Evaluation of the effects of *Spondias mombin* extract

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**Aim:** analyze the effects of *Spondias mombin* extract

**Methods:** Cell viability was evaluated by the MTT test. Fifteen Wistar rats were used, divided into 4 groups (control group – CT; control with extract – CT+EX; hyperlipidic diet – HL; hyperlipidic diet and extract HL+EX). For 12 weeks the animals were weighed and their blood glucose assessed. Afterwards, they were euthanized and the biological material was collected to evaluate the biochemical parameters and weighing the organs. Microbiological analyses showed the microbicidal action. Statistical analyses were performed by ANOVA, Two-way ANOVA, Brown-Forsythe, Bartlett’s ant T-test.

**Results:** The evaluation of the animals confirmed the efficacy of the extract os *Spondias mombin* against the cell metabolism of rats, without negatively altering cell viability; the group of rats with a hyperlipidic diet showed an increase in body wight, however, in the individual assessment of the organs, there were no significant changes. The glycemic index, liver parameters, lipids, and mineral ions did not show significant chamges. Furthermore, the antimicrobial potencial of *Spondias mombin* extract was evidenced in relation to *Staphylococcus aureus ATCC 29213* and *Staphylococcus aureus BLACC*.

**Conclusion:** The results show that *Spondias mombin* extract does not interfere with cell viability and did not show cytotoxicity to the cells to which they were exposed, nor did it interfere with the metabolism, organs and biochemical indices of rats with a normal or hyperlipidic diet. With the microbicide potential observed, research can be carried out in order to obtain new drugs with antimicrobial action, and possible beneficial action to the cardiovascular system.

Keywords: *Spondias mombin,* hyperlipidic diet, antimicrobial inhibition

# Introduction

*Spondias mombin*, popularly known as Cajá, Cajazeira and Taperebá is a fruit species that belongs to the *Anacardiceae* family and is found mainly in the North and Northeast of Brazil (1). All parts of its tree are used in traditional medicine since its bioactive compounds, such as flavonoids, carotenoids, phenolic compounds and ß-cryptoxanthin, play important roles in the body such as preventing oxidative stress and codegenerative diseases (2, 3, 4, 5, 6, 7).

Biochemical analyses showed that *Spondias mombin* is a food with high nutritional and functional content, with considerable amounts of vitamin C and provitamin A and with low energy content, since its structure is low in starches and in the presence of insoluble fibers (8).

Suplementation with *Spondias mombin* has the potential to attenuate cardiac remodeling after myocardial infarction, as it is responsible for the reduction of processes such as fibrosis, myocardial hypertrophy, and better development in oxidative stress cascades, energy metabolism and inflammatory processes, such as those that occur during the infarction, thus denoting its cardioprotective effect (9, 10).

The ability of *Spondias mombin* compounds, especially flavonoids, to prevent oxidative stress, act to reduce inflammation markers and lead to an improvement in the lipid profile, wich alters the synthesis, accumulation and storage pathways of lipids present in hepatocytes and adipocytes, makes it an alternative to attenuate and even reduce the number of overweight or even obese individuals (11, 12).

It was also found that the extract of *Spondias mombin* has constituents that improve psychiatric disorders, in addition to having antiviral, antifungal and antimicrobial activity against selected microorganisms, such as strains of *Staphylococcus aureus* (13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24).

In line with the aforementioned facts, it is necessary to assess whether the extract, despite having several benefits, interferes with cell metabolism, in such a way that its microbicide potential can be explored. Thus, our study, wich is an experimental research with *Spondias mombin* extract in an animal model, verified its effects on Wistar rats submitted or not to a hyperlipidic diet.

# Materials and methods

## Cell cultivation

RAW 264.7 cells (murine macrophages) were donated by Dr. Milton Adriano Pelli Oliveira from the Institute of Tropical Pathology and Public Health at the Federal University of Goiás (UFG), Brazil. These cells were cultured in RPMI 1640 (Sigma Chemical Co. St Louis, MO, EUA) supplemented with 10% fetal bovine serum (FBS, Cripion, São Paulo, Brazil), 1640 inactivated at 56°C for 30 min, 2 nM L-glutamina (sigma Chemical Co), 50µM of 2 mercaptoethanol (Sigma-Aldrich®), 10U/mL penicilin and 100 µg mL streptomycin (Sigma-Aldrich®) and 2 nM Herpes (Sigma-Aldrich®). Were cultured 2x105 cells in 2 mL of complete RPMI medium by wells 6-well culture plates (Costar, Nova York, EUA), incubated in an oven with 5% CO2 and 35°C at the Cell Cultivation Laboratory of the Pontifical Catholic University of Goiás (EMFB/PUC-GO).

## Mitochondrial metabolic activity (MTT)

The mitochondrial metabolic activity (MTT) can be verified by Tetrazoliun dye uptake assay, whose principle of action is the [3-(4,5-dimethylthiazol-2-yl)-2,5 diphenyltetrazolium bromide salt] by the viable cells, wich are reduced, within the mitochondria, to a product called formazan, through the enzyme succinate-dehydrogenase and form insoluble purple crystals (25).

Raw 264.7 cells (1x105 cells/mL) were seeded, in triplicate, in flat-bottom microplates with individual sterile lid in RPMI 1640 medium and exposed to five concentrations from 5 to 60 µg/mL (5, 10, 20, 40 and 60 µg/mL) of the studied extract*.*  After 48 hours of incubations in an incubator at 37° C with 5% CO2, 5 µL of MTT was added to each well and incubated for another 3 hours. With this process, the reading was performed in an ELISA reader (Spectophotometer) (Biolisa Reader, Bioclin, Belo Horizonte, MG) with a double filter of 450 and 630 nm. Table 1 shows the schematic of the cytotoxity test of *S. mombin* extract by RAW cell.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Table 1. Scheme of the microplate used in the cytotoxicity test of the extract of *S. mombin* fruits per RAW cell | | | | | | | | | | | | | |
|  | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | | **12** |
| **A** | 100 µL RPMI | | 20 µL of extract + 80 µL RPMI | | | | | | | | | 100µL RPMI | |
| **B** |  | 40 µL cél. + 60 µL RPMI | 1 x 10⁵ cél. + 60 µL of extract + RPM e.t. 100 µL | | | | | | | | |  |  |
| **C** |  | 1 x 10⁵ cél. + 40 µL of extract + RPM e.t. 100 µL | | | | | | | | |  |  |
| **D** |  | 1 x 10⁵ cél. + 20 µL of extract + RPM e.t. 100 µL | | | | | | | | |  |  |
| **E** |  | 1 x 10⁵ cél. + 10 µL of extract + RPM e.t. 100 µL | | | | | | | | |  |  |
| **F** |  | 1 x 10⁵ cél. + 5 µL of extract + RPM e.t. 100 µL | | | | | | | | |  |  |
| **G** |  |  | | | | | | | | |  |  |
| **H** |  | 100 µL RPMI | 20 µL of extract + 80 µL RPMI | | | | | | | | | 100 µL RPMI |  |

Cells not treated with the extracts were considered as a parameter of 100% cell viability.

Citotoxicity was calculated according to the equation:

Cell viability was expressed, when applicable, as IC50 (concentration that inhibited cell growth by 50% compared to the untreated group). Therefore, the IC50 was defined as it was applied in the experiment. The results were analyzed with calculations and expressed in graphs using the statistical tool GraphPad Prism version 7.0.

## Animals

Fifteen male animals of the Wistar lineage were used. These were kept in the Sectorial Animal Facility of the Pontifical Catholic University of Goiás (PUC-GO). After 21 days of weaning, the animals were kept in polypropylene boxes, with a maximum capacity of 4 animals per box, which were lined with wood shavings, changed every 3 days. The environment in which they stayed was controlled, the temperature was 21°C, there was a light-dark cycle of 12-12h, with water and feed, both industrialized and hyperlipidic, in free demand.

The procedures performed in this study were submitted and approved by CEUA/PUC-GO number 8820121018, in accordance with Arouca Law (11.794/08).

## Diet protocol and administration of Spondias mombin extract

Two types of diets were made avaible to the animals: the standard diet consisting of commercial feed for small rodents and the hiperlipidic diet. The hyperlipidic diet is composed of a mixture of standard feed, milk chocolate, peanuts and cornstarch biscuit, in the respective ratio of 3:2:2:1. After the ingredients were mixed, the hyperlipidic feed was molded and stored in clear plastic bags identified in a refrigerated environment, until it was distributed to the animals.

Concentrated *Spondias mombin* extract was dissolved at 0,15 % in filtered water and administered orally through drinking fountains. The rest of the animals received filtered water. Both offered *ad libitum*.  The amount of water and extract ingested by the groups were recorded daily, using a graduated glass beaker.

Thus, the animals in the experiment were divided into 4 groups, namely:

* Group 1: Standard diet with filtered water intake (DP);
* Group 2: Standard diet with ingestion of *S. mombin* extract (DPS);
* Group 3: Hyperlipidic diet with ingestion of filtered water (DH);
* Group 4: Hyperlipidic diet with ingestion of *S. mombin* extract (DHS).

## Blood glucose and body weight

During the experimental period, the rats were weighed on a scale (10 kg Vonder) to assess body mass and blood glucose was measured using a high-precision digital glucometer (Accu-Chek Active). Both procedures were performed twice a week on standardized days.

## Biochemical analysis

The experimental period lasted 12 weeks and was based on a comparison of the control groups, with and without the addition of *S. mombin* extract, and the hyperlipidic diet group, which is an induced obesity model that simulates the human model, with and without addition of the extract.

On the last day of the experimental period, the animals were anesthetized (thiopental, 80mg in a single dose) and the rib was exposed for blood collection through cardiac puncture and 2mL of blood was collected for biochemical evaluation. Samples were collected in a sterile test tube without anticoagulant centrifuged (1000gp or 10min) and stored in eppendorf’s tubes at less than 20°C until the moment of analysis. Biochemical dosages were performed using Biosystems® brand kits, through kinetic, enzymatic and colorimetric methodologies, in automated A15 equipament, also Biosystems® brand.

Biochemical analysis consisted of parameters: albumin, aspartate aminotransferase (AST), alanine aminotransferase (ALT), calcium, HDL cholesterol, total cholesterol, creatinine, glycemia, phosphorus, total protein, triglycerides and urea.

## Organ weight assessment

On the last day of the experiment, the animals were euthanized and had their heart, kidneys, brain and liver removed. These organs were stored in formalin and weighed on a BK400 GEHAKA semi-analytical scale.

## Bacterial susceptibility test against Spondias mombin extract

The experiments were carried out in the Microbiology Section of the Clinical Laboratory of PUC-Goiás. The technique of diffusing the extract in wells on Mueller agar was chosen to carry out bacterial susceptibility tests with hydroalcoholic vegetables extracts (26, 27).

In a flat-bottom flask graduated in 1000 mL, 22,8 grams of OXOID brand Mueller-Hinton agar, lot: 1485367 and 600 mL of deionized water were added, the flask was sealed with tape for autoclave, be autoclaved for 15 minutes at 121°C. The agar was distributed in petri dishes measuring 150 mm in diameter and 15 mm in depth. Soon, after the agar solidified, the plates were exposed to germicidal (UV) light in a biological safety cabinet for 30 minutes.

Strains of *Escherichia coli* ATCC25923, *Klebsiella pneumoniae* ATCC 700603 *Staphylococcus aureus* ATCC 29213 and a clinical isolate of *Staphylococcus aureus* BLAC that were stored and made avaible by the Microbiology sector of the Laboratory of Clinical Analysis at PUC Goiás were used.

The bacterial strains used in the study were seeded in selective culture media (MacConkey agar for *E. coli* and *K. pneumoniae*; Mannitol Salt for *S. aureus*) and incubated for 24 hours in bacteriological incubator at a temperature of 36,5°C.

From the colonies isolated in the selective culture media mentioned, bacterial suspensions were prepared in a sterile 0,85% NaCl solution, corresponding to the 0,5 MacFarland scale. Subsequently, the bacterial suspensions were used for seeding on the surface of Mueller Hinton agar by the *swab* sweeping method.

Next, circular cavities with a diameter of 10mm were made on Mueller Hinton agar, using sterile test tubes, where different volumes of *Spondias mombin* extract were deposited, namely: 50 µL, 100 µL and 200 µL. The tests were carried out in triplicate, on different dates.

## Statistical analysis

For data analysis, the ANOVA analysis of variance was applied, followed by Bonferroni, to analyze wheter the variance would determine wheter the mean of the groups used in the experiments were different. In this way, for each evaluated parameter, mean, standard deviation and variance data were expressed. The collected data were relocated to the Graph prism, version 7, in order to tabulate and graph the data obtained in the experiment. The results regardind blood glucose and wight were analyzed by analysis of variance with two factors, Two-way ANOVA. The result of the weight of the organs was passed throught ANOVA, Brown-Forsythe and Bartlett’s tests to verify the equality of variances and the biochemical analyses were carried out with Tukey’s multiple comparison test or t test when relevant, in wich all are compared the possible averages and are based on the reduced difference, considering the percentiles of the groups used.

# Results

## Evaluation of the cytotoxicity of S. mombin L. fruit extract

RAW 264.7 cells were exposed to *S. mombin L.* fruit extract at concentrations of 5, 10, 20, 40 and 60 µg/mL in 98-well plates and read in a spectrophotometer.

After analyzing the absorbances and data, an IC50 of 27,5 µg/mL was determined (Figure 3), with no impairment of viability when increasing the concentration of the alcoholic extract of *S. mombin,* from 10 µg/mL to 20 µg/mL it is observed that this increase is in cell viability from 15% to 48%.

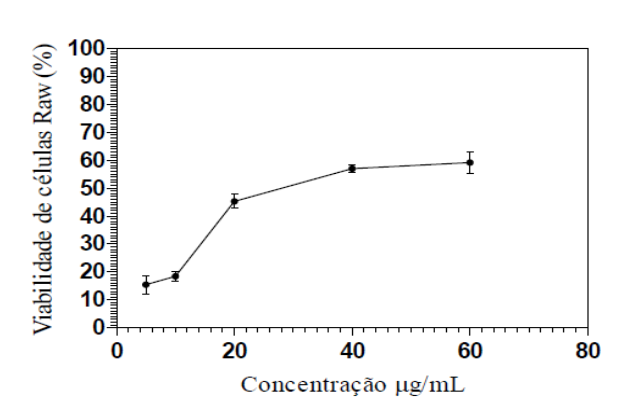


Figure 1. Variation of cell viability (%) in concentrations (µg/mL) of the extract of *S. mombin L.*

## Weight and blood glucose assessment

The animals were kept on a fixed diet for 12 weeks and weekly weighed to observe weight gain and blood glucose. Figure 2 shows the variation in weight (in grams) of the groups of animals during the three months of the experiment. A significant difference in weight is observed from the sixth week between the hyperlipidic group (HL group) and the other groups – hiperlipidic diet group with addition of *Spondia mombin* extract (HL + EX group), control diet group (CT group) and the group with the addition of *Spondias mombin* extract (CT + EX group). The HL group exhibited a final weight, in the twelfth week, greater than those observed in the other groups, followed by the CT + EX group, then with the HL + EX group and lastly the CT group. The average weight variation was 49,75g (± 22,77) in the HL group, 35,75g (± 29,97) in the CT + EX group, 33,25g (± 14,77) HL + EX group and 31,33g (± 0,57) in the CT group.

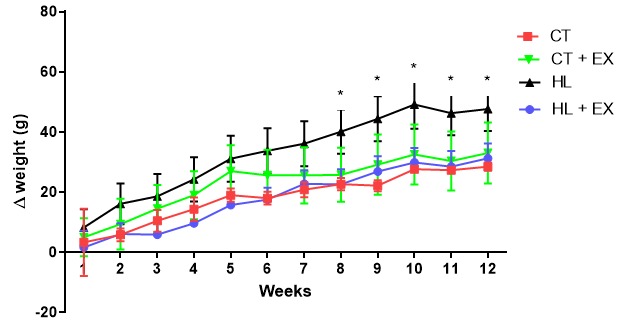


Figure 2. Wistar rats body mass gain curve. Each curve represents a group of animals (CT, CT+EX, HL, HL+EX), with a mean ± 0,05 (SD at each point \* p < 0,05 (HL vs HL at 8, 9, 10, 11 and 12 weeks).

Blood glucose was measured from a blood sample collected weekly from the tail of all animals. Figure 3 shows the mean values of blood glucose in the groups during the twelve weeks of the experiment. The mean blood glucose in the twelfth week was 259,33 mg/dL (± 65,39) in the CT group, 237,5 mg/dL (± 203,61) in the CT + EX group, 232,5 mg/dL (± 76,42) in the HL group, then 204,25 mg/dL (± 43,23) in the HL + EX group. It can be inferred, then, that there was no significant difference in the glycemic index between the groups in the experiment, regardless of the diet they were given. Therefore, the addition of *Spondias mombin* extract did not alter the glycemic metabolism of rats.

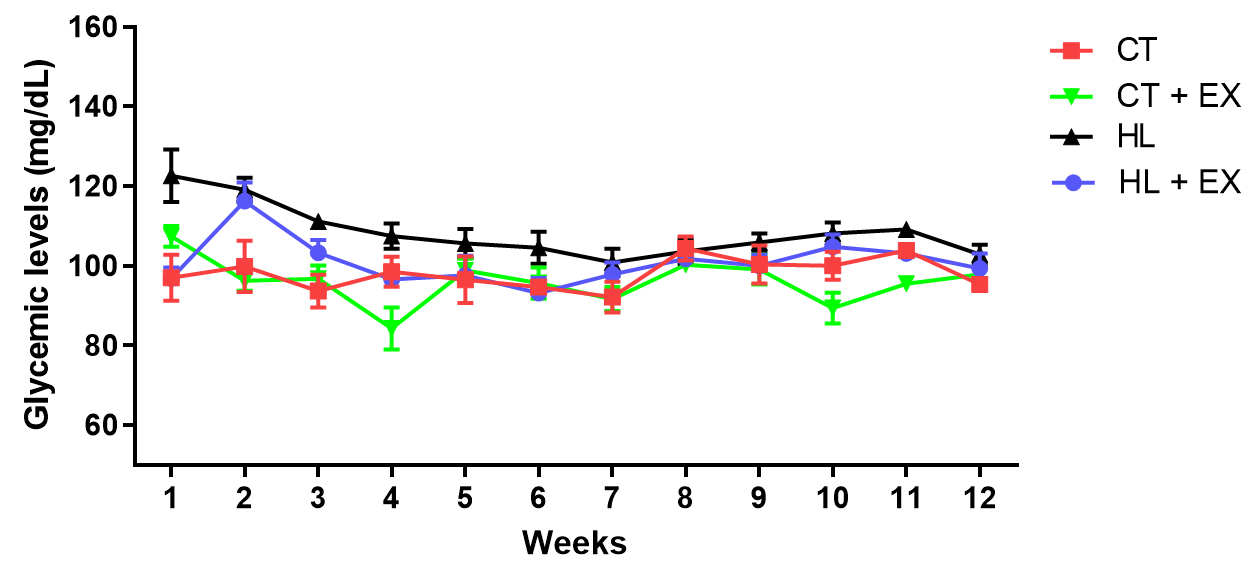


Figure 3. Wistar rats tall glycemia curve. Each curve represents a group of animals (CT, CT+EX, HL, HL+EX), with a mean ± SD at each point.

## Evaluations of biochemical parameters

Hepatic parameters (ALT, AST, total protein and albumin), renal (urea and creatinine), lipids (HDL cholesterol, total and triglycerides), glycemic and mineral ions (calcium and phosphorus) were measured. The above parameters were analyzed and when compared it was noticed that the *S. mombin* extract did not interfere in the biochemical parameters between the groups without extract when compared with those who consumed the extract. There was a statistically significant difference in the urea of animals with a hyperlipidic diet (p<0.0001), however this is due to the induced obesity model of these animals whose implemented diet is part of the hyperlipidic diet protocol of the Pontifical Catholic University of Goiás.

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| --- | --- | --- | --- | --- |
| Table 2. Means and standard deviation of the biochemical parameters. | | | | |
|  | | | | |
| Parameters | **CT** | **CT EX** | **HL** | **HL EX** |
| **ALBUMIN-SER (g/dL)** | 2,9466 ± 0,0141 | 3,2075 ± 0,2828 | 2,6975 ± 0,6151 | 2,7025 ± 0,3323 |
| **ALT-SER (U/L)** | 111,0333 ± 16,6170 | 145,15 ± 59,1848 | 51,625 ± 24,1123 | 70,775 ± 32,5976 |
| **AST-SER (U/L)** | 52,6333 ± 27,7366 | 22,375 ± 5,9918 | 42 ± 37,3759 | 22,5333 ± 22,2336 |
| **CALCIUM ARSENAZO-SER (mg/dL)** | 11,1933 ± 0,3271 | 10,745 ± 1,4012 | 8,7825 ± 2,3874 | 9,7025 ± 2,1742 |
| **CHOL HDL DIRECT-SER (mg/dL)** | 40,3666 ± 26,6503 | 32,875 ± 9,6160 | 21 ± 5,2933 | 24,7 ± 7,1610 |
| **CHOLESTEROL-SER (mg/dL)** | 58,6666 ± 10,2632 | 57,25 ± 12,4733 | 54,25 ± 8,9209 | 51,5 ± 15,0665 |
| **CREATININE-SER (mg/dL)** | 0,41 ± 0,02 | 0,4525 ± 0,1575 | 0,3475 ± 0,0340 | 0,285 ± 0,0869 |
| **GLUCOSE-SER (mg/dL)** | 259,3333 ± 65,3936 | 237,5 ± 203,6164 | 232,5 ± 76,4264 | 204,25 ± 43,2309 |
| **PHOSPHORUS-SER (mg/dL)** | 9,36 ± 0,9101 | 11,53 ± 3,2343 | 8,6625 ± 1,0190 | 9,0425 ± 1,4365 |
| **PROTEIN TOTAL-SER (g/dL)** | 5,98 ± 0,1352 | 6,18 ± 0,5742 | 5,265 ± 1,0170 | 5,3125 ± 1,3064 |
| **TRIGLYCERIDES-SER (mg/dL)** | 109,3333 ± 51,1598 | 94,25 ± 7,8475 | 71,25 ± 22,3811 | 86,5 ± 62,4633 |
| **UREA UV-SER (mg/dL) \*** | 41 ± 2 | 50,25 ± 2,8722 | 28,25 ± 0,9574 | 28,75 ± 3,5939 |
| Subtitles: CT (Control group); CT EX (Control group + extract); HL (Hyperlipidic), HL EX (Hyperlipidic + extract); SER (Serum); UV (enzymatic system for detecting serum urea by photometry); CHOL (Cholesterol); AST (Aspartate aminotransferase; ALT (Alanine aminotransferase); g/dL (Gram per deciliter); U/L (International unit per liter); mg/dL (Miligram per deciliter). | | | | |

## Organ weight assessment

The animals, after 12 weeks of the dietary protocol, had their organs such as the heart, kidneys, brain and liver extracted. All were weighed and placed in a solution containing formaldehyde. When evaluated comparatively between the groups, it is noted that there was no statistically significant difference in organ weight. Such protocol was adopted since the adoption of the extract with different dietary protocols could promote histological changes in these target organs. Such modifications would come to be verified both with the naked eye and microscopically, when present.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Table 3. Means and standard deviation of the organs weight | | | | |
| **Organs** | **CT** | **CT EX** | **HL** | **HL EX** |
| Heart | 1,231 ± 0,2507 | 1,3777 ± 0,2435 | 1,2142 ± 0,1403 | 1,178 ± 0,0884 |
| kidney | 2,8063 ± 0,1395 | 3,023 ± 0,4129 | 2,5417 ± 0,1403 | 2,5805 ± 0,1625 |
| Brain | 1,887 ± 0,0582 | 1,9682 ± 0,2386 | 1,8175 ± 0,1218 | 1,8522 ± 0,1335 |
| Liver | 10,506 ± 2,2,0886 | 11,001 ± 1,0829 | 10,536 ± 0,8330 | 9,4145 ± 1,1056 |
| Subtitles: CT (Control group); CT EX (Control group + extract); HL (Hyperlipidic), HL EX (Hyperlipidic + extract) | | | | |

## Antimicrobial evaluation

The *Spondias mombin* extract did not inhibit the growth of *K. pneumoniae* ATCC 700603 and *E. coli* ATCC 25923 in any of the volumes tested. However, an antimicrobial potential of the extract in the volume of 200µL was observed, inhibiting the growth of *S. aureus* ATCC 29213 and *S. aureus* BLAC, as shown in Table 4.

Table 4. Diameter of bacterial inhibition by extracts in different concentrations.

|  |  |  |  |
| --- | --- | --- | --- |
|  | *Spondias mombin* | | |
| 50 µl | 100 µl | 200 µl |
| *Escherichia coli* ATCC 25923 | - | - | - |
| *Staphylococcus aureus ATCC* 29213  *Staphylococcus aureus BLAC*  *Klebsiella pneumoniae* ATCC 700603 | -  -  - | -  -  - | 01 mm  01 mm  - |

Subtitles: Antimicrobial activity of the studied extract in volumes of 50 µL, 100 µL e 200 µL in *Escherichia coli* ATCC 25923*, Staphylococcus aureus* ATCC 29213*, Staphylococcus aureus* BLAC and *Klebsiella pneumoniae* ATCC 700603*.*

# Discussion

The present study proved that the *Spondias mombin* extract did not interfere with the cellular metabolic activity of the animals that participated in the experiment. Therefore, the application of the *Spondias mombin* extract in contact with the cells of the animals did not show any change, being therefore considered non-toxic to the cellular conditions and consequently to the organs of the animals, since the body homeostasis of rats and their physiological process remained stable. Therefore, with the absence of compromised cell viability, it was found that cell viability increased by 33% when the concentration of alcoholic extract of *S. mombin* increased from 10 µg/mL to 20 µg/mL.

In addition to the assessment of cytotoxicity, this study confirmed that a hyperlipidic diet induces obesity. During the 12 weeks of the experiment, the animals belonging to the group with hyperlipidic (HL group) showed the greatest weight gain when compared to animals belonging to the other groups. Thus, contributing to the development of various chronic diseases associated with obesity, such as hypertension and diabetes (28). Thus, the current study presents data that show that the administration of *Spondias mombin* extract can contribute to a lower absorption of carbohydrates and lipids in the body since the mass gain indexes of the HL+EX group were lower (11, 12).

However, the evaluation of the *Spondias mombin* extract as a weight gain reducer and blood glucose reducer needs further study. This statement is valid when we analyze the difference in weight and blood glucose reduction between the CT groups and the CT+EX group. The administration of *Spondias mombin* extract in the diet of Wistar rats with a control diet did not show significant difference in total mass gain and blood glucose reduction, requiring further studies to prove the the mass-reducing and glycemic-reducing effects of *Spondias mombin* extract. This absence in the difference in glycemic and weight measurement is one of the factors that corroborate and evidende that the *Spondias mombin* extract did not contribute to the alteration of the rats’ metabolism.

Corroborating the above, *Spondias mombin* is composed of flavonoids, carotenoids, phenolic compounds and ß-cryptoxanthin (2). Among these, flavonoids, which are polyphenolic molecules, have been listed in several studies because their consumption prevents some diseases such as some types of cancer, type 2 diabetes, neurodegenerative disorders, osteoporosis and decreased lipid levels, which could contribute to attenuate, and even decrease the overwheight and obesity index, as evaluated in our study, since the mass gain index of the HL+EX group was lower than that of the other groups (29, 30, 31, 32, 33, 34, 11, 12).

In addition to reducing lipid indices, supplementation with *Spondias mombin* contributes to the cardiovascular system by reducing the process of fibrosis, myocardial hypertrophy and generating better development in the cascade of oxidative stress and inflammatory processes (9, 10).

Studies with aqueous extract of *Spondias mombin* leaves, in different procotols of doses orally, demonstrated that the extract did not induce signs of toxicity in rats, both in terms of biochemical and behavioral, histological and hematological aspects (35). This fact is in agreement with the results we collected in our experiment, demonstrating that the extract, in addition to not altering markers such as kidney and liver function, are not cytotoxic and additionaly have antimicrobial activity.

In addition to the above, the *Spondias mombin* extract inhibited the activity of *Staphylococcus aureus ATCC 29213* and *Staphylococcus aureus BLACC*. The inhibition diameter in both assays was 1mm at concentrations of 200 µl, thus confirming the antimicrobial activity shown by previous studies and other experiments (13, 17, 18, 19, 20). However, the antimicrobial effect of *Spondias mombin* extract did not show any bacterial inhibition at concentrations of 50 µl and 100 µl for the assays of the respective bacteria. Furthermore, no inhibitory diameter was observed against *Escherichia coli ATCC 25923* and *Klebsiella pneumoniae ATCC 700603* in any of the concentrations performed.

# Conclusion

It is concluded, therefore, that the results obtained are promising for the scientific community as they show that *Spondias mombin* extract does not interfere with cell viability and did not show cytotoxicity to the cells to which they where exposed, not interfering with the body homeostasis of the rats in the experiment. Furthermore, the absence of changes in glycemic indices and mineral ions, in the lipid profile, and the liver parameters only corroborate the data found in the absence of physiological change in rats when subjected to administration of *Spondias mombin* extract. So, from the results presented here, a range of future experiments and research can be carried out with *Spondias mombin* extract in order to obtain new drugs with antimicrobial action, in addition to drugs with possible beneficial action to the cardiovascular system and others.

# Disclosure statement

No potential conflicts of interest were reported by the authors.

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