Chapter 2 Cashew bagasse (*Anacardium occidentale* L.) as a source of fiber-antioxidant and its possible use in lipoinflammation models

Capítulo 2 Bagazo de anacardo (*Anacardium occidentale* L.) como fuente de fibra-antioxidante y su posible uso en modelos de lipoinflamación

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Abstract

Diet has a strong influence on health so that people with good eating habits and moderate exercise decrease the chance of developing diseases. As a result, the consumption of foods containing compounds with a value-added to the per se nutrient value is recommended; these compounds are known as bioactive compounds, such as fiber and antioxidants, which have been related to the decrease of oxidative stress and inflammation present in obesity and that, when not treated, they trigger multiple conditions such as diabetes, hypertension, metabolic syndrome, insulin resistance, and cardiovascular diseases. Cashew (*Anacardium occidentale* L.) is a fruit from Brazil that serves as a possible source of fiber-antioxidant by containing phenolic compounds and dietary fiber.

Fiber-Antioxidant, Cashew, Inflammation, Obesity

Resumen

La alimentación tiene una fuerte influencia en el estado de salud, de manera que personas con buenos hábitos alimenticios y que realicen ejercicio moderado, disminuyen la probabilidad de desarrollar enfermedades. Por lo que se recomienda el consumo de alimentos que contengan compuestos con un valor agregado al valor nutrimental *per se* del alimento, a estos compuestos se les conoce como compuestos bioactivos, como la fibra y los antioxidantes, los cuales han sido relacionados con la disminución del estrés oxidativo y la inflamación presentes en obesidad y que al no ser tratados desencadenaran en multiples padecimientos como diabetes, hipertensión, síndrome metabólico, resistencia a la insulina y enfermedades cardiovasculares. El Anacardo (*Anacardium occidentale L.*) es un fruto procedente de Brasil el cual funge como una posible fuente de fibra-antioxidante al contener compuestos fenólicos y fibra dietética.

Fibra-Antioxidante, Anacardo, Inflamación, Obesidad

2.1 Introduction

Obesity is a disease that afflicts 75.2% of Mexicans, who develop this condition through excessive intake of foods rich in refined carbohydrates and saturated fats, lack of physical exercise, and, to lesser extent, genetics (ENSANUT, 2018). This disease is visualized by the increase in adipose tissue in different areas of the body, with visceral adipose tissue being the most studied due to its direct participation in the development of diseases such as Diabetes Mellitus II, insulin resistance, and cardiovascular diseases (CVD). Adipose tissue is made up of adipocytes, endothelial cells, and immune cells such as macrophages and T lymphocytes. In obese patients, adipose tissue is modified and is unable to perform its functions correctly, since macrophages present a phenotypic change of a state anti-inflammatory to pro-inflammatory; various processes are also generated such as the secretion of adipokines involved in the inhibition of insulin, a decrease in leptin (the hormone that regulates appetite) and the inhibition of adiponectin known for its anti-inflammatory capacity. All this leads to the generation of an acute inflammatory process that, when not resolved, may evolve chronically (Olatz *et al.*, 2015; Clària *et al.*, 2012; Guilherme *et al.* 2008) resulting in the development of other diseases.

Some ways of treating obesity have focused on food restriction, however, studies have shown that in diets <800 Kcal/day adipokine levels persist and adipose tissue remains infiltrated by pro-inflammatory macrophages, concluding that the inflammatory process is not totally solved with caloric restriction, so it is recommended the intake of foods that provide extra compounds to the basic nutrients. Such is the case of fiber and antioxidants found in various vegetables. Both fiber and antioxidants are considered bioactive compounds that provide added value to the nutritional benefits of the food (Cencic and Chingwaru, 2010). Among its benefits are to improve the state of health and quality of life, as well as to reduce the risk of contracting diseases (Herrera *et al.*, 2014). The benefits of fiber lie in its ability to restore intestinal motility and promote the growth of beneficial bacteria that exert anti-inflammatory actions in the colon, blocking the growth and adherence of pathogens, as well as the production of short-chain fatty acids that serve as intermediaries in pro-inflammatory cascades (Escudero and Gonzáles, 2006). Currently, the fiber requirement is estimated between 25 and 35 g / day for an adult with an average intake of 2500 Kcals in order to obtain the aforementioned benefits (Sanchez and Romero, 2015). Antioxidants are beneficial due to their ability to give up electrons to stabilize free radicals, thus reducing the development of inflammation (Paredes and Roca, 2002).

Among the most common antioxidants are those of an exogenous nature that is acquired through the diet, such as polyphenols and phytoestrogens, found in red fruits, peaches, black tea, guava, and cashew, among others (Caballero and Gonzales, 2016).

Fruits have been studied for their high content of fiber and antioxidants, such is the case of cashew, a fruit from Brazil and to which a series of benefits and applications in the health area have been attributed. This document focuses on evaluating *Anacardium occidentale* L. as a possible source of fiber-antioxidant and its possible impact on an inflammation model, in order to provide information to support the treatment of obesity.

2.2 Obesity

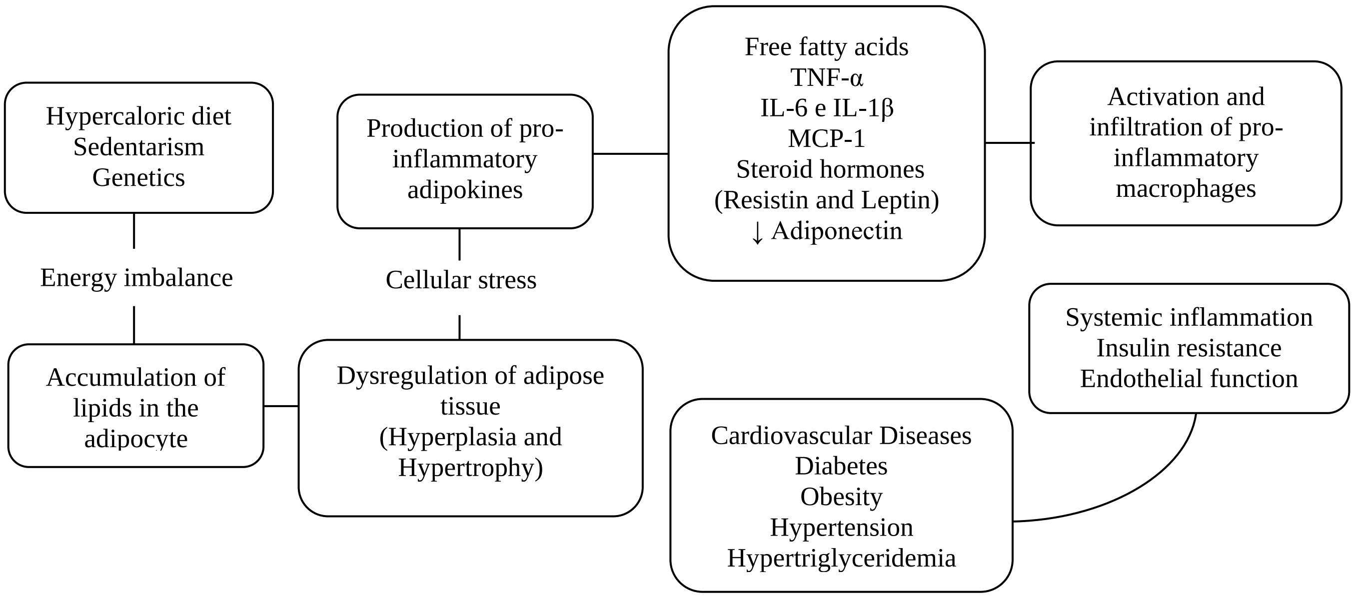
Obesity is a multifactorial chronic disease that is distinguished by the increase in adipose tissue in certain areas of the body, due to various factors such as a high consumption of foods rich in refined sugars and saturated fats, sedentary lifestyle, and in certain cases, environmental and genetic factors. It is diagnosed through the body mass index (BMI) where the weight (kg) and the height square (Cm^2) of the patient are taken into account. Therefore, a BMI $\geq$ 30kg/m^2 categorizes the patient as obese, while a BMI of 18.5 to 24.9kg/m^2 is considered adequate. However, it should be noted that diagnostic methods other than BMI are currently used to provide a better evaluation criteria, such as the relative composition of fat and musculoskeletal mass (Kim and Valdez, 2015), as well as a more detailed diagnosis that considers the metabolic and physiological abnormalities of the human body such as biomarkers related to inflammation and oxidative stress (adipocytokines and steroid hormones) (Zulet *et al.*, 2007; Ripka *et al.*, 2014). The location of the body fat or adipose tissue must also be taken into account since depending on where it is located, it can be associated with a greater or lesser risk of metabolic complications (Mathieu *et al.* 2009).

Currently, 75.2% of people in Mexico are overweight or obese, being Veracruz, Quintana Roo, Colima, Sonora, and Tabasco the states with the highest percentage of obese or overweight people. The importance of treating this condition lies in its consequences since various diseases such as insulin resistance, type 2 diabetes mellitus, CVD, metabolic syndrome, and polycystic ovary syndrome are triggered by the remodeling and increase of adipose tissue (Flores-Lazaro *et al.*, 2011).

2.1. Adipose tissue

The adipose tissue of the breasts and buttocks is susceptible to estrogens, while the visceral adipose tissue is related to the secretion of adipokines involved in inflammatory processes (lipoinflammation) and type 2 diabetes (Flores-lazaro *et al.*, 2011). In periods of overfeeding, the adipose tissue fat cells increase in size (hypertrophy), and new mature adipocytes are also generated from pre-adipocytes (hyperplasia) in order to store excess energy in the form of triglycerides. However, if these periods become constant and combined with sedentary lifestyle and genetics, a metabolic overload is generated that makes the adipocyte incapable of fulfilling its functions, causing dysregulation in the synthesis of adipokines, increasing inflammatory cytokines and decreasing adiponectin (adipokine with anti-inflammatory and anti-atherogenic capacity); the recruitment of inflammatory cells (macrophages M1) into adipose tissue begins, generating the activation of an intracellular inflammatory response and the overproduction of reactive species, causing a state of oxidative stress and inflammation (Bays *et al.*, 2008; De Ferranti and Mozaffarian, 2008; Blüer, 2009) (Figure 2.1).

Figure 2.1 Mechanism of adipose tissue dysfunction and its metabolic impact



Source: Adapted from Flores-Lazaro et al., 2011

2.2. Adipose tissue and its participation in inflammatory processes

These dysfunctions described in Figure 2.1 are carried out through various substances secreted by adipose tissue such as fatty acids, prostanoids, cholesterol, retinol, steroid hormones, and protein factors, the latter known as adipokines, which serve as mediators between adipose tissue and adjacent and distant organs such as the endothelium, liver, muscle, pancreas, adrenal glands, and nervous system. A large part of adipokines are considered inflammatory factors such as tumor necrosis factor (TNF-α), interleukins 1-β, 6, 8, 10, 4, and 13 (IL 1-β; IL-6, IL-8, IL-10, IL-4, and IL-13), and monocyte chemoattractant protein 1 (MCP-1) which is directly related to the inflammatory response by inhibiting the expression of glucose transporter-4 (GLUT-4) and to the peroxisome-proliferator-activated receptor-γ (PPAR-γ) responsible for the differentiation and proliferation of adipocytes, and the increase of adiponectin, thus determining a link between inflammation and obesity (Bastarrachea *et al.,* 2007).

2.3 Dietary fiber

The main sources of dietary fiber in the human diet are fruits and vegetables since their cell wall is made of polysaccharides such as pectins, celluloses, and hemicelluloses (Caffall *et al.,* 2009), providing them with appreciable characteristics in the treatment and prevention of pathologies such as CVD, diabetes, colon cancer, and obesity (Viuda-Marctos *et al.*; Kendall *et al.,* 2010). Cellulose is a cell wall homopolymer constituted by D-glucose monomers linked by β-(1 → 4) glycosidic bonds that in turn form microfibrils and macro fibers linked by hydrogen bonds, which results in the fiber insolubility in water (Mudgil *et al.*, 2013; Bajpai *et al.*, 2017). Hemicellulose is made of more than one type of monosaccharide, giving rise to different heteropolymers such as xyloglucans, glucuronoxylans, glucomannan, and arabinoxylans (Scheller *et al.*, 2010). Finally, pectins are the most complex group of cell wall polysaccharides since they are characterized by the presence of galacturonic acid, rhamnose, arabinose, and galactose, giving rise to homogalacturonans and rhamnogalacturonans (Arnous *et al.*, 2009). It should be noted that pectins are the main component of the soluble fraction of dietary fiber. As mentioned above, the consumption of soluble fiber presents a series of health benefits such as a reduction in the glycemic response and cholesterol, while the insoluble fraction formed by cellulose and hemicellulose promotes a decrease in intestinal transit and an increase in fecal mass (Mudgil *et al.*, 2013). Cellulose, hemicellulose and pectin have functional properties such as swelling capacity (Sw), water retention (WRC), and lipid adsorption (FAC), which play an important role in the regulation of digestive flow, the availability of nutrients, viscosity, and bolus formation (Elleuch *et al.*, 2011).

The American Association of Cereal Chemists (2001) defines dietary fiber as “The edible part of plants or analogous carbohydrates that are resistant to digestion and absorption in the small intestine, with complete or partial fermentation in the large intestine. Dietary fiber includes polysaccharides, oligosaccharides, lignin, and associated substances from the plant. Dietary fibers promote physiologically beneficial effects on health by improving intestinal transit, cholesterol, and blood glucose levels”.

Dietary fiber can fall into the following categories:

- Polymers of edible carbohydrates that are consumed directly from food.

- Carbohydrate polymers obtained from food raw materials by physical, enzymatic, or chemical treatments that have a physiologically beneficial effect on health by generally accepted scientific evidence and provided to the competent authorities.

There are three classifications of dietary fiber (DF) regarding its composition, water retention capacity, and fermentation capacity. If we talk about its water retention capacity, fiber can be divided into soluble and insoluble, where soluble fiber is characterized by its ability to form gels, a property that slows gastric emptying and the absorption of nutrients, such as glucose, lipids, minerals, and bile acids in the intestine (Cherbut, 1998). Insoluble fiber passes through the colon unchanged, increasing the weight of the stool by absorbing water, making stools voluminous and soft, thus increasing intestinal regularity (Kin, 2001). Regarding its fermentative capacity, all fibers with the exception of lignin can be fermented by colonic bacteria, the main ones being soluble fibers. The ingestion of soluble fibers such as guar gum increases the weight of stool by 20%, improving gastrointestinal transit. The intake of fructooligosaccharides (prebiotic soluble fiber "FOS") can increase the proliferation of probiotic bacteria such as bifidobacteria (Bouhnik *et al*., 1996). Researchers such as Gibson *et al*. (1995) supplemented 15 g of inulin (FOS) / day to healthy volunteers, significantly increasing the number of bifidobacteria and reducing the number of Bacteroidetes, Clostridium and Fusobacterium. The National Cholesterol Education Program Adult Treatment Panel (NCEP ATP III) recommends increasing the intake of soluble fiber (10-25g / day) to lower serum cholesterol and therefore the risk of heart disease, and consumption of 20-30g / day total fiber to reduce 12-20% the probability of developing cardiovascular diseases.

One of the main functions of dietary fiber is to reach the large intestine and serve as a substrate for the resident bacteria in the colon, which produce short-chain fatty acids (SCFA), gases (hydrogen, carbon dioxide, and methane) and energy by using fiber as the main substrate. 90% of the SCFA produced by the microbiota are rapidly absorbed by the colonocyte, butyrate being the most used, followed by acetate and propionate (Roediger, 1982). Butyrate is metabolized to CO_2, ketone bodies, and water. It is the main source of energy, it stimulates the production of mucus, the absorption of ions, and the formation of bicarbonate. Likewise, butyrate exerts specific anti-inflammatory actions in the colon, decreasing the production of some pro-inflammatory cytokines (TNF), modulating the activity of the transcription nuclear factor enhancing the kappa light chains of activated B cells (NF-kB) in colonic cells *in vitro* (Inan *et al*., 2000).

As mentioned above, the intake of dietary fiber improves the intestine function, however, an excess can cause negative effects, so the American Diabetes Association recommends a daily consumption of 14g per 1000 Kcal in the diet to be able to obtain the benefits of fiber, such as control and reduction of hemorrhoids and constipation (Bosaeus, 2004), protection against colon cancer through the production of fatty acids (Eswaran *et al*., 2013), weight reduction due to increased satiety (Pereira *et al*., 2004), prevention of diabetes if consumed together with a diet low in fat and carbohydrates and decreased absorption of simple carbohydrates favoring blood glucose levels (Cho *et al*., 2013).

According to the European Parliament in regulation (CE) # 1924/2006 “A food can only be declared to have high fiber content, as well as any other declaration that may have the same meaning for the consumer, if the product contains at least 6g of fiber per 100g or 3g of fiber per 100 Kcal”.

At present, foods that have high fiber content and that in turn present bioactive compounds such as vitamins, antioxidants, minerals, have been investigated to improve the health of the consumer; examples are fruits like guava, apple, grape, peach, and cashew among others (Sudha *et al*., 2007; Tseng and Zhao, 2013; Matias *et al*., 2015).

2.4 Antioxidants in food

A dietary antioxidant is a substance that is part of foods that can prevent the adverse effects of reactive species on normal physiological functions in humans (Patthamakanokporn *et al*., 2008). There are two main types of antioxidants: endogenous (enzymatic) and exogenous (non-enzymatic). Endogenous antioxidants are defense mechanisms developed by the body itself, among the best known are the enzymes catalase (CAT), superoxide dismutase (SOD), and glutathione peroxidase (GPx), while exogenous antioxidants are known as dietary antioxidants, for example alfa-tocopherol that helps to prevent membrane peroxidation by stabilizing peroxyl radicals; vitamin C or ascorbic acid that acts in combination with vitamin E and carotenoids, as well as in conjunction with enzymatic antioxidants (Griffiths and Lunec, 2001); carotenoids especially β-carotene, which reduces genetic damage and mutations and inhibits tumor induction caused by UV rays and chemical agents (Krinsky, 1989). For their part, flavonoids and polyphenols are phenolic compounds known to be present in a wide variety of plants in higher concentrations than other antioxidants such as vitamin C and E, which makes them the main antioxidants acquired in the diet (Lotito and Frei, 2006). Although in *in vivo* studies it has been observed that antioxidants show a low availability and a high clearance rate (Manach *et al*., 2005), in some epidemiological studies a protective effect of the consumption of flavonoids has been reported against the risk of cardiovascular diseases (Knekt *et al*., 2002; Arts and Hollman, 2005) relating it to its antioxidant capacity in the face of the oxidative imbalance of these pathologies (Aviram and Fuhrman, 2002; Rietveld and Wiseman, 2003).

Polyphenols can be divided into several subgroups depending on their basic structure. Examples of this are flavonoids that include anthocyanins, flavonols, flavones, flavanones and isoflavones. Another subgroup is composed by the phenylpropanoids, which include hydroxycinnamic acid derivatives (caffeic, ferulic, synaptic, p-coumaric), as well as stilbenoids such as resveratrol and benzoic acid derivatives (gallic and ellagic acid, among others) and the anthocyanins responsible for the pigmentation of red fruits, some vegetables and proanthocyanidins (condensed tannins), and hydrolyzable tannins that confer the astringent flavor in some fruits (Tomás-Barberán, 2003). Within this classification, there are also extractable polyphenols (PE), so-called because they can be extracted with aqueous-organic solvents (Pérez-Jiménez *et al*., 2013), examples of which are flavonoids (catechins, proanthocyanidins, anthocyanidins, flavonoids, flavones, and isoflavones), phenolic acids, stilbenes, and lignans. Non-extractable polyphenols (PNE) remain retained in the residues after extraction (Saura-Calixto, 2013), examples of these are hydrolyzable tannins and proanthocyanidins associated with dietary fiber and protein. Of the total polyphenols consumed in the diet, 50% are PE that are absorbed in the small intestine while PNE (proanthocyanidins) reach the colon intact and can be fermented by the intestinal microbiota or broken down by some intestinal enzymes such as esterases (Pérez -Jiménez *et al*., 2013).

The most studied are hydrolyzable tannins, specifically those resulting from the esterification of gallic acid or ellagic acid, such as pentagalloyl glucose (PGG), which has a certain anti-cancer activity (prostate and lung cancer), and anti-diabetic activity since tannin has an effect similar to that of insulin, by binding to specific insulin receptors on the cell membrane, favoring the transport of glucose into the cell, even in the absence of insulin, in addition to a proven antioxidant activity *in vitro*. On the other hand, in *in vivo* models, it has been observed that the proanthocyanidins present in cranberry juice exhibit antibacterial activity, preventing the adhesion of *E. coli* to cell surfaces of the urinary tract (Álvarez *et al*., 2012).

2.5 Fiber-antioxidant and their influence on obesity

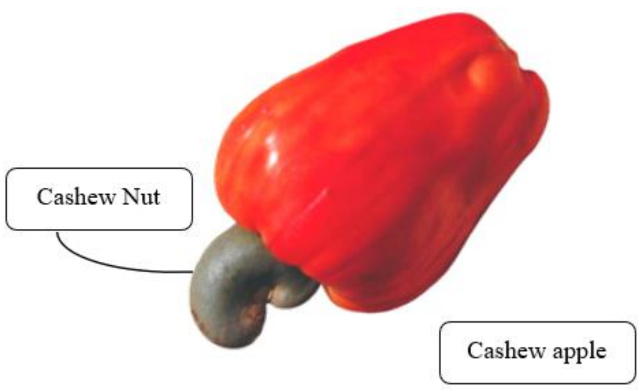
The term fiber-antioxidant (FA) was coined after observing that most of the dietary antioxidants are totally or partially absorbed in the small intestine, but an appreciable amount of these, mainly polyphenols and carotenoids, are transported together with the dietary fiber towards the large intestine, where they are released from the fibrous matrix by the action of the microbiota and can produce metabolites and an antioxidant environment (Mainai *et al*., 2009; Arranz *et al*., 2010). An example of this are *in vivo* studies that have shown that by consuming the fruit, peel, and grape pomace (rich in antioxidant fiber), it is possible to modulate the redox status and defense system of rats, due to the increase in the activity of the enzyme glutathione peroxidase in blood plasma and liver inducing a hepatoprotective effect (Bobek, 1999; Dani *et al*., 2008; Young *et al*., 2000).

A lipid-lowering effect has also been attributed to AF. Martín-Carrón *et al*. (2000) evaluated the effect of the addition to the diet of grape antioxidant dietary fiber (GADF) in adult Wistar rats on a cholesterol-free diet and another diet added with 10 g kg-1 of cholesterol. GADF intake increased weight and the amount of fat and protein excreted in the feces and did not affect animal growth and/or protein efficiency. In addition, it decreased total serum cholesterol and LDL-cholesterol concentrations in hypercholesterolemic rats. Hogan *et al*. (2010) studied the effect of FA on the modification of the bacterial profile in the cecum of rats fed for four weeks. The results showed that the intake of FA stimulates the *in vitro* proliferation of *Lactobacillus*, such as *Lactobacillus reuteri* and *Lactobacillus acidophilus*, but slightly affects the species composition of *Bifidobacterium*, therefore, these findings suggest that the consumption of a diet with food vegetables rich in FA can improve the gastrointestinal health of the host through modulation of the microbiota (Pozuelo *et al*., 2012).

2.6 Cashew (*Anacardium occidentale* L.) as a source of fiber-antioxidant

The cashew tree (*Anacardium occidentale* L.) belongs to the *Anacardiaceae* family that includes about 60 genera and 400 species. It is native to the northwest of Brazil, its leaves are evergreen and can reach between 8 and 12 m in height, and until the third year of life, it begins to bear fruit. According to the International Nut & Dried Fruit (INC, 2016), the cashew fruit consists of two parts: the pseudo fruit or apple, which represents the majority, and the nut or true fruit, the smallest (Figure 2.2) (CONABIO, 2020). The largest cashew producers worldwide are Vietnam, India, and Brazil with a maximum production of almost 3, 000,000 Ton/year (FAO, 2020). In México, the states with the highest production are Campeche, Guerrero, and Chiapas, producing a maximum of 3,000 Ton/year, however, in the states of Colima, Oaxaca, Sinaloa, Tabasco, and Veracruz, cashew nuts are found growing wild (SIAP, 2020).

Figure 2.2 Cashew Fruit (*Anacardium occidentale L.)*



Source: Own elaboration

The cashew pseudo fruit is firm and juicy, contains fiber, tannins, and carotenoids (Fonteles *et al*., 2017), a high concentration of sugars, strong flavor, low acidity, high astringency (Das and Arora, 2016) and high content of vitamin C, in juice (203.5mg / 100mL) and fresh pulp (229mg / 100g), almost four times more than orange (54.7mg / 100mL), lemon (33.7mg / 100mL), pineapple (14.70mg / 100mL) and mango (30.9mg / 100mL) (Akinwale, 2000; Figuereido *et al*., 2002). Other main components of the juice are esters (226.46 µg / kg) representing 45% of the total volatile mass, followed by terpenes (118.98 µg / kg), acids (45.23 µg / kg), aldehydes (39.10 µg / kg), alcohols (18.91 µg / kg), lactones (19.15 µg / kg), hydrocarbons (18.02 µg / kg) and ketones (11.05 µg / kg) (Telles *et al*., 2015). In the stage of physiological maturity of the pseudo fruit, polyphenols are found in concentrations of 1337.67 mg EAG / 100g of fresh pulp and flavonoids of 1018 mg EAG / 100g of fresh pulp, while in overripe stages their concentration decreases (614.33 mg EAG / 100g and 339.33 mg EAG / 100g of fresh pulp, respectively) (Flores, 2018). Bioaccessibility studies have been carried out on some minerals in cashew juice such as copper, iron, and zinc, finding that only 15%, 11%, and 3.7% are bioaccessible after the digestion process (De Lima *et al*., 2014).

2.6.1 Uses and applications of cashew

After extraction of the juice by pressing, 25% of a residue called bagasse is generated with a high concentration of fiber, which varies from 41.53% ps (Matias *et al*., 2005), to 33% in fresh bagasse (Rodrígues *et al*., 2007). Various authors have reported the effect of the administration of cashew bagasse in murine models, such as the case of Carvalho *et al*. (2017), who administered 10% of sonicated and lyophilized bagasse to a group of healthy rats, causing an increase in body weight and elevation of serum triglyceride and LDL cholesterol levels after 15 weeks. Later, Carvalho *et al*. (2019) administered natural cashew fiber (IcF) and cashew fiber after undergoing a low molecular weight metabolite (cFSM) extraction process to obese male Swiss mice for 15 weeks. At the end of the treatment, a reduction in glycemia and serum levels of insulin and ghrelin was found, while the animals fed IcF showed hyperlipidemia, hyperleptinemia, and increased abdominal fat, concluding that the elimination of low molecular weight metabolites in cashew bagasse is correlated with the improvement of the health of obese mice. For their part, Beejmohun *et al*. (2015) used 200 mg of the ethanolic extract of lyophilized bagasse in obese rats, reducing body weight, liver weight, and adipose tissue. With regard to industrial uses, Guedes-Oliveira *et al*. (2016) evaluated washed cashew fiber as a fat substitute in food, demonstrating its viability as a texture modifier. Its possible use as a prebiotic has also been evaluated since it satisfactorily modulates the intestinal microbiota, increasing the *Lactobacillus* and *Bifidobacterium* genera (Dantas *et al*., 2017). Cashew bagasse evaluations have been carried out after microwave drying at 390W and it has been found that it has a higher content of phenolic compounds (777 ± 0.01 mg EAG / 100g dehydrated bagasse) compared to the control (681mg EAG / 100g sample fresh), and that the color and other bioactive compounds such as carotenoids are preserved (Morales *et al*., 2019). Studies have also been carried out on the various parts of the cashew tree (Table 2.1) such as leaves, stem, roots, bark, gum and in both nut shell and liquid (CNSL), demonstrating antitumor, antibacterial activity, fungicide, anticorrosive, decontaminant, anti-inflammatory, and healing, among others (Sokeng *et al*., 2001; Lorenzi, 2004; Perone, 2012; Gómez and Pereira, 2016).

Table 2.1 Studies on uses and applications of cashew in various areas

Part of the tree	Health Benefit	References
Stem and leaves	Treatment of eczema, psoriasis, scrofula, dyspepsia, venereal diseases, sexual impotence, bronchitis, cough, menstrual and intestinal cramps and skin-related disorders.	Franca *et al*., 1993
Stem, leaves and fruit	Anti-inflammatory	Sokeng *et al.,* 2001
Bark	Treatment of leprosy, burns and as a healing	Perone, 2012
	Decreased levels of alanine and aspartate aminotransferase, protects against death from sepsis	Olajide *et al.,* 2004
Leaves	Antibacterial activity	Gómez y Pereira, 2016
Gum	Fungicide and insecticide	Lorenzi, 2004
	Anti-inflammatory activity	Yamassaki *et al.,* 2015
	Blood pressure reduction	Mothe *et al.,* 2006
	Antitumor activity	Mothe y Calazans, 2008
Juice	Antioxidant potential and mutagenic activity	Ferguson, 2001
Bagasse	Inhibits fat storage and the development of insulin resistance	Beejmohun *et al.,* 2015
	Prebiotic effect in *Lactobacillus johnsonii*	Vergara *et al.,* 2010; Dantas *et al.,* 2017
Fiber	Prevents the increase of body weight, liver and abdominal fat, reduces ghrelin, leptin, TNF- α and adiponectin levels	Carvalho *et al.,* 2019
	Adjuvant in the treatment of *Heamonchus contortus* (intestinal nematode)	Lopes *et al.,* 2018
CNSL (Cashew Nutshell liquid)	Elimination of plantar warts caused by human papilloma	Ñurinda y Valle, 2020
	Antibacterial activity on *Streptococcus mutans*	Ponce, 2011
	Antimicrobial activity on *Staphylococcus aureus*	Tello, 2011; Vicanco, 2011
Ánacardic acids	Increases glucose absorption in cells	Tedon *et al.,* 2010
	Increased expressión of PPAR-γ	*Chung *et al.,* 2019

CNSL: Corrosive oil obtained from pressing cashew nut shells. Source consulted: Own elaboration.

2.7 Conclusions

Both antioxidant compounds and fiber have been extensively studied throughout history. Fiber has been recognized for its direct health benefits, as well as its importance in modulating the intestinal microbiota, however, the relationship with antioxidant compounds such as non-extractable polyphenols have not been fully clarified. For their part, antioxidant compounds such as condensed and hydrolyzable tannins have proven their effectiveness in diseases such as cancer, diabetes, and chronic non-communicable diseases. Therefore, studies involving the bioavailability of antioxidants bound to fiber are of utmost importance to better understand the interaction of these compounds and their positive relationship to health. In the case of lipoinflammation or inflammation of adipose tissue, the antioxidant fiber shows promising results in improving health since by promoting an antioxidant environment and the release of SCFA by the microbiota, free radicals formed in inflammatory processes can be fought. Some foods have been proposed as sources of fiber antioxidant, as they have high fiber content linked to antioxidant compounds, such as guava, mango, and cactus. Therefore, the cashew is proposed as a possible source of fiber antioxidant since it has high concentrations of condensed tannins, vitamin C, and fiber, comparable with fruits such as guava, pineapple, orange, and apple that stand out for their use as functional foods in chronic degenerative diseases related to inflammation. It is also recommended to undertake the pertinent studies to cashew bagasse in order to evaluate its application in a model of obesity induced by a diet high in fat and carbohydrates in order to elucidate its anti-inflammatory potential.

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