. *Pereskia aculeata* juice increased the visceral adipose tissue mass. Thus, the *Pereskia grandifolia* juice presented a better effect on weight gain. These cacti are rich in nutrients and bioactive compounds that can improve food quality, and prevent chronic non-communicable diseases.

Keywords: *Pereskia grandifolia*. Monosodium glutamate. Sucrose. Fat tissue.

Resumo

O objetivo foi avaliar se o suco das folhas de cactáceas de três espécies do gênero *Pereskia* promove alterações dos parâmetros fisiológicos de ratos Wistar. O estudo foi dividido na etapa 1 (indução da obesidade com dieta hipercalórica, glutamato monossódico e solução de sacarose) e etapa 2 (utilização do suco das cactáceas). Os dados do peso corporal, Índices de Massa Corporal e de Lee, consumo alimentar, massa dos tecidos adiposos e seus Índices de Gordura Visceral e Epididimal foram comparados pelo Teste de Tukey a 5%. O glutamato monossódico e a sacarose em associação com a dieta hipercalórica não aumentaram os tecidos adiposos. Não houve diferença estatística entre as médias do peso corporal, Índice de Massa Corporal e Índice de Lee, peso hepático e o Índice Hepato-Somático. O suco da *Pereskia grandifolia* promoveu um menor ganho de peso total como resultado do baixo consumo alimentar. O suco da *Pereskia*

aculeata aumentou a massa do tecido adiposo visceral. Concluiu-se que o suco da *Pereskia grandifolia* apresentou melhor efeito sobre o ganho de peso. Tais cactáceas são ricas em nutrientes e compostos bioativos que poderão melhorar a qualidade alimentar e prevenir doenças crônicas não transmissíveis.
Palavras-chave: *Pereskia grandifolia*. Glutamato monossódico. Sacarose. Tecido adiposo.

Introduction

Obesity is a worldwide public health problem, whose main causal factors are genetics, the environment with the intake of foods rich in lipids and carbohydrates, and sedentary behavior(1). Malnutrition, along with obesity and climate change has become a global syndemic(2), which increases the risks for diabetes mellitus, cardiovascular diseases, arterial hypertension, dyslipidemia, and some neoplasia(3).

Hypercaloric diets made with highly palatable foods such as chocolates, nuts, and condensed milk, which are rich in lipids and carbohydrates, are used to induce obesity in experimental models(3). These diets are called cafeteria diet and can induce obesity in rats(4), due to their physiological and metabolic similarity to humans(5). Monosodium glutamate alone or in association with sucrose solution also contributes to the induction of obesity in rats and mice, as it promotes excess adipose tissue(6,7) which is a biological marker of this pathology.

Brazil has a plant diversity with phytotherapeutic and pharmacological properties(8,9). Plants of the genus *Pereskia*, belonging to the family Cactaceae, are native to the Brazilian flora and are found from the state of Bahia to Rio Grande do Sul(9,10).

Pereskia, popularly known as ora-pro-nobis, rose cacti and leaf cacti, is a Non-Conventional Food Plant(11), with high contents of proteins, fibers, minerals (iron and calcium), and bioactive compounds that prevent and treat diseases(9,12). Its leaves are non-toxic(9) and can be used in salads, stews, pies(13), pasta(13,14) and various sweet and savory recipes(15).

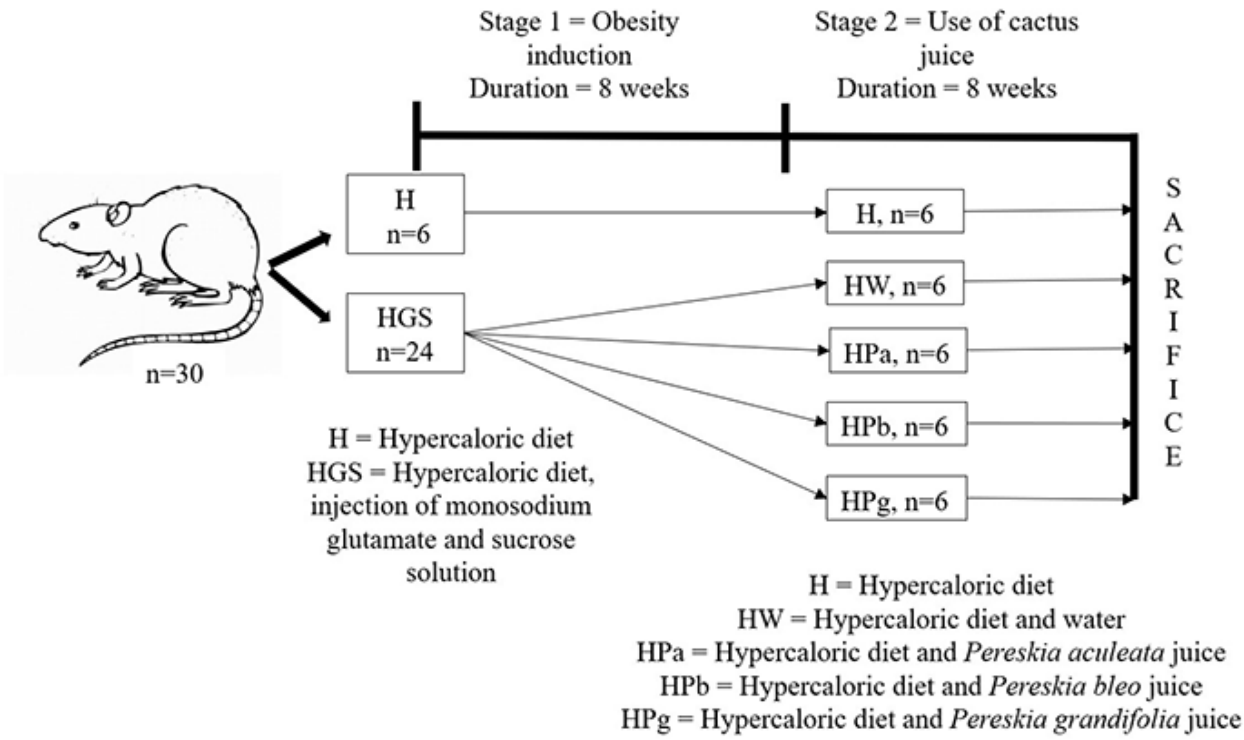
These plants are used to treat some types of cancers, ulcers, inflammation, and edema in Malaysia and India(15,16), and have promising potential against obesity, dyslipidemia, and diabetes mellitus, by reducing body weight, lipid content (serum, liver, and adipose tissue mass), and blood glucose(3).

Juice from cacti of the genus *Pereskia* in association with a hypercaloric diet based on condensed milk has been little studied in the metabolism of rats(17). Thus, this study aimed to evaluate whether the juice from the leaves of cacti of three species of the genus *Pereskia* promotes changes in the physiological parameters of Wistar rats.

Material and methods

The experimental study, carried out at the Laboratory of Experimental Nutrition of the Federal University of Viçosa (UFV), Campus Rio Paranaíba, was based on the ethical principles of Brazilian Animal Experimentation, according to Law nº 11,794, of October 8, 2008[18], and was developed after the approval of the Ethics Committee on the Use of Animals (CEUA) of the Federal University of Viçosa (UFV) (Protocol nº 100/2017).

Thirty-day old male Wistar rats (*Rattus norvegicus*) with an average weight of 50 g and from the Central Vivarium of the Center for Biological and Health Sciences at the Federal University of Viçosa (UFV), Campus Viçosa, Brazil, were used in this study. The rats remained in individual cages at 22 °C and a 12-hour light/dark cycle (7 am to 7 pm), receiving food and water ad libitum in the feeding and drinking troughs. The experiment lasted 16 weeks and was carried out in two stages (Figure 1).



The hypercaloric diet was prepared with 46% ground rodent rations (rats and mice), 46% condensed milk, and 8% corn oil.

The rats of the HGS group received subcutaneous injections of monosodium glutamate (240 mg/mL of solution) once a week in the posterior cervical region at the dose of 4 mg/g of body weight[19]. The cage of the HGS group rats had a trough with water and another with a sucrose solution (90% water and 10% sucrose). The sucrose solution was prepared weekly to avoid contamination with microorganisms.

Leaves of the three species of the genus *Pereskia* (*Pereskia aculeata*, *Pereskia grandifolia*, and *Pereskia bleo*) were collected in a household in the municipality of São Gonçalo do Abaeté, MG, Brazil. Subsequently, the leaves were washed and sanitized with 200 ppm sodium hypochlorite solution for 10 minutes to prepare the juices in the proportion of 90% mineral water and 10% thin slices of each *Pereskia* leaf. The ingredients (water and slices) were ground in a domestic blender and filtered through a paper filter to be offered to the rats via gavage. The HW group rats received water via gavage, following the same procedures adopted for the juice groups.

Wistar rats usually eat 85% of their food at night. Thus, the administration of juice via gavage occurred twice a week (Monday and Wednesday) in an amount of 1 mL/day per animal, from 5 pm to 6 pm. The drug Lidocaine Hydrochloride, which has a local anesthetic action and short duration (<60 minutes), was used to reduce the painful perception of the gavage needle when it was introduced from the mouth to the stomach.

Body weight and naso-anal length were measured weekly for calculations[(4)] of the Body Mass Index = [body weight (g)/length × length (cm)], and of the Lee Index = [cube root of body weight (g)/naso-anal length (cm)].

The weekly feed intake was calculated by the difference between the amount of diet offered and the leftovers in the troughs. Feces were collected at weeks 4 and 8 after the use of cactus juice to calculate[(4)] the Apparent digestibility = [(amount of feed intake - amount of excreted feces)/amount of feed intake] × 100.

The rats were subjected to general anesthesia (intraperitoneally) by overdosing Ketamine (300 mg / kg) and Xylazine (30 mg/kg) at the end of the experiment. Euthanasia was performed after confirmation of loss of consciousness.

The liver was removed for the calculation[(4)] of the Hepatosomatic Index (HSI) = (liver weight/final body weight) × 100. Epididymal adipose tissue was collected for the calculation[(4)] of the Epididymal Fat Index (EFI) = (epididymal fat mass/final body weight) × 100. Visceral adipose tissue was removed to calculate[(4)] the Visceral Fat Index (VFI) = (visceral fat mass/final body weight) × 100.

The data were analyzed using the Tukey test at a 5% significance level, using the Statistical Package for the Social Sciences (SPSS) program, version 20.0.

Results and discussion

Monosodium glutamate and sucrose in association with the hypercaloric diet did not induce obesity, as the adipose tissue means showed no statistical difference between H and HW groups. *Pereskia grandifolia* juice promoted a lower total weight gain as a result of low feed intake, suggesting higher satiety, which may contribute to the prevention and/or treatment of obesity. However, *Pereskia aculeata* juice increased the amount of visceral adipose tissue compared to the *Pereskia bleo*.

No statistical difference was found during the use of cactus juice between the weekly body weight means (Figure 2A) and those at the end of the experiment (Figure 2B). However, the HW group showed a higher total weight gain ($p<0.05$) than the H, HPb, and HPg groups (Figure 2C). Among the cactus groups, HPg presented the lowest total weight gain ($p<0.05$).

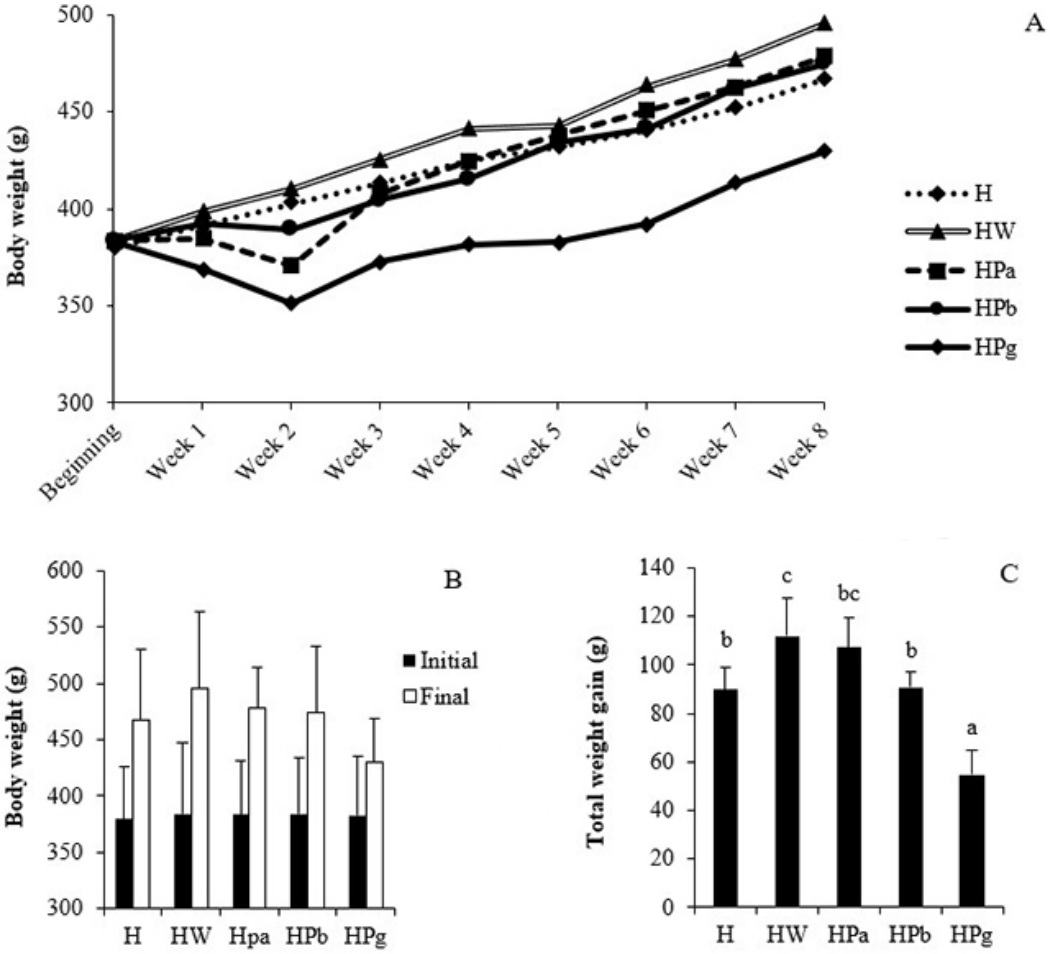


Figure 2. Body weight (A), initial and final body weight (B), and total weight gain (C) of rats treated with a hypercaloric diet and cactus juice.

Means and standard deviation followed by the same letters between groups do not differ by the Tukey test at a 5% probability. The absence of letters between groups did not differ by the Tukey test at 5%.
H = Hypercaloric diet, HW = Hypercaloric diet and water, HPa = Hypercaloric diet and *Pereskia aculeata* juice, HPb = Hypercaloric diet and *Pereskia bleo* juice, HPg = Hypercaloric diet and *Pereskia grandifolia* juice.
Source: The authors.

The use of monosodium glutamate and glucose solution, in association with the hypercaloric diet, changed only the total weight gain when comparing the H and HW groups. The means of the average and weekly feed intake, the total weight gain, visceral adipose tissue mass, and the Visceral Fat Index showed a statistical difference when comparing the HW group (monosodium glutamate, sucrose solution, and water) with those that received juice from cacti. The administration of monosodium glutamate (2 to 4 mg / g of body weight) in newborn rats destroyed the ventromedial arcuate nucleus of the hypothalamus and promoted obesity due to the lack of control between macronutrient absorption and energy expenditure[6]. The sucrose solution (30%)

in association with a balanced diet for rats increased adipose tissues (visceral and epididymal)[7].

The average body weight showed no statistical difference between groups (Figure 2), differing from other studies with Wistar rats[20,21], in which the cacti reduced this physiological parameter. Rats fed a hypercaloric diet with 5 and 10% *Pereskia grandifolia* flour reduced body weight[3].

The group in which the *Pereskia grandifolia* juice (HPg) was administered had a lower total weight gain than the other groups of cacti (HPa and HPb) which were equal to each other and the H group. The reduction in weight gain was observed in rats that ingested *Pereskia aculeata* flour[20,21].

The means of Lee's Body Mass Index did not differ (p>0.05) between groups at the end of the study (Figures 3A and 3B), as observed by Souza *et al.*[17] who did not identify differences in the Lee Index among rats (male and female) treated with *Pereskia aculeata* juice. However, rats fed a hypercaloric diet containing 5 or 10% *Pereskia grandifolia* flour reduced these Indexes[3]. The intake of caloric foods with a low nutritional value increases the Body Mass Index and the Lee Index, as well as contributes to the emergence of chronic non-communicable diseases[22].

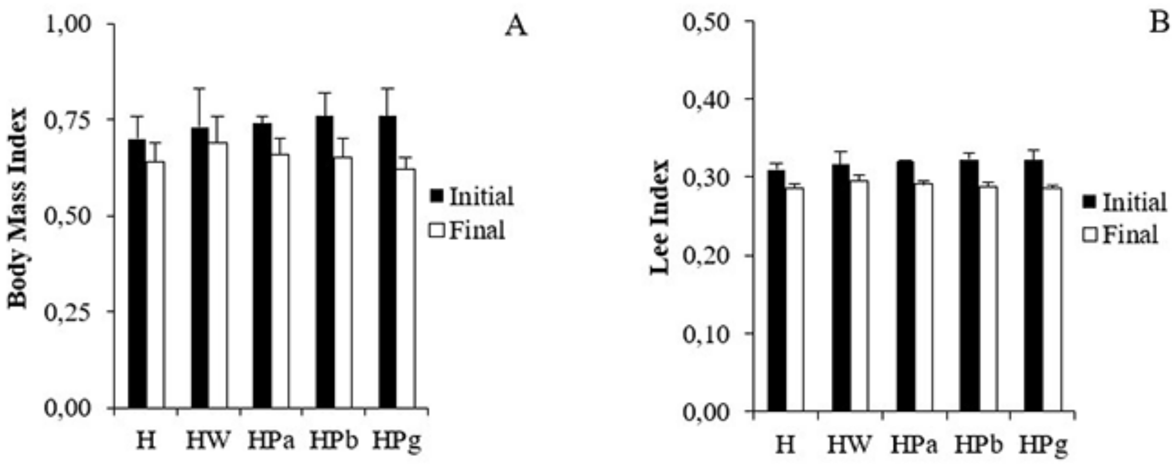


Figure 3. Body Mass Index (A), and Lee Index (B) of rats treated with a hypercaloric diet and cactus juice.

Means and standard deviation with the absence of letters between groups did not differ by the Tukey test at 5%.

H = Hypercaloric diet, HW = Hypercaloric diet and water, HPa = Hypercaloric diet and *Pereskia aculeata* juice, HPb = Hypercaloric diet and *Pereskia bleo* juice, HPg = Hypercaloric diet and *Pereskia grandifolia* juice.

Source: The authors.

Feed intake showed no statistical difference between groups only at weeks 5, 7, and 8

(Tab

Table 1. Mean and standard deviation of the feed intake of rats treated with hypercaloric diets and cactus juice.

Feed intake (weeks)	GROUP				
	H	HW	HPa	HPb	HPg
1	187.00±15.31^{b}	184.33±14.00^{b}	183.00±19.74^{b}	167.50±18.68^{b}	132.17±23.46^{a}
2	159.67±20.73^{b}	171.00±12.03^{b}	142.08±24.51^{ab}	149.44±6.95^{ab}	115.00±30.70^{a}
3	164.17±10.50^{a}	191.67±18.01^{ab}	203.20±20.32^{b}	185.67±15.31^{ab}	160.67±31.39^{a}
4	176.00±21.33^{ab}	189.67±30.47^{ab}	200.00±21.37^{b}	160.72±20.44^{ab}	155.72±24.11^{a}
5	170.00±29.47	177.83±26.48	187.20±21.60	195.50±17.39	177.12±14.04
6	166.17±21.48^{a}	212.60±18.75^{b}	190.40±15.18^{ab}	179.33±23.60^{ab}	169.80±15.77^{a}
7	181.00±24.06	203.72±16.84	200.72±12.23	201.67±33.75	188.40±23.10
8	171.33±24.09	189.67±20.39	181.20±14.41	177.50±20.33	170.20±29.24

Means and standard deviation followed by the same letters between groups in the row do not differ by the Tukey test at a 5% probability. The absence of letters between groups did not differ by the Tukey test at 5%.

H = Hypercaloric diet, HW = Hypercaloric diet and water, HPa = Hypercaloric diet and *Pereskia aculeata* juice, HPb = Hypercaloric diet and *Pereskia bleo* juice, HPg = Hypercaloric diet and *Pereskia grandifolia* juice.

Source: The authors.

The group that received *Pereskia grandifolia* juice (HPg) decreased the average feed intake ($p<0.05$) compared to the H, HW, and HPa groups in a few weeks, but this fact did not interfere with the final body weight of rats (Figure 4A). These data are similar to those of Almeida *et al.*[3] who found that groups that received a hypercaloric diet with *Pereskia grandifolia* flour (5 and 10%) reduced feed intake during the 4 weeks of evaluation.

The juices of *Pereskia aculeata* and *Pereskia bleo* did not change feed intake. Silva[23] observed a lower feed intake of rats that received 40% *Pereskia aculeata* flour. The intake of foods rich in lipids and carbohydrates is directly related to obesity[22], while balanced and fiber-rich diets increase satiety and promote a reduction in feed intake[24].

The HPg group showed less Apparent digestibility than the H group at week 4 (Figure 4B). However, no statistical difference in the mean between groups at week 8, with the cactus juice not interfering with the digestion and absorption of macronutrients of the diet. Silva[23] observed a higher fecal excretion of rats fed 40% *Pereskia aculeata* flour.

The average liver weight (Figure 4C) and the Hepatosomatic Index (Figure 4D) showed no statistical difference, suggesting that the cactus juice did not interfere with these parameters. However, Almeida *et al.*[3] identified that the *Pereskia grandifolia* flour reduced the weight of this organ. The increase in liver weight can contribute to the development of liver diseases and other chronic diseases, as metabolic changes in this organ promote systemic cellular changes[25].

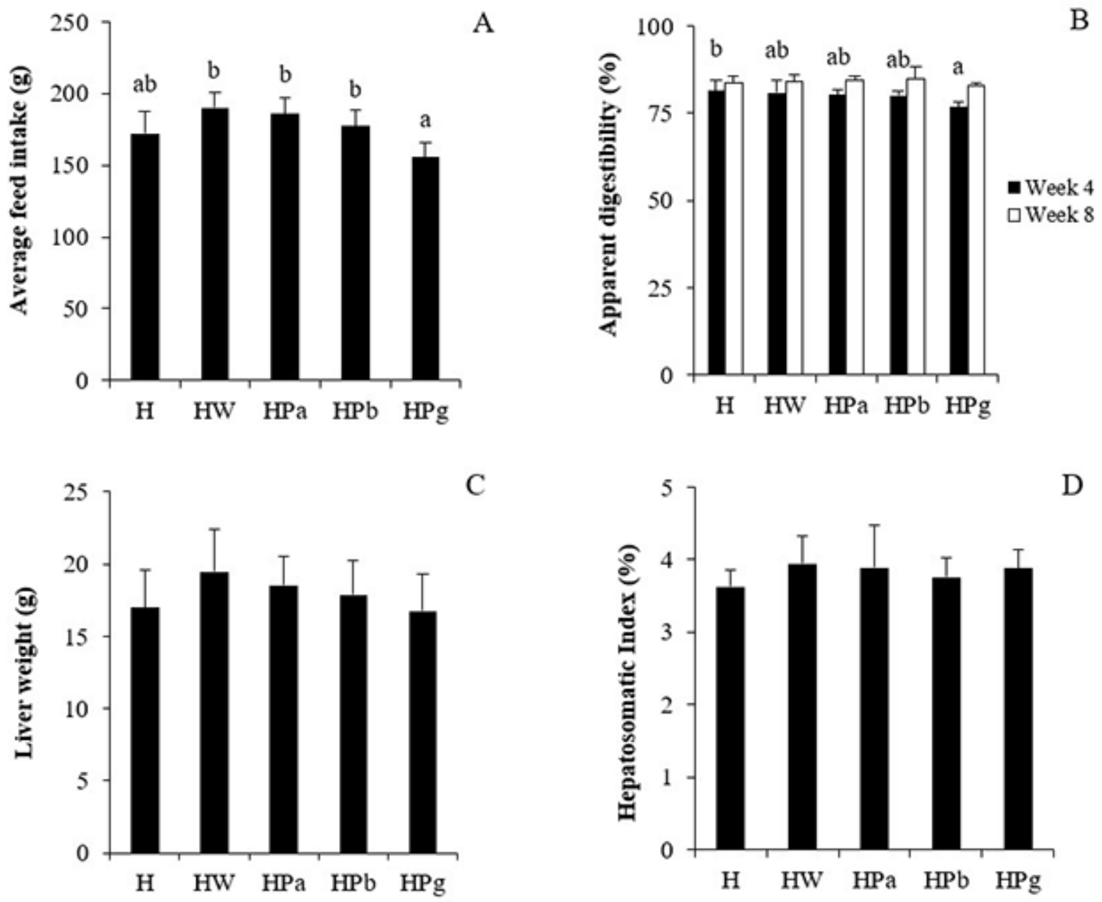


Figure 4. Average feed intake (A), Apparent digestibility (B), liver weight (C), and Hepatosomatic Index (D) of rats treated with a hypercaloric diet and cactus juice.
Means and standard deviation followed by the same letters between groups do not differ by the Tukey test at a 5% probability. The absence of letters between groups did not differ by the Tukey test at 5%.
H = Hypercaloric diet, HW = Hypercaloric diet and water, HPa = Hypercaloric diet and *Pereskia aculeata* juice, HPb = Hypercaloric diet and *Pereskia bleo* juice, HPg = Hypercaloric diet and *Pereskia grandifolia* juice.
Source: The authors.

The epididymal adipose tissue mass did not differ between groups (p>0.05). However, the HPa group showed a higher visceral adipose tissue mass than the HPb and HW groups (Table 2).

The Epididymal Fat Index showed no difference between groups (p>0.05), but the HPa group had a higher visceral fat index than the HW group (Table 2). This result differs from other studies that observed a decrease in the visceral fat of rats fed *Pereskia aculeata* juice[17] and flour[20]. However, Almeida *et al.*[3] did not found differences regarding the total body lipids of rats fed *Pereskia grandifolia* flour (5 and 10%) and the hypercaloric diet group. The increase in visceral tissue is directly related to obesity, cardiovascular diseases, some types of cancer, and diabetes mellitus, as it produces inflammatory cytokines (TNF-α, IL1, IL6) that promote insulin resistance and other

Table 2. Mean and standard deviation of adipose tissues (visceral and epididymal), Visceral Fat Index, and Epididymal Fat Index of rats treated with a hypercaloric diet and cactus juice.

EVALUATED PARAMETERS	GROUP				
	H	HW	HPa	HPb	HPg
EAT (g)	11.42±2.16	10.65±3.06	11.33±0.92	11.74±1.70	11.44±0.81
VAT (g)	11.88±1.89[ab]	11.14±3.75[a]	16.02±1.69[b]	14.30±2.38[a]	12.17±1.29[ab]
Total (g)	23.30±3.44	22.39±4.35	27.59±1.02	26.04±4.06	23.60±1.60
EFI (%)	2.46±0.44	2.12±0.34	2.38±0.24	2.49±0.38	2.67±0.23
VGI (%)	2.57±0.40[ab]	2.26±0.39[a]	3.36±0.40[b]	3.03±0.48[ab]	2.86±0.46[ab]
Total (%)	5.05±0.89	4.68±0.59	5.79±0.41	5.52±0.85	5.53±0.64

Means and standard deviation followed by the same letters between groups in the row do not differ by the Tukey test at a 5% probability. The absence of letters between groups did not differ by the Tukey test at 5%.

EAT = Epididymal adipose tissue, VAT = Visceral adipose tissue, EFI = Epididymal Fat Index; VGI = Visceral Fat Index, H = Hypercaloric diet, HW = Hypercaloric diet and water, HPa = Hypercaloric diet and *Pereskia aculeata* juice, HPb = Hypercaloric diet and *Pereskia bleo* juice, HPg = Hypercaloric diet and *Pereskia grandifolia* juice.

Source: The authors.

Conclusions

The results indicate that monosodium glutamate and sucrose did not increase adipose tissues. However, *Pereskia aculeata* juice in association with the hypercaloric diet increased the visceral adipose tissue mass compared to *Pereskia bleo* juice. Rats treated with *Pereskia grandifolia* juice showed lower feed intake and total weight gain, justifying its use in the prevention and/or treatment of obesity.

The intake of juice from cacti of the genus *Pereskia*, which has several bioactive molecules, may promote benefits to human health in the prevention and treatment of chronic non-communicable diseases.

Acknowledgments

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Declaration of interest

The authors declare that there is no conflict of interest.

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