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Anacardium occidentale L. as a source of antioxidant compounds and their applications

Anacardium occidentale L. como fuente de compuestos antioxidantes y sus aplicaciones

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Abstract

Antioxidants have demonstrated their biological importance in various pathologies such as Cancer, metabolic, cardiovascular and neurodegenerative diseases, due to their ability to stabilize free radicals generated by the organism itself or by external sources such as radiation, stress, poor diet among others, which is why currently looking for foods that have a high content of antioxidant compounds such as flavonoids, anthocyanins, tannins that can be used as adjuvants in the treatment of these diseases, such is the case of functional foods that in addition to exerting their benefits per se have been scientifically proven to provide an extra health benefit when consumed as part of a daily diet. *Anacaridum occidentale* L. is a fruit native to Brazil that has been studied due to its high content of antioxidant compounds such as quercetin, myricetin, condensed tannins, unsaturated fatty acids such as oleic, linoleic, fiber and vitamin C, present in the juice, peel, fruit and seed, while in the by-products we can find compounds with environmental and industrial applications such as shell oil.

Antioxidant, Cashew, Health

Resumen

Los antioxidantes han demostrado su importancia biologica en diversas patologias como Cancer, enfermedades metabolicas, cardiovasculares y neurodegenerativas, debido a su capacidad para estabilizar los radicales libres generados por el propio organism o por fuentes externas como la radiación, estres, mala alimentación entre otros, es por ello que en la actualidad se buscan alimentos que presenten alto contenido de compuestos antioxidantes como flavonoides, antocianinas, taninos que puedan ser utilizados como coadyuvantes en el tratamiento de dichas enfermedades, tal es el caso de los alimentos funcionales que ademas de ejercer sus beneficios per se han demostrado cientificamente que brindan un beneficio extra a la salud al ser consumidos como parte de una dieta diaria. *Anacaridum occidentale* L. es un fruto originario de Brasil que ha sido estudiado debido a su alto contenido de compuestos antioxidantes como quercetina, miricetina, taninos condensados, acidos grasos insaturados como oleico, linoleico, fibra y vitamina C, presents en el jugo, cascara, fruto y semilla, mientras que en los subproductos podemos encontrar compuestos con aplicaciones ambientales e industrials como el aceite de la cascara.

Antioxidante, Anacardo, Salud

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Introduction

Antioxidants are molecules that have the ability to donate electrons to unstable molecules known as free radicals (RL). An RL is a species that contains one or more unpaired electrons, that is, an electron that is only in its orbital, so they tend to form pairs of electrons to reach a more stable configuration. A radical can donate its unpaired electron to another molecule, or it can steal an electron from another molecule to form its electron pair. However, when a radical takes an electron from another molecule or donates an electron, the other molecule is transformed into a free radical. So a characteristic of free radicals is their tendency to cause chain reactions (one radical generates another radical and so on) (Haliwell, 1989).

Among the existing antioxidants we can find those of an endogenous and exogenous nature, being those of exogenous character those from the diet such as phenolic compounds (flavonoids), carotenoids, tannins, vitamin C, A and E, found mainly in fruits (Sayago *et al*., 2014). Several studies have shown that the consumption of anthocyanins, quercetin, myricetin belonging to the group of flavonoids decreases the risk of developing cardiovascular and cerebrovascular diseases, strengthens the immune system, prevents carcinogenicity, and increases HDL cholesterol, as well as decreases the oxidative stress present in the development of metabolic diseases (Hollman and Arts, 2000; Scalbert and Williamson, 2000; Ross and Kasum, 2001; Gee and Johnson, 2001; Kris-Ertherton *et al*., 2002; Aisling-Aherme and O'Brien, 2002; Poyrasogluet *et al*., 2002; Thomas-Barberan. 2003; Espín and Tomás-Barberán, 2005).

Anacardium occidentale L. is a tree native to northwestern Brazil, cultivated by its seed found on the underside of the fruit. Studies have demonstrated the functionality of cashew tree products and by-products in various areas of health such as antifungal, antimicrobial, anti-inflammatory, anticorrosive, antiobesogenic, due to its bioactive compounds such as flavonoids, quercetin, myricetin, anthocyanins, tannins, polyunsaturated fatty acids such as oleic and linoleic, vitamin C, anacardic acids, cardanol, fiber among others (Franca *et al*., 1993; Sokeng *et al*., 2001; Lorenzi, 2004; Mothe *et al*., 2006; Akinhanmi, 2008; Perone, 2012; Mubofu and Mgaya, 2018).

Therefore, this work focuses on the collection of studies of the antioxidant compounds reported in the products and by-products of the cashew tree and their possible impact on health.

What are antioxidants? and How do they act?

An antioxidant is any substance that, being present at low concentrations, with respect to those of an oxidizable substrate (biomolecule), slows or prevents the oxidation of that substrate. (Halliwel and Gutteridge, 1998 as cited in Criado and Moya, 2009). The body's cells and organs have antioxidant systems, which can be enzymatic, non-enzymatic, or binding proteins. All act synergistically to neutralize the different reactive species, forming a network of antioxidants.

With respect to oxidizable substrates, we find free-radicals that are atoms or groups of atoms that have an unpaired or free electron so they are very reactive since they tend to capture an electron of stable molecules in order to achieve their electrochemical stability. Free radicals comprise free radicals from oxygen, nitrogen, sulfur, and chlorine, the most abundant being oxygen free radicals, also called reactive oxygen species (ROS). Free radicals have a short half-life; however, they have the ability to react quickly with DNA, proteins, and lipids, generating damage in these that last longer in the body. This is where the work of the antioxidant comes in, as the antioxidant molecule gives an electron to the free radical, oxidizing in turn and transforming into a weak non-toxic free radical. This process is called redox reaction or is also known as oxidation-reduction reaction since there is a transfer of electrons between two species. Where one atom is oxidized (loses electrons) and the other is reduced (gains electrons) (Figure 1) (Avello *et al*., 2006).

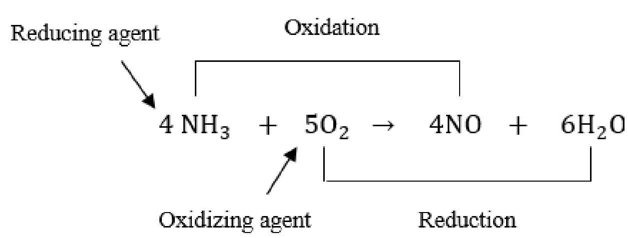

Figure 1 Oxide-reduction reaction of ammonia to nitric oxide

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Classification

Antioxidants are classified into two groups: endogenous or exogenous, which will be detailed below.

Endogenous antioxidants are those produced in the body itself as certain enzymes and coenzymes, among which are three enzymes that are fundamental in this activity: Superoxide dismutase, Glutathione peroxidase, and Catalase.

– Superoxide dismutase (SOD) acts on the superoxide anion (O_2•-) transforming it into a secondary radical (e.g., H_2O^2) for a subsequent action of GPx (Villa *et. al.*, 2007).

– Glutathione peroxidase (GPx) is an enzyme that uses selenium as a cofactor. It catalyzes the reaction through which reduced glutathione (GSH) reacts with peroxides to transform them into water and alcohol. During the process, glutathione is oxidized (GSSG) to be subsequently returned to its original state by the enzyme glutathione reductase (Alberro, 2013).

– Catalase (CAT) catalyzes the dismutation of hydrogen peroxide into water and dioxygen thus preventing the formation of the hydroxyl radical and singulete oxygen, oxygen species that are very reactive (Diaz, 2002).

Instead, exogenous antioxidants are those found in nature primarily in the food, and these are obtained through food. Among the exogenous antioxidants, we can find vitamins E and C, beta-carotene or pro-vitamin A, flavonoids, lycopene.

– Vitamin E: It focuses specifically on the inhibition of lipid peroxidation caused by free radicals, an action that takes place in the phospholipids of the cell membrane, lipoproteins, adipose tissue, brain, and in all tissues that contain a high proportion of polyunsaturated fatty acids (Vilaplana, 2007).

– Vitamin C is a water-soluble antioxidant with high reducing power. It participates in intermediate and oxidative metabolism, in the reabsorption of iron, is necessary for the immune response, acts as a cofactor for numerous enzymes involved in the biosynthesis of collagen, carnitine, and some neurotransmitters, and can trap a wide variety of reactive oxygen and nitrogen species in aqueous media. (Sanchez, 2013).

– Polyphenols can be divided into several subgroups depending on their basic structure. Examples of this are flavonoids that include anthocyanins, flavonols and flavones, flavanones, isoflavones and flavan-3-ols. Another subgroup is the phenyl propanoids that include the derivatives of hydroxycinnamic acids (caffeic, ferulic, synapic, p-coumaric). Like stilbenzoids such as resveratrol and benzoic acid derivatives (gallic and ellagic acid, among others), without forgetting proanthocyanidins (condensed tannins), hydrolyzable tannins that confer the astringent flavor in some fruits and anthocyanins responsible for the pigmentation of red fruits and some vegetables (Tomás-Barberán, 2003).

Methods for evaluating antioxidant capacity in food

Measuring the antioxidant activity/capacity of foods and biological samples is therefore essential not only in ensuring the quality of functional foods but more importantly in studying the efficiency of food antioxidants in preventing and treating the diseases related to oxidative stress (Munteanu and Apetrei, 2021).

The methods and instruments used to measure the activity of antioxidants have made remarkable progress in recent decades. Until now, highly sensitive and automated detection technologies have been used to evaluate antioxidant activity by special methods, such as scanning activity against different types of free radicals or ROS, reducing power, and metal chelation, among others. (Shahidi and Zhong, 2015).

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A standardized method for the antioxidant activity of a food component must comply with the following ideal requirements (Rodriguez *et al*., 2018):

– The source of radicals used must be biologically relevant.

– It is desirable that it be simple.

– The method used must have a defined endpoint and chemical mechanism.

– Both the instruments used and the chemicals must be readily available.

– Reproducibility within the cycle and between days is appropriate.

– Allows the analysis of both hydrophilic and lipophilic antioxidants, using different radical sources.

– The method must be applicable for quality control analysis.

It should be emphasized that antioxidant activity should not be tested based on a single method, several *in vitro* antioxidant procedures must be performed to determine antioxidant activities for the sample of interest. Bearing this in mind, it is difficult to compare one method completely with another. Therefore, the methods of analysis must be checked before choosing one for research purposes. The various methods of evaluating antioxidant capacity are divided into three distinct categories, namely spectrometry, electrochemical assays, and chromatography (Fereidoon *et al*. 2015).

Table 1 summarizes the principle of the method and the end-product determination, despite the diversity, as well as the advantages and disadvantages that each one provides, conventional methods are still needed to measure antioxidant activity and specific methodological protocols are complex and require a long time of testing. One of the important selection parameters of the antioxidant test is the working pH. Tests are operating in acidic (FRAP), neutral (CUPRAC) or alkaline (Folin-Ciocalteu) conditions.

Furthermore, the applicability of the antioxidant test to both hydrophilic and lipophilic antioxidants is an important factor. While the ABTS and CUPRAC tests can measure both hydrophilic and lipophilic antioxidants, some methods only measure hydrophilic antioxidants (FRAP and Folin-Ciocalteu), and others only apply to hydrophobic systems (DPPH). At the same time, the background color in the food matrix can trigger absorbance. Modifications, which have more important adverse effects in case of discoloration reactions (ABTS, DPPH), compared to color formation reactions (FRAP, CUPRAC). Consequently, there is enormous potential in this area of research, with the purpose of developing new analytical methods to determine the antioxidant capacity of compounds, especially in food products. For example, the development of electrochemical biosensors (Ojha *et al*., 2018).

Techniques	Antioxidant Capacity Assay	Principle of the Method	End-Product Determination
Spectrometry	ORAC	Antioxidant reaction with peroxyl radicals, induced by 2,2´-azobis-2-amidino-propane (AAPH)	Loss of fluorescence of fluorescein
	HORAC	Antioxidant capacity to quench OH radicals generated by a Co(II) based Fenton-like system	Loss of fluorescence of fluorescein
	TRAP	Antioxidant capacity to scavenge luminol-derived radicals, generated from AAPH descomposition	Chemiluminescence quenching
	CUPRAC	Cu (II) reduction to Cu (I) by antioxidants	Colorimetry
	FRAP	Antioxidant reaction with a FE (III) complex	Colorimetry
	PFRAP	Potassium ferricyanide reduction by antioxidants and subsequent reaction of potassium ferrocyanide with Fe^{3+}	Colorimetry
	ABTS	Antioxidant reaction with an organic catión radical	Colorimetry
	DPPH	Antioxidant reaction with an organic radical	Colorimetry

Fluorimetric Analysis		Emission of light by a compound, which has absorbed light or other electromagnetic radiation of a different wavelength	Recording of fluorescence excitation/emission spectra
Electrochemical techniques	Voltammetry	The reduction or oxidation of a compound at thesurface of a working electrode, at the appropiate applied potential, resulting in the mass transpoprt of new material to the electrode surface and in the generation of a current	Measurement of the catholic/anodic peak
	Amperometry	The potential of the working electrode is set at a fixed value with respect to a reference electrode	Measurement of the current generated by the oxidation/reduction of an electroactive analyte
	Biamperometry	The reaction of the analyte (antioxidantea9 with the oxidised form of a reversible indicating redox couple	Measurement of the current flowing between two identical working electrodes, at a small potential difference and immersed in a solution containing the analised simple and a reversible redox couple
Chromatography	Gas chromatography	Separationof the compounds in a mixture is base don the repartition between a liquid stationary phase and a gas mobile phase	Flame ionisationor termal conductivity detection
	High performance liquid chromatography	Separation of the compounds in a mixture is base don the repartition between a solid stationary phase with dofferent polarities, at high flow rate and pressure of the mobile phase	UV-vis (e.g., diode array) detection, fluorimetric detection, mass spectrometry or electrochemical detection

Table 1 Techniques for determination of antioxidant

Antioxidant's health benefits and mechanism of action

Several studies have reported the biological and pharmacological effects of carotenoids, flavonoids, and anthocyanidins, their antioxidant capacity, their anticancer, antiviral, antibacterial, anti-inflammatory, antiallergic, antithrombotic, cardioprotective, hepatoprotective, neuroprotective, antimalarial, antileishmanial, properties antiamebias (Lu *et al*., 2021).

Carotenoids

Found in various bacteria, fungi, algae, and plants, so far, more than 800 are reported with colors of red, orange, yellow, etc. Carotenoids and their metabolites have positive effects on cardiovascular diseases, osteoporosis, cancer, and myocardial infarction in smokers (Cazzonelli and Pogson 2010). An epidemiological study indicated that carotene-rich foods and supplements could prevent prostate cancer to some extent (Perez *et al*., 2017). Other reports also showed that carotenoids could improve cognitive function (Lindbergh *et al*., 2017) and act as photo protectors of the skin with cosmetic benefits (Rodriguez *et al*., 2018). They are widely used in the food, pharmaceutical, and cosmetic industries due to their health benefits. The mechanism of action can be explained by the characteristic structure of carotenoids which consists of a conjugated polyunsaturated double bond, a particular chemical structure that gives it on the one hand capacity to inhibit free radicals, and on the other a lipophilic character, therefore, it protects lipoproteins and cell membranes from free radical attack (Santos *et al*., 2019).

Flavonoids

Belong to the superfamily of polyphenols, they are synthesized by plants, they exist widely in stems, leaves, flowers, and fruits, usually appear in yellow colors, light yellow or white, more than 5000 different types have been identified from plants (Cetinkaya, *et al*., 2017). Flavonoids have long been a focus of research in phytology, food science, and nutrition, and their benefits have been gradually explored, including but not limited to antioxidants, anticancer, cardioprotective, neuroprotective, anti-atherosclerosis, anti-mutagenic, anti-allergic, anti-tumor, and anti-inflammatory capabilities (Singh *et al*., 2020, Chen *et al*., 2017, Asadi *et al*., 2019). Antioxidants could scavenge free radicals that confer strong anticancer properties and flavonoids could inhibit tumor cell growth (Baby *et al*., 2017). Polymethoxylated flavones (PMF) exist widely in citrus, which has been shown to be lethal to a variety of cancer cell lines (DLA, MCF-7, A549, and HepG2) (Ajikumaran *et al*., 2018). Multiple methoxy groups endow PMFs with the ability to penetrate cell membranes, allowing them to work directly within target cancer cells (Gao *et al*., 2018).

Compared to vincristine (an anticancer drug), the extract of citrus peel has less toxicity to normal cells, which means it can be added to foods as nutraceuticals and cancer preventive agents (Ajikumaran *et al*., 2018). Hyperlipidemia and hyperglycemia are frequent diseases, they seriously threaten human health and are often difficult to cure completely. They will cause a variety of complications, including cardiovascular and cerebrovascular disease, chronic kidney failure, and fatty liver disease. Tangerine and Nobiletine May Lower Serum Cholesterol and triacylglycerol, possibly by inhibiting the binding of the sterol regulatory element protein (Duan, *et al*., 2017). The mechanism underlying the antibacterial activity of antioxidants is still unclear, however, some studies have shown that there are three possible mechanisms due to its antibacterial activity: permeability of the outer membrane, cytoplasmic leakage, and inhibition of nucleic acid formation (Zhang, *et al*., 2017). Flavonoids can directly affect the growth of bacteria and inhibit their pathogenic activity (Papuc, *et al.* 2017), such as Cutibacterium acnes (they lead to acne), Streptococcus mutans, and Lactobacillus acidophilus (cause dental caries) (Shetty *et al*. 2016). Flavonoids are closely related to the cellular oxidant-antioxidant enzyme system and inhibit some of the enzymes that produce reactive oxygen species, including NADH oxidase, glutathione S-transferase, mitochondrial succinoxidase, and microsomal monooxygenase, and improve the the activity of the antioxidant enzymes SOD, CAT, and GPx (Lu *et al*., 2021).

Anthocyanins

Proanthocyanidins and anthocyanidins come from the same branch of flavonoids biosynthesis pathway, which mainly includes catechins, epicatechins, and their polymers, which are unique reddish-brown substances found in fruits, they also determine the bitterness and astringency of the fruits and their secondary products (Zhou, *et al*. 2019). So far more than 600 different anthocyanidins have been identified and widely distributed in at least 27 families, 73 genera, and innumerable species exhibit health benefits; such as inhibition of certain cancers, protection of the cardiovascular and nervous systems, balance of glucose and lipid metabolism, which have been shown in experiments in vitro mammalian, and human clinical and epidemiological models studies.

They are capable of scavenging free radicals by donating the hydrogen atom or indirectly inhibiting free radicals by chelating free metal ions(Yue, *et al*. 2019, Blagojevi´c, *et al*. 2021, Lila *et al*. 2016).

Anacardium occidentale L.

Botanical description

Anacardium occidentale L. also known as cashew, pajuil, marañon, anacardo belongs to the Anacardiaceae family (Table 2). It is a tree native to South America (Figure 2). The trees measure approximately 25 m in height and 40 cm in diameter, has simple leaves of light green color, alternate with petioles 3 to 25 mm long and 3 to 12 cm wide, showing a rounded or obtuse apex, the base has a cuneate or obtuse shape with venation printed on the beam and prominent on the underside of yellowish color contains 8 to 18 pairs of glabrous secondary veins. The flowers are presented in pedicels 2 to 5 mm long, sparse to densely pubescent with lanceolate, elliptical-lanceolate or ovate sepals 3 to 6.5 mm long and 1 to 2 mm wide, pubescent abaxially; The petals are white or greenish with pink or red lines in the anthesis turning to dark red after pollination. On the other hand, the fruits are fleshy yellow, orange or red, 5 to 15 cm long, while the seeds have a gray or brown coloration when ripe with subreniform shapes of 2 to 3.5 cm long and 1 cm wide, thick leathery testa with oily cotyledons and parallel to each other (Fonseca and Medina-Lemos, 2012; La selva, 2013; CONABIO, 2021; FN, 2021).

Figure 2 Tree and fruit of *Anacardium occidentale* L.
Source: KonaboSur [Photograph]

Kingdom	Plantae
Division	Magnoliophyta
Class	Magnoliopsida
Order	Sapindales
Family	Anacardiaceae
Genus	*Anacardium*

Table 2. Botanical classification of *Anacardium occidentale* L.
Source: Cronquist, 1981; Cronquist 1988

Cashew production

Regarding cashew production globally (Figure 3), FAO (2019) announced Ivory Coast (792,678 t), India (743,000 t) and Burundi (283,383 t) as the main producers of cashew in shell. In Mexico, the cashew producing states are Campeche, Chiapas and Guerrero, with a production of 3,563 t (SIAP, 2019). It can also be found in tropical areas of several states such as Colima, Guerrero, Oaxaca, Sinaloa, Tabasco, Yucatan and Veracruz.

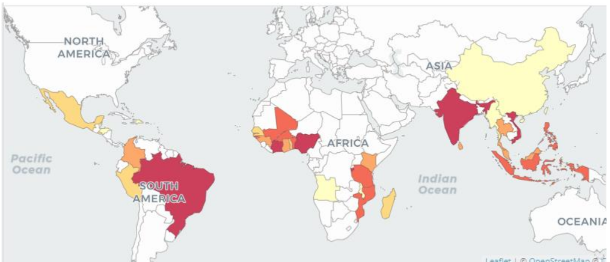

Figure 3 Geographical distribution of the main cashew producers
Source: FAOSTAT, 2019

Applications of cashew tree and its by-products

The cashew tree provides various products and by-products with various applications in health and the environment.

Leaves and stems

From the cashew tree, the leaves and/or stem are used as traditional medicine for the treatment of eczema, psoriasis, scrofula, dyspepsia, venereal diseases, sexually transmitted diseases, sexual impotence, bronchitis, cough and menstrual and intestinal cramps (Franca *et al*., 1993).

Tree bark

In populations of Brazil, the inhabitants use the bark of the cashew tree as an infusion for the treatment of leprosy and burns, and as a healing agent. These infusions are prepared with pieces of approximately 9 cm2 of bark dehydrated in the sun (Perone, 2012). Authors such as Sokeng *et al*. (2001) mention that extracts from cashew roots, stems and fruits have been used by Camaruneses and other countries for traditional medicine as it is known for its anti-inflammatory effects.

Resin

From the bark of the tree a yellowish resin is obtained by natural exudation or by incisions in the trunks and / or branches, has fungicidal and insecticidal properties and is used as a glue for wood when mixed with water, it can also be used in the manufacture of paints and varnishes (Lorenzi, 2004). Mothe *et al.* (2006) studied the intragastric intake of cashew gum in spontaneously hypertensive rats, observing a 20% reduction in blood pressure and a 4% decrease in left ventricular weight/cardiac mass, indicating that cashew gum may have contributed as a promoter of cardiac cells, delaying their hypertrophy.

Seed

The seed or also known as cashew nut or "Indian nut" (Figure 4a) has been used as a snack or as a main ingredient in culinary preparations and desserts. Cashew nut is rich in unsaturated fatty acids such as palmitoleic acid, oleic acid and linoleic acid, as well as good sources of protein, carbohydrates and dietary fiber (INC, 2016).

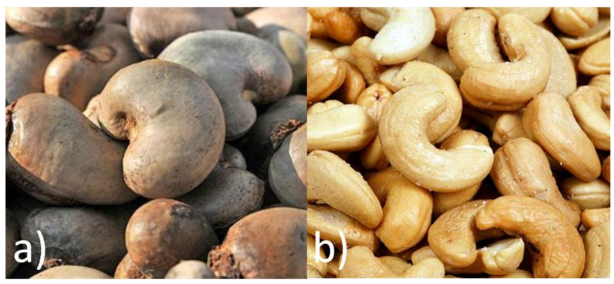

Figure 4 (a) Shelled cashew seed and (b) shelled

Seed Shell

The seed is covered by a dark green hard shell (Figure 4b). This peel has been studied for its phenolic content (107mg EAG/100g) (Uslu and Özcan, 2017). From the shell can be extracted 15 to 30% of oil called "cashew shell liquid", also known as Cashew nut Shell liquid or CNSL (for its acronym in English) used in industry as a raw material for anticorrosives, waterproofing, preservatives and in the manufacture of paints, fungicides, insecticides, disinfectants, emulsifiers, surfactants and plastics (Akinhanmi, 2008; Mubofu and Mgaya, 2018).

This oil is toxic and corrosive to the skin. However, it has high concentrations of saturated and unsaturated long-chain phenols such as cardol 15.15 ± 0.37, anacardial acids 26.49 ± 1.07 (15:3), 15.18 ± 1.98 (15:2) and 21.44 ± 0.31 (15:0) and cardanol 0.80 (Tyman *et al*. 1989). It is worth mentioning that the composition of the CNSL varies with respect to the extraction method used (Table 3).

Extraction method	Composition	Reference
Solvents	60-65% anacardiac acid 10-15% cardanol 20% cardol and traces of 2-methylcardol	Kumar *et al*., 2002.
Hight temperaturas	60-65% de cardanol	
Mechanics	42% cardol 47% anacardic acid 3% cardanol	Rodriguez *et al*., 2011
Combined extraction (mechanical-solvent)	97.78 ± 1.32% oil of which 61% is oleic acid	Lafont *et al*., 2010
Microwave heating	44% Oil Phenolic Compounds (catechin 17-50 mg/100g) 59.59-61.82% oleic acid 18.20-26.28% palmitic acid 4-9.49% stearic acid	Uslu and Özcan, 2017

Table 3 Different methods of extraction of CNSL and its composition

Fruit

The cashew fruit is firm and juicy and has a high concentration of sugars, strong flavor, low acidity and high astringency (Das and Arora, 2016). It contains fiber, tannins and carotenoids (Fonteles *et al*., 2017). Its main use is to obtain juice used in the production of alcoholic beverages and vinegar (Vergara *et al*., 2010). Some studies carried out on cashew pseudofruit have shown its high content of vitamin C, 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).

Bagasse

After the extraction of the juice by pressing, 25% of the residue called bagasse is generated. Fonteles *et al*., (2016) evaluated the vitamin C content in sonicated samples of dehydrated cashew bagasse with hot air, showing content of 2244mg EAG/100g in sonicated sample, while the non-sonicar samples obtained values of 200mg EAG/100g. Nagaraja *et al*., (2007) obtained a similar result, where they determined 269mg of vitamin C/100g. Morales *et al*., (2019) dehydrated cashew bagasse by microwave at 390W and obtained 777 ± 0.01 mg EAG/100g of dehydrated bagasse of phenolic compounds with respect to fresh bagasse (681mg EAG/100g of fresh sample), preserving color and other bioactive compounds such as carotenoids. Matias *et al*., in 2005 analyzed fresh cashew bagasse dehydrated by a tray dryer at 55°C, finding that fresh bagasse contains 33.10 ±0.75% fiber and dehydrated bagasse 44.53 ± 0.24% fiber. Brito *et al*., (2007) detected 13 flavonols and an anthocyanin, of which 3-O-galactoside, 3-O-glucoside, 3-O-rhamnosside, 3-O-xylopyranoside, 3-O-arabinopyranoside, 3-O-arabinopyranoside, kaemperol 3-O-glucoside in a hydroalcoholic extract of the Cashew Pseudofruit, demonstrating the content of quercetin (0.1139 ± 0.00 mg/g) and myricetin (0.1511 ± 0.01 mg/g) in a hydroalcoholic extract of cashew bagasse. Among the uses and applications of cashew bagasse, is the work of Guedes-Oliveira *et al*., (2016) where they evaluated washed cashew fiber, as a substitute for fat 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 genera of Lactobacillus and Bifidobacterium (Dantas *et al*., 2017). Table 4 shows some *in vivo* studies carried out on cashew bagasse and its impact.

Specifications	Results	Reference
Evaluation of hydroalcoholic extract obtained from cashew bagasse in mice with induced obesity	↓ 67% liver weight ↓ 48% body weight ↓ 44% blood glucose ↓ 37% adipose tissue	Beejmohun *et al*., 2015
Evaluation of the anti-obesity activity of ethanolic cashew extract	The group fed with standard diet and the one supplemented with cashew extract did not present differences compared to the obese group where the values of body weight, total cholesterol, LDL and VLDL were elevated.	Jhansyrani *et al*., 2019
Cashew fiber without low molecular weight metabolites in obesity-induced mice	↓ Body weight ↓ Abdominal adipose tissue ↓ Liver weight	Carvalho *et al*., 2019

Table 4 Cashew bagasse assessments in in vivo models

Conclusion

Antioxidants are molecules with great biological impact since they are related to the stabilization of compounds harmful to health. So it is very important to publicize their basic concepts, the methods by which they are detected in food, and their relationship with various pathologies, in order to find natural sources that can be used as adjuvants in the treatment of some diseases. There are some little-known fruits that contain appreciable amounts of bioactive compounds such as polyphenols, such is the case of the cashew tree that have large amounts of phenolic compounds in the fruit and seed with great antioxidant activity such as flavonoids especially quercetin, myricetin that have been favorably related to the treatment of cardiovascular diseases, and condensed tannins that have been studied for their antibacterial and anticarcinogenic activity, as well as for their participation in inhibition in the formation of thrombi in the circulatory system. Not forgetting that the stem, leaves, and bark of the tree also have bioactive compounds with anti-inflammatory and healing activity.

The studies presented here give way to various investigations for future evaluations *in vivo* models and as possible components of functional foods.

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