Received: 31 December 2022 | Accepted: 17 April 2023

DOI: 10.1002/fft2.250

FOOD FRONTIERS Open Access

REVIEW ARTICLE

The nutritional and bio-active constituents, functional activities, and industrial applications of cashew (*Anacardium occidentale*): A review

Ying-Ying Chen[1] | **Ning-yang Li**[2] | **Xu Guo**[1] | **Hai-jie Huang**[3] | **P. Garcia-Oliveira**[4] | **Jin-yue Sun**[1] | **Jian-dong Zhang**[5] | **M. A. Prieto**[4,6] | **Zhi-qing Guo**[7] | **Chao Liu**[1]

[1]Key Laboratory of Novel Food Resources Processing, Ministry of Agriculture and Rural Affairs/Key Laboratory of Agro-Products Processing Technology of Shandong Province/Institute of Agro-Food Science and Technology, Shandong Academy of Agricultural Sciences, Jinan, China

[2]College of Food Science and Engineering, Ocean University of China, Qingdao, Shandong, China

[3]Tropical Crops Genetic Resources Institute, Chinese Academy of Tropical Agricultural Sciences & National Cultivar Improvement Center of Tropical Fruit Tree, Haikou, China

[4]Nutrition and Bromatology Group, Department of Analytical Chemistry and Food Science, Faculty of Science, Universidade de Vigo, Ourense, Spain

[5]Department of Oncology, The First Affiliated Hospital of Shandong First Medical University & Shandong Provincial Qianfoshan Hospital, Shandong Key Laboratory of Rheumatic Disease and Translational Medicine, Jinan, China

[6]Centro de Investigação de Montanha (CIMO), Instituto Politécnico de Bragança, Bragança, Portugal

[7]Shandong Peanut Research Institute, Shandong Academy of Agricultural Sciences, Qingdao, China

Correspondence
M. A. Prieto, Nutrition and Bromatology Group, Department of Analytical Chemistry and Food Science, Faculty of Science, Universidade de Vigo, E32004 Ourense, Spain.
Email: mprieto@uvigo.es

Jin-yue Sun and Chao Liu, Key Laboratory of Novel Food Resources Processing, Ministry of Agriculture and Rural Affairs/Key Laboratory of Agro-Products Processing Technology of Shandong Province/Institute of Agro-Food Science and Technology, Shandong Academy of Agricultural Sciences, 23788 Gongye North Road, Jinan 250100, China.
Email: moon_s731@hotmail.com and liuchao555@126.com

Zhi-qing Guo, Shandong Peanut Research Institute, Shandong Academy of Agricultural Sciences, 126 Wannianquan Road, Qingdao 266100, China.
Email: zhiqingivy2011@hotmail.com

Abstract

Cashew nut is a globally popular nut not only for its delicious and crunchy flavor but also for bioactive compounds, which present positive benefits to human health. Different parts of cashew have characteristic compounds. The kernel of cashew nut is rich in fatty acids, the testa is rich in polyphenols, cashew apple is rich in polyphenols and carotenoids, and phenols with aliphatic long chain are present in the cashew nutshell liquid. Therefore, the edible part of cashew possesses a wide range of bioactive compounds, with reported biological properties, including anti-tumor, brain health, cardiovascular and cerebrovascular protection, anti-diabetic, gastroprotection, pathophysiological disorders protection, and antioxidant. On the other hand, the inedible part of cashew, the cashew nutshell liquid, could play an important role in the industry as surface coatings, insulating formulations and so on. Hence, there are considerable demands to increase the added value of cashew, thereby exploring greater economic value. Thus, this review summarizes nutrients, bioactive compounds, biological functions, and applications of *Anacardium occidentale* to provide a theoretical basis and inspiration for further in-depth studies and utilization.

Ying-Ying Chen, Ning-yang Li, and Xu Guo contributed equally to this study.

Jian-dong Zhang, Department of Oncology, The First Affiliated Hospital of Shandong First Medical University & Shandong Provincial Qianfoshan Hospital, Shandong Key Laboratory of Rheumatic Disease and Translational Medicine,16766 Jingshi Road, Jinan, China.
Email: zhangjd165@sina.com

Funding information
National Key R&D Program of China, Grant/Award Number: 2021YFE0109200; Natural Science Foundation of Shandong, Grant/Award Numbers: ZR2020MH401, ZR2021QH351; National Natural Science Foundation of China, Grant/Award Number: 82003632; Province Agricultural Major Application Technology Innovation Project of Shandong, Grant/Award Number: 2021SFGC0904; Provincial Agricultural Science and Technology Fund for Park Promotion Project of Shandong, Grant/Award Number: 2019YQ026; Agriculture Scientific and Technological Innovation Program of Shandong Academy of Agriculture Sciences, Grant/Award Number: CXGC2022B07

KEYWORDS
Anacardium occidentale, applications, bioactive compounds, bioactivities, cashew nut

1 | INTRODUCTION

Anacardium occidentale L., commonly known as cashew nut, is a popular nut worldwide. Together with hazelnuts, almonds, and walnuts, cashew nuts are considered four big nuts. The genus *Anacardium* (Anacardiaceae family) is composed of 15 species including *A. occidentale*. This species is a perennial tree native to the northeast of Brazil, now widely cultivated in tropical areas around the world. In 2020, estimates of Food and Agriculture Organization of the United Nations (FAO) indicated that the worldwide production of cashew nut with shell was 4.18 million tons harvested in 7.10 million hectares, with Cote d'Ivoire, India, Vietnam, Philippines, and Tanzania being the main producers.

From an anatomical point of view, *A. occidentale* is divided into cashew apple, cashew nutshell, and cashew nut. Cashew apple is a pseudocarp, formed by the swelling of the receptacle. It makes up approximately 90% of the total weight of the whole cashew fruit (Schweiggert et al., 2016). Different varieties of ripe cashew apples have three colors: yellow, orange, and red. Cashew apples can be consumed directly as fresh fruits because of soft peel, juicy pulp, and no seed (Rodríguez et al., 2017). However, since cashew apples contain tannins, they always give an astringent taste and dry mouth feeling when consumed fresh (Rodríguez et al., 2017). In addition, the short storage period and easy to decay limit the consumption of cashew apple. This matrix can be processed into juices, alcoholic beverages, and preserves, even though the processing rate is less than 20% (Poornakala et al., 2020). Since cashew nuts are the main exploited and commercial product, abundant cashew apples are discarded as byproducts in the fields after cashew nuts harvest, which results in a huge waste of resources, giving rise to environmental complications and economic expenses. Therefore, to increase their utilization rate, it is necessary to develop new processing technologies with cashew apples, which could solve the issue of environmental pollution and also increase the profit of the food industry.

The fruit of cashew consists of an outer shell (cashew nutshell, CNS), the cashew nutshell liquid (CNSL), an inner shell (testa), and the kernel (cashew nut, CN). On average, the CNS, CNSL, testa, and CN make up approximately 25%, 25%, 2%, and 48% of the total fruit weight, respectively (Peungjitton et al., 2009; Setianto et al., 2009). The CNSL amounts to 30%–35% of the shell, is a dark brown viscous liquid (Shi et al., 2019), and is caustic and inedible. This matrix is rich in unsaturated long-chain phenols, which possess more chemical reactive nature. Depending on the extraction process, two types of CNSL are considered: extracted immature CNSL (iCNSL) and technical CNSL (tCNSL), which is a residue obtained during the processing of cashew nut. From an industrial perspective, tCNSL could be a promising raw material for different products such as surface coatings, insulating formulations, lacquers, phenolic resin, epoxy resin, alkyd resin, anticorrosive paint, refractory heat insulation coating, mildew resistant coating, and brake lining (Roy et al., 2022). Therefore, the application of CNSL cannot be underestimated in the cashew industry.

Cashew nut is a kidney-shaped seed. It is the core product of the cashew industry. According to FAO statistics, in 2020, its global export quantity was 0.69 million tons, with an export value of 4.41 million USD of shelled cashew nut. The cashew nuts need to be shelled after roasting or cooking. Then, the nuts are dried and peeled to obtain the white kernel. This kernel is a high-quality nut, which consists of approximately 20% proteins, 23% carbohydrates, and 45% fats (Das et al., 2014). Through parching or oil roasting, the kernel possesses a crispy texture and a delicious flavor. The excellent organoleptic properties, high nutritional quality, and attributed beneficial health effects (mainly related to the regulation of lipid profile and blood pressure) make the cashew popular among consumers globally. However, cashew nut may cause food allergy, similar to other types of tree nuts, because of the seed storage proteins.

Therefore, this review summarized the nutrients of edible parts of cashew, the bioactive compounds of all parts of cashews, and their biological functions for the first time. Furthermore, the authors discussed the exploitation and applications of all parts of cashew, focusing on food processing, advanced material, and the chemical product industry, providing strategies for the utilization of cashew and other tree nut byproducts. It is considered that this extensive information could stimulate more in-depth studies to continue the development of high value-added products based on cashews.

2 | NUTRIENTS AND BIOACTIVE COMPOUNDS OF CASHEW

2.1 | Cashew nut

Previous studies on the kernel of cashew have revealed its main nutrients and their corresponding contents (Table 1). In the following sections, some of these compounds will be described in more detail.

TABLE 1 Nutritional value of cashew nuts.

Energy (kcal)	**574**
Energy (kJ)	2402
Protein (g per 100 g)	15.31
Essential amino acids (mg/100 g cashew nut)	
Lysine	5287
Tryptophan	107
Phenylalanine	2139
Methionine	387
Threonine	414
Isoleucine	874
Leucine	2229
Valine	1347
Histidine	1823
Arginine	<5.00
Cystine	632
Tyrosine	1064
Non-essential amino acids (mg/100 g cashew nut)	
Alanine	918
Aspartic acid	1266
Glutamic acid	3055
Glycine	784
Hydroxylysine	<5.00
Proline	1011
Serine	674
Total lipids (g per 100 g)	46.35
FA saturated	9.157
FA monounsaturated	27.317
FA polyunsaturated	7.836
Carbohydrates (g per 100 g)	32.69
Sugars, total	5.01
Fiber, total dietary	3
Water (g per 100 g)	1.7

Source: USDA National Nutrient Database for Standard Reference (2017–2018 FNDDS data). Abbreviation: FA , fatty acid.

2.1.1 | Lipidic compounds

Cashew nuts are energy-dense food and provide 24.02 kJ/g energy. About 46.35% of the nut weight is fat, representing 9.157% saturated fatty acids and 35.153% unsaturated fatty acids. Other relevant fat-soluble compounds have been identified in cashew nuts, including vitamin E and phytosterols. As has been extensively described, in natural matrix, vitamin E exists mainly as four tocopherols (α, β, γ, and δ) and four tocotrienols (α, β, γ, and δ). Among these compounds, γ-tocopherol is the most abundant, which exhibits a potent efficient antioxidant activity. Regarding phytosterols, β-sitosterol is the most abundant. These compounds have been reported to have positive effects on cardiovascular diseases because of their ability to reduce the levels of serum low-density lipoprotein (Delgado-Zamarreño et al., 2016). Specifically, 100 g cashew nut oil contains 6.18 mg of β- and γ-tocopherol, 0.51 mg of α-tocopherol, 0.41 mg of δ-tocopherol, 176.80 mg of β-sitosterol, 11.67 mg of stigmasterol, 10.53 mg of campesterol, and 12.7 mg of squalene (Alasalvar & Pelvan, 2011; Esche et al., 2013). In addition, phenolic lipid compounds have been identified in cashew nut (Suo et al., 2012).

2.1.2 | Proteins

In cashew nut, 20 types of amino acid were detected after protein hydrolyzation (Table 1), including nine essential acids (Wattanathorn et al., 2017). Cashew nut also contain histidine, cystine, and tyrosine. Besides, non-essential amino acids such as glutamic acid, aspartic acid, and proline were also present in high amounts. Therefore, cashew nut is a high-quality protein source because of its abundant variety of amino acids and great quantity (Wattanathorn et al., 2017). As mentioned above, cashew nut allergens have been identified as seed storage proteins. Vicilin-like protein or 7S globulin, legumin-like protein or 11S globulin, and 2S albumin have been characterized as the major allergens (Mattison et al., 2018; Robotham et al., 2005; Wang et al., 2003).

2.1.3 | Other bioactive compounds

Other remarkable bioactive compounds that have been identified in cashew nut are shown in Figure 1. It is a considerable source of

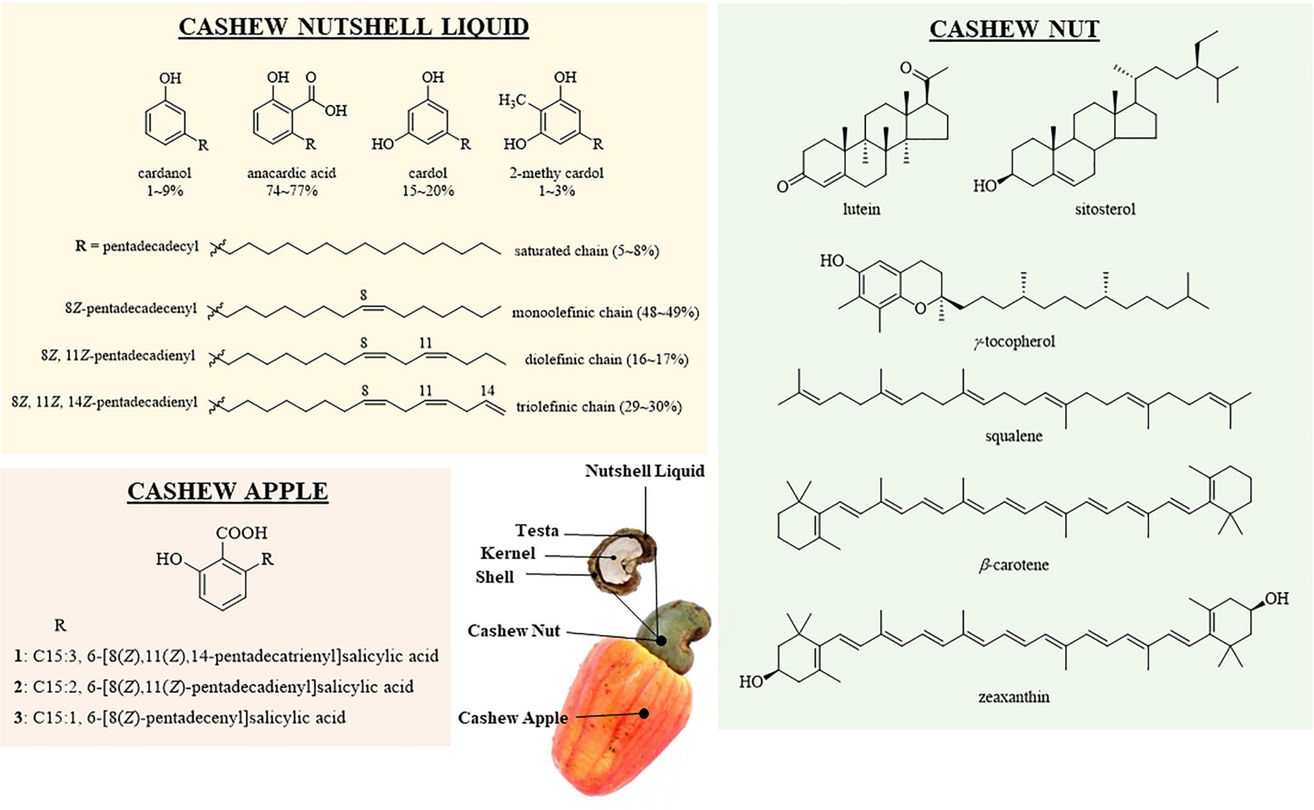


FIGURE 1 Chemical structures of bioactive compounds from cashew nut, cashew nutshell liquid (CNSL), and cashew apple.

B-vitamins, showing high concentrations of thiamine (B1), riboflavin (B2), and pyridoxine (B6), with values of 93, 402, and 306 μg per 100 g of cashew nut, respectively (Stuetz et al., 2017) (Table 2). Additionally, phytochemical studies have reported the presence of phenolic compounds, flavonoids, alkaloids, terpenoids, steroids, tannins, saponins, and cardiac glycosides (Nkwocha et al., 2020).

Quantitative phytochemical analysis of cashew nut showed that it contained flavonoids (2.980 ± 0.560%), alkaloids (0.440 ± 0.080%), phenols (26.513 ± 1.996 mg/kg), terpenoids (5.220 ± 0.319 mg/kg), steroids (0.670 ± 0.051 mg/kg), cardiac glycosides (33.840 ± 0.020%), saponins (1.540 ± 0.360%), and tannins (0.765 ± 0.000%) (Sajilata & Singhal, 2006). Phenolic acids such as syringic, flavonoids such as (+)-catechin, (−)-epicatechin, and epigallocatechin were identified in the kernel and testa (Table 2) (Chandrasekara & Shahidi, 2011).

2.2 | Cashew apples

Cashew apples are rich in dietary fibers, reducing sugars (fructose and glucose), ascorbic acid (vitamin C), and diverse bioactive compounds (Das et al., 2021; Fonteles et al., 2017). Specifically, dietary fibers correspond to 61.21% of the dry matter, including 13.25% soluble and 47.96% insoluble fibers (Tamiello-Rosa et al., 2019). Regarding bioactives, every 100 g of fresh cashew apples contains 190 mg of vitamin C, 9.5 mg of anthocyanins, 63.8 mg of flavonoids, and 0.4 mg of total carotenoids (Rufino et al., 2010). On the other hand, dry fruits were richer in extractable polyphenols, reaching 830 mg of gallic acid equivalents. It seemed that the pulps contained more bioactive compounds, with 739 mg gallic acid equivalents (GAE)/kg of total phenolics, 122 mg of catechin equivalents/kg of flavonoids, and 0.69 mg of β-carotene and 0.95 mg of lycopene per 100 g of sample (Zielinski et al., 2014). Moreover, phytochemical investigations on yellow-, orange-, and red-peeled cashew apples revealed that their predominant bioactive metabolites are carotenoids, polysaccharides, and a wide range of phenolics including anthocyanins and flavonoids (A. G. Cunha et al., 2017; Tamiello-Rosa et al., 2019).

2.3 | Cashew nutshell liquid

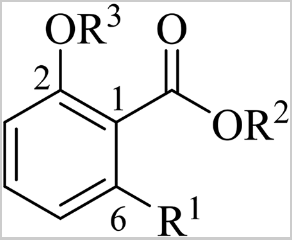
CNSL is a good source of unique phenols with an aliphatic side-chain (Himejima & Kubo, 1991; Kubo et al., 1986). The side-chain of 15 carbon atoms includes saturated, mono-olefinic, di-olefinic, and tri-olefinic (Zhuang et al., 2010), with an average value of two double bonds per compound. The phenols can be classified into four types, according to the substituents on the benzene ring: cardanol, cardol, 2-methyl cardol, and anacardic acid (Caillol, 2018; Oliveira et al., 2011). In addition, other compounds have been identified in tCNSL using gas chromatography–mass spectrometry, revealing the presence of cardanols (40.26%), cardols (29.95%), phytosterol (10.68%), triacontanes (4.66%), and anacardic acid (1.79%) (Dos Santos et al., 2011). With the continuous research on the constituents of CNSL,

TABLE 2 Vitamins, carotenoids, tocopherols, squalene, and phenols of raw cashew nut (μg per 100 g).

B1 (thiamine)	**93 ± 10**			
Total B2 (riboflavin, FAD, and FMN)	402 ± 6			
%FAD of total B2	13			
%FMN of total B2	39			
%Riboflavin of total B2	48			
Total B6 (PM, PL, and PN)	306 ± 25			
%PM of total B6	11			
%PL of total B6	59			
%PN of total B6	30			
Lutein/zeaxanthin	88 ± 3			
β-Carotene	6 ± 1			
Tocopherols (mg/g nut)	0.07 ± 0.00			
Tocopherols (μg/100 mg oil)	15.5 ± 1.0			
%*α*-Tocopherol	6.1 ± 1.2			
%*γ*-Tocopherol	88.6 ± 0.4			
%*δ*-Tocopherol	5.3 ± 0.9			
Squalene (mg/g nut)	0.06 ± 0.04			
Squalene (μg/100 mg oil)	12.7 ± 8.3			
	Soluble phenolics		Bound phenolics	
	Kernel	Testa	Kernel	Testa
Yield (g/100 g of DM)	23.1 ± 1.20	42.9 ± 0.90	0.18 ± 0.01	7.32 ± 0.15
TPC (GAE mg/g of DM)	1.14 ± 0.43	269.05 ± 9.77	0.028 ± 0.01	1.36 ± 0.10
PC (CE mg/g of DM)	0.11 ± 0.01	23.89 ± 0.50	0.01 ± 0.01	0.31 ± 0.01

Note: Data are expressed as the mean ± SD ($n = 3$). Means SD followed by the same letter within a column are not significantly different ($p > 0.05$).
Abbreviations: CE, catechin equivalents; DM, defatted meal; FAD, flavin adenine dinucleotide; FMN, flavin mononucleotide; GAE, gallic acid equivalents; PC, proanthocyanidins content; PL, pyridoxal; PM, pyridoxamine; PN, pyridoxine; TPC, total phenolic content.

TABLE 3 New compounds of cashew nuts (Suo et al., 2012).



		***R*¹**	***R*²**	***R*³**
1	$C_{42}H_{70}O_4$	8*Z*-pentadecenyl	H	8*Z*-eicosenoyl
2	$C_{39}H_{62}O_4$	8*Z*, 11*Z*-pentadecadie	CH_3	9*Z*-hexadecenoyl
3	$C_{41}H_{64}O_4$	8*Z*, 11*Z*-pentadecadieny	H	10*Z*, 13*Z*-nonadecadienoyl
4	$C_{47}H_{80}O_4$	8*Z*-pentadeceny	H	16*Z*-pentacosenoyl
5	$C_{41}H_{66}O_4$	8*Z*, 11*Z*-pentadecadienyl	CH_3	9*Z*-octadecenoyl

new compounds are still being discovered and identified as shown in Tables 3-5.

TABLE 4 Antioxidant activity analyses in cashew apple and juice.

Antioxidant activity method	Cashew apple	Cashew apple juice
2,2-Diphenyl-1-picrylhydrazyl	9397 g/g	4.07 mg Trolox/g
2, 2′-Azino-bis (3-ethylbenzo thiazoline-6-sulfonic acid)	7.8 m mol Trolox/g	1.73 mg Trolox/g
Ferric reducing ability of plasma	22.9 m mol Fe_2SO_4/g	1.34 mg ascorbic acid/g
Total polyphenol content	1.18 ± 0.04 mg gallic acid/g	1.29 ± 0.15 mg gallic acid/g
Total flavonoid content	0.59 ± 0.01 mg quercetin/g	0.61 ± 0.06 mg quercetin/g

TABLE 5 Occurrences of microbes isolated from cashew nut oil.

	Weeks						
	0	2nd	4th	6th	8th	10th	12th
Bacteria							
Bacillus licheniformis	–	–	+	+	–	–	–
Staphylococcus aureus	+	+	+	+	–	–	–
Fungi							
Articosporium inflate	–	+	+	–	–	–	–
Aspergillus flavus	–	+	+	–	+	+	+
Aspergillus saprophyticus	–	–	–	+	+	+	+
Penicillium notatum	+	–	+		+	+	+

Note: +, positive; –, negative.

3 | FUNCTIONAL PROPERTIES OF CASHEW BIOACTIVE COMPOUNDS

The biological properties of cashew bioactives have been studied in recent decades, which will be discussed in later subsections. In addition, numerous studies have been compiled in Figure 2.

3.1 | Anti-tumor activity

Several studies have reported the anti-tumor activity of cashew bioactive compounds. For example, in BT-20 breast carcinoma cells, three anacardic acids (6-[8(*Z*),–11(*Z*),14-pentadecatrienyllsalicylic acid (1), 6-[8(*Z*),11-(Z) pentadecadienyllsalicylic acid (2), and 6-[8(*Z*)-pentadecenyl] salicylic acid (3)) isolated from cashew apple were identified as the main cytotoxic agents (Kubo, Ochi, et al., 1993). Similarly, anacardic acid (AA) was demonstrated to inhibit nuclear factor-κB (NF-κB). The release of the intermembrane proapoptotic factors from the mitochondria disequilibrated between pro- and anti-apoptotic B-cell lymphoma-2 (Bcl-2) family members diminished heat shock protein 70 (Hsp 70) and increased apoptosis-inducing factor (Zheng et al., 2020), which could have a key role in mitochondrial-mediated apoptosis in AA-treated A549 cells. The investigation indicated AA as a potential drug for curing lung cancer (Seong et al., 2013).

3.2 | Neuroprotective effects

Alzheimer's disease (AD) is one of the most common types of dementia. Lately, researchers have proposed that the neurodegeneration associated with this disease is caused by a reduction in the acetylcholine, due to the action of acetylcholinesterase (AChE), which terminated the cholinergic neurotransmission. Thus, utilizing AChE inhibitors to palliate symptoms caused by cholinergic disequilibrium has been considered a promising approach in the treatment of AD. In this sense, several studies have reported the neuroprotective effects of cashew bioactive compounds. For instance, Silva's research results supported iCNSL providing potent cellular antioxidant preservation against hydrogen peroxide and inhibiting AChE activity. Such characteristics can be related to iCNSL's chemical compounds, including anacardic acids, cardol, and cardanol. Therefore, iCNSL could be a candidate in research for the treatment of neurodegenerative processes, including cognitive deficiencies that occurred during regular cerebral aging and Alzheimer's and Parkinson's diseases (M. I. G. Silva et al., 2005). Other studies reported that alkylphenolic (cardanol and anacardic acid) and resorcinolic lipids (cardol and methylcardol) from CNSL inhibited the activity of AChE from *Electrophorus electricus*. The results indicated that these compounds were effective inhibitors of AChE, and IC_{50} values of alkylphenol, anacardic acid, cardol, and methylcardol were 4 ± 0.24, 3 ± 0.24, 3.5 ± 0.2, and 5 ± 0.41 μM, respectively (Stasiuk et al., 2014).

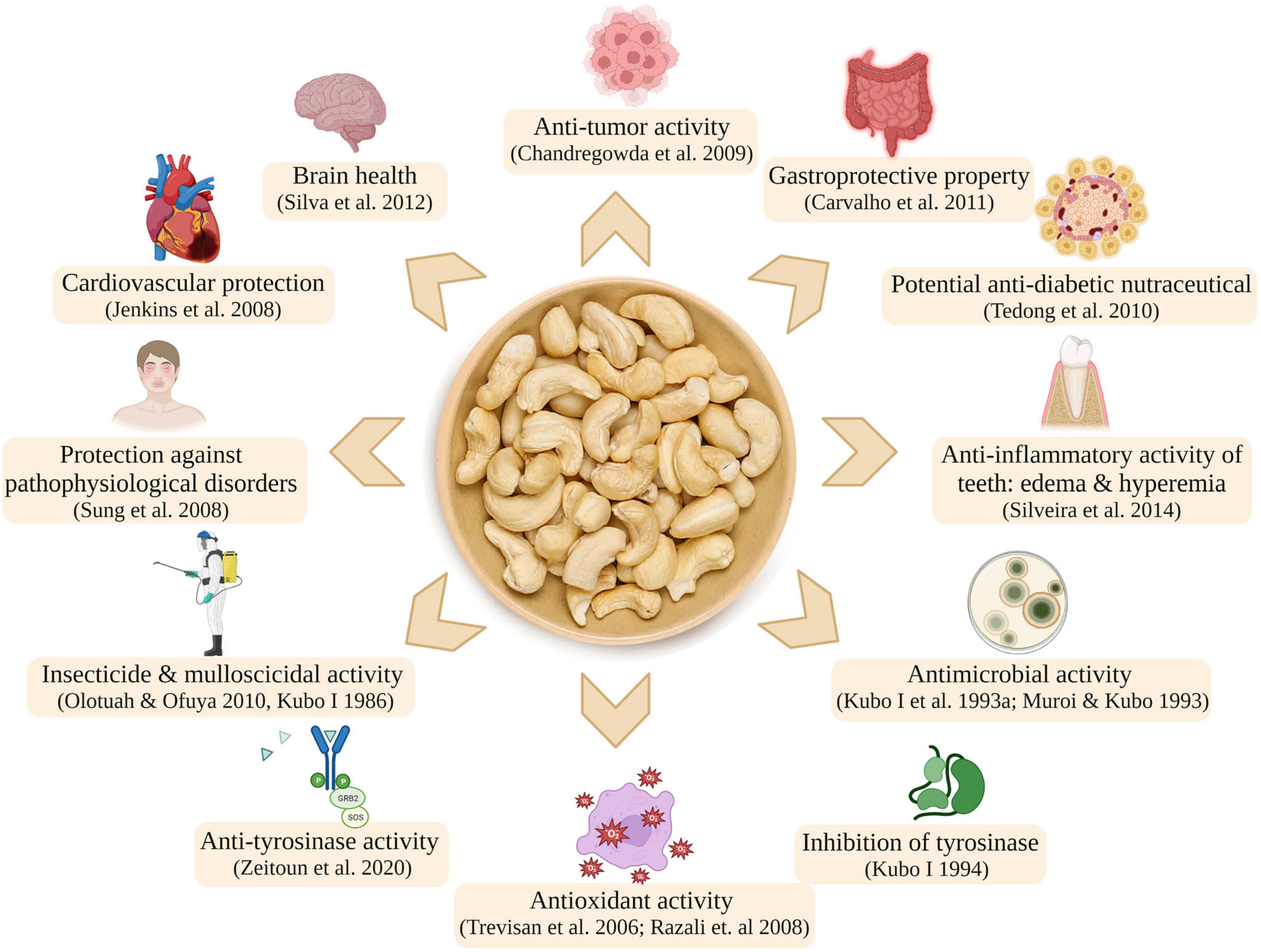


FIGURE 2 Functions of bioactive compounds from cashew nuts.

3.3 | Cardiovascular and cerebrovascular protection

The beneficial effects of cashew nut ingestion on cardiovascular system have been extensively proved, which have been attributed to lipids and lipoproteins metabolites. Lately, several epidemiological and clinical studies have demonstrated that regular cashew nut consumption was associated with favorable plasma lipid profiles (Griel & Kris-Etherton, 2006; King et al., 2008) and decreased danger of coronary heart disease (Kelly & Sabaté, 2006; Kris-Etherton et al., 2008; Li et al., 2009; Ros et al., 2010; Sabaté & Wien, 2010), type II diabetes (Jenkins et al., 2008; Jiang et al., 2002; Kendall et al., 2010), and cancer (Davis et al., 2008; González & Salas-Salvadó, 2006) and improved metabolic syndrome situations (Kendall et al., 2010).

Cashew apple is rich in dietary fiber, and the cashew nut comprises abundant protein (So et al., 2010). Thus, cashew was an appropriate natural resource for exploiting food supplement to prevent ischemic stroke. Cashew nut-derived protein was regarded as the potential cerebroprotectant for the treatment of focal cerebral ischemia. The consumption safety threshold value was up to 5000 mg/kg body weight. Since it can make great effect on multitargets simultaneously, it may provide high benefit for the complex disorders such as stroke (Wattanathorn et al., 2017).

3.4 | Anti-diabetic characteristics

The anti-diabetic characteristics of cashew sections were studied utilizing differentiated C2C12 myotubes and rat liver mitochondria. Hydroethanolic cashew seed extract and its active ingredients, mainly AA, increased glucose transport into C2C12 myotubes in a dose-dependent mode. Activation of adenosine monophosphate-stimulated protein kinase by the extract and AA likely increased plasma membrane glucose transporters, causing a rise in glucose consumption. In addition, the dysfunction of mitochondrial oxidative phosphorylation may uplift glycolysis and promote glucose consumption raise (Tedong et al., 2010).

3.5 | Gastroprotective property

Lately, AAs from *A. occidentale* were also investigated for their gastroprotective capacities utilizing the ethanol-induced gastric damage in mice (Morais et al., 2010). Results demonstrated that these components provided gastroprotection, principally relying on antioxidant mechanism, stimulated endogenous prostaglandins and nitricoxide, and unfolded K + ATP channels. In addition, AAs in the CNSL were biologically active as gastroprotectors, inhibitors of the capacity of different deleterious enzymes, anti-*Helicobacter pylori*, antitumor agents, and antioxidants (A. L. N. Carvalho et al., 2011).

3.6 | Antioxidant activity

In cashew nut, AAs, cardanols, and sand cardols have been demonstrated to exert antioxidant activity. For instance, a study reported that the shape of the inhibition curve of xanthine oxidase by AA ($C_{15:3}$) is sigmoidal ($IC_{50} = 162 \pm 10\ \mu M$) (Kubo et al., 2006). The antioxidant activity of the fruit is also high among several commercial fruits, presenting antioxidant activities measured by 2,2-diphenyl-1-picrylhydrazyl (DPPH), 2,2′-azino-bis(3-ethylbenzothiazoline-6-sulfonic acid) (ABTS), and ferric reducing ability of plasma (FRAP) assays. The results showed values of 9397 g/g DPPH, 7.8 m mol Trolox/g, and 22.9 m mol Fe_2SO_4/g, respectively (Rufino et al., 2010). The antioxidant potential of cashew apple was assessed by different assays aiming at a throughout view of the main class of compounds that provided a good estimation of the potential in different oxidative reactions. The total polyphenol content and the total flavonoid content of the untreated cashew apple juice were 1.29 ± 0.15 mg gallic acid/g and 0.61 ± 0.06 mg quercetin/g, respectively. Research from Rufino et al. (2010) and Moo-Huchin et al. (, 2014) reported similar values (1.18 ± 0.04 mg gallic acid/g and 0.59 ± 0.01 mg quercetin/g for cashew apple). The antioxidant activity of the untreated cashew apple juice was measured by FRAP, DPPH, and ABTS assays, and the values were of 1.34 mg ascorbic acid/g, 4.07 mg Trolox/g, and 1.73 mg Trolox/g, respectively (Rodríguez et al., 2017) (Table 4). As reported, testa-containing kernels provide high amounts of catechins and higher concentrations of β-carotene, lutein, and α-tocopherol than those of testa-free cashew nut kernels. These antioxidant ingredients could have potential health benefits for consumers (Trox et al., 2011). Moreover, high-temperature short time roasting effectively enhanced the antioxidant capacity of cashew nuts and testa. In addition, cashew testa possessed a higher extract yield, total phenolic content, and proanthocyanidins in both soluble and bound fractions compared to that in entire kernels. Beside CNSL, cashew nut, apple, and testa, cashew apple wine (CAW) had also demonstrated effective antioxidant capacities in the employed in vitro assays. The total polyphenols content and total antioxidant activity were 160 mg GAE/100 mL and 132 mg/100 mL which indicated that phenolic compounds and ascorbic acid may play a pivotal role in the antioxidant function (Zhong & Li, 2012).

3.7 | Antityrosinase activity

Tyrosinase is a key component of the enzyme polyphenol oxidase, which plays an important role in the melanogenesis and enzymatic browning. Therefore, tyrosinase inhibitors can be attractive in cosmetical industries as depigmentation compounds, as well as in food industries as antibrowning agents. Phenolic and triterpenoid compounds obtained from plants are widely reported as tyrosinase inhibitors. For instance, phenolic compounds and other phytochemicals in the extracts of *A. occidentale* fruits have been demonstrated to be effective in inhibiting the enzymatic capacity of tyrosinase (Zeitoun et al., 2020). Cardol triene isolated from CNSL was first reported to be a potent irreversible inhibitor to mushroom tyrosinase for the oxidation of $_L$-DOPA. Compared to cardanol and AA, cardol triene exhibited the highest inhibitory potency (Kubo et al., 1994). The tyrosinase enzymatic activity was completely inhibited, while the cardol triene concentration reached 55 μM. The inhibitor concentration leading to 50% activity lost (IC_{50}) was estimated up to 22.5 μM (Zhuang et al., 2010).

3.8 | Antimicrobial activity

Cardol ($C_{15:3}$), cardol ($C_{15:2}$), and cardol ($C_{15:1}$) had antimicrobial capacities against several Gram-positive bacteria such as *Staphylococcus aureus*, *Streptococcus mutans*, *Bacillus subtilis*, *Brevibacterium ammoniagenes*, and *Propionibacterium acnes* (Himejima & Kubo, 1991; Kubo, Muroi, et al., 1993). Antimicrobial activity of AA has been demonstrated against *P. acnes*, *H. pylori*, *S. mutans*, and *S. aureus* (Hollands et al., 2016; Kubo, Muroi, et al., 1993; Muroi, 1996). The bactericidal and antimicrobial activities of AA against *S. aureus* and methicillin-resistant *S. aureus* (MRSA) have already been reported. AA had a minimum inhibitory concentration of 6.25 μg/mL against *S. aureus* (Muroi, 1996).

3.9 | Insecticide

AA, cardanol, and cardol, the main ingredients of natural CNSL, were acquired by solvent extraction and assessed for antioxidant, larvicidal, and antiacetylcholinesterase activity. The utilization of CNSL has been attracting more attention because of its possession of the active phenolic compounds, AA and cardol which also have corrosive and abrasive characteristics. It was proved that proper concentration of CNSL could be efficacious in preventing *Callosobruchus maculatus*. Moreover, CNSL was also reported in controlling oviposition in *C. maculatus* (Olotuah & Ofuya, 2010); powders and oils of *A. occidentale* seed and *Allium sativum* can be utilized as biopesticides against *C. maculatus* especially when weevil perforation index is taken into account (Ileke & Olotuah, 2011). In addition, the remarkable toxicity effects of *A. occidentale* shell wastes extract against the third and fourth instars larvae of *Aedes aegypti* demonstrate their promising utilization as natural larvicides for the prevention of dengue vector. The mechanism of behavior of many insecticides was the constraint of the enzyme acetylcholinesterase; hence, CNSL constituents may also prevent *A. aegypti* mosquitoes based on this mechanism. Larvicidal products can be exploited from the isolated ingredients of the *A. occidentale* shell wastes (Ileke & Olotuah, 2011). CNSL was also reported to be a potential natural insecticide against termites and demonstrated 100% mortality at concentrations of 6%, 8%, and 10%. Recent research revealed the utilization of the technical CNSL ingredient cardol as a new environmentally friendly larvicidal agent that can abate the spread of dengue (Lomonaco et al., 2009).

4 | APPLICATIONS AS INGREDIENT IN FUNCTIONAL FOODS, INDUSTRY, PHARMACY

4.1 | Application in food science

The byproducts generated during the cashew apple agro-industrial processing may exert prebiotic effects on different potentially probiotic *Lactobacillus* species using in vitro experimental models (Lomonaco et al., 2009). Many studies have proved byproducts as a source of bioactive phytochemicals, particularly those with validated antioxidant properties (De Abreu et al., 2013; de Albuquerque et al., 2015)

Prebiotic components promote the selective growth of beneficial probiotic bacteria in the colon, which have been related to numerous beneficial effects in the host, such as regulating intestinal transit and stimulation of colon enzymes, improving mineral absorption, regulating cholesterol and glucose levels, reducing the incidence of colon cancer, and strengthening immune system and inhibiting pathogenic bacteria (Gan et al., 2020; Gibson et al., 2004; Sreenivas & Lele, 2013). Among the probiotics, the *Lactobacillus* species are the most abundant, and they have been intensively studied during the past decades for their probiotic properties (Liu et al., 2014). Specifically, the species of this genus produce different organic acids, which reduce the luminal pH, inhibiting the growth of pathogenic bacteria (Piccioni et al., 2023).

The economic losses of cashew apples could be diminished by means of processing them into a shelf-stable intermediate moisture product (Paramasivam, 2010). Many processes have already been exploited and standardized for transforming cashew apples into value-added products such as power, candy, distilled products, jam, and juice (Nwosu et al., 2016) (Figure 3). Juice from the cashew apple offers potential alternative uses, including fermenting into wine, probiotic beverages, and bioethanol (Prommajak et al., 2014). In addition, cashew apple pectins could contribute to exploit future pharmacological, nutritional, and biotechnological utilization for this industrial garbage from the cashew nut production (Tamiello-Rosa et al., 2019).

4.1.1 | Unfermented cashew apple beverages

Cashew apples contain about 65%–85% of juice. Analytical results indicated that this juice (CAJ) possessed specific gravity and pH of 1.050 and 4.52, respectively. The highest sugars were glucose (40.56 g/L) and fructose (57.06 g/L). Other chemical compounds of the juice were vitamin C (112 mg/100 mL), condensed tannin (55.34 mg/mL), and total protein (1.78 g/L). In addition, the mineral content was as follows: sodium (5.44 ppm), magnesium (4.320 ppm), copper (2.18 ppm), zinc (1.39 ppm), iron (1.32 ppm), and manganese (1.24 ppm). With these findings, South African CAJ is a suitable biomass feedstock for ethanol production (Deenanath et al., 2015).

Commercially, two types of juices, namely pulpy and clarified juice, are currently available on the market. Unlike clarified juice, pulpy juice retains larger amount of compounds, which contribute to aroma and flavors of the fruit compared to clarified juice (Da Silva et al., 2000). Therefore, pulpy juice is more popular among consumers. However, a concern related to the pulpy juice was that it became sediment within handful days of storage and presented an unappealing appearance. The extent of sedimentation was associated with the amount and size of the particles presented in the suspension. To solve this problem, juice concentrate, squash, syrup, and ready-to-serve drinks are some of the nutritious beverages that are made from the cashew apple juice by adding sugar, citric acid, and other preservatives. Several studies reported that blending of the cashew apple juice with other tropical fruits that contained relatively lower vitamin C content (orange, grapes, pineapple, mango and lemon) enhanced the taste, flavor, and acceptability of cashew apple juice (Akinwale, 2000). De Carvalho et al. developed a blended beverage based on cashew apple juice, coconut water, and caffeine. Though all tested formulations showed good microbiological qualities, the formulation of 12.5% of cashew apple juice and 87.5% of coconut water attained the highest sensory scores. In addition, the residual solid part after extraction of the juice (pomace) was suggested to be utilized as an animal feed or further processed to recover the dietary fiber for its subsequent use in bakery products (J. M. de Carvalho et al., 2007).

4.1.2 | Fermented cashew apple beverages

Cashew apples fermented products such as wine, ethanol, and probiotic beverages have also been reported, which mainly fermented with *Saccharomyces* species (J. M. de Carvalho et al., 2007). Recently, non-conventional yeast with more diverse aroma profiles capacity have been employed (Gamero et al., 2019). Mohanty et al. (2006) reported the detailed process of an undistilled alcoholic beverage (wine) by fermenting CAJ employing *S. cerevisiae* var. *bayanus* yeast. Mohanty et al. discovered that the taste, aroma, and flavor of cashew apple wine were of inferior quality compared with grape wine. The principal reason was no attempt removing tannins from the CAJ before fermentation, therefore, the presence of high tannins caused an astringent wine taste. And it obtained poor sensory score on taste and flavor (Mohanty et al., 2006). Neelakandan & Usharani (2009) optimized conditions for ethanol production from cashew apple juice utilizing immobilized yeast cells. The maximum yield of ethanol was up to 7.6% at optimized fermentation parameters. However, due to the initial moderate sugar content concentration (about 10% w/v) of the cashew apple, their utilization for bioethanol production may not be feasible compared with other competing substrates (Neelakandan & Usharani 2009). Besides wine and bioethanol, cashew apple can also be used as a good source for enzymes production.

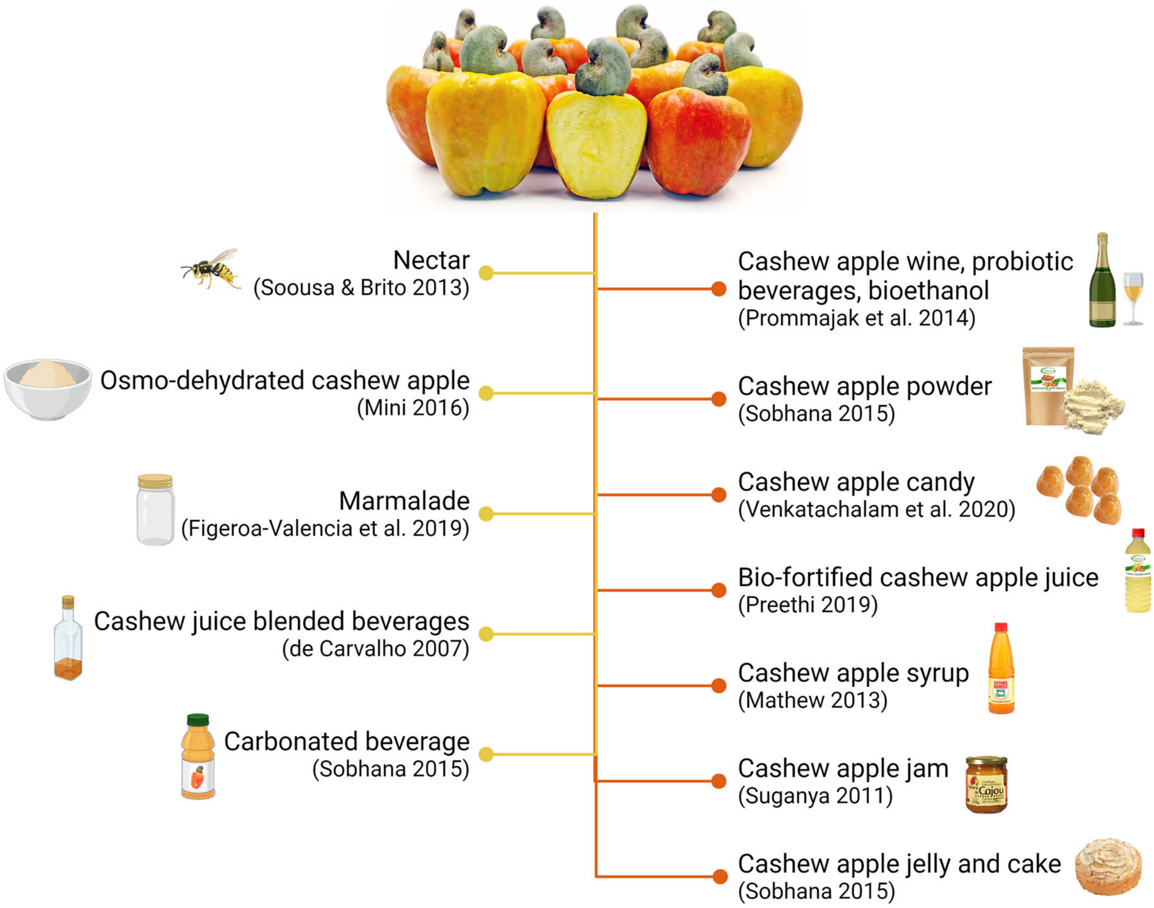


FIGURE 3 Value-added cashew apple processed products.

4.1.3 | Cashew apple powder

Utilizing cashew apple to make value-added products has an enormous scope in the market. Dried cashew apple powder of high quality and beneficial sensory characteristics could be utilized in the improvement of derived products such as bread spread, chocolates, sponge cakes, wheat derived confectionaries, and cookies (Neelakandan & Usharani 2009). Cakes and chocolates have been standardized at the Cashew Research Station, Kerala, India. Nevertheless, the big issue in the process of producing cashew apple power was the large financial investment in the drying equipment manipulation. The values of vitamin C loss in the process of drying were reported up to 34%–44% (Kuila et al., 2011). To boost the cashew apple powder-derived products, the producer needs to deeply find out the production cost, market potential, shelf life of the derived products, the current status of the technology, and so on.

4.1.4 | Functional extract from cashew apple waste

After juice extraction, up to 30%–40% of the cashew apple remained as pomace that could be utilized as animal feed (Rodrigues et al., 2008). Chemical analysis was conducted on cashew apple pomace, and the ingredients were moisture (58%), volatile matter (32%), cellulose (14.2), reducing sugar (7.25%), starch (4.28%), and ash (1.07%) (Kuila et al., 2011). The proximal composition of cashew apple pomace was previously reported as follows: ash (1.92%), starch (15.09%), and protein (22.66%). Antioxidant compounds and mineral composition were also studied (Preethi et al., 2021). Bioactive compounds such as anthocyanins (Da Silva, et al., 2000), carotenoids, and flavonoids (de Lopes et al., 2012) were reported in the cashew apple pomace. A large amount of these bioactive compounds (ranging from 700 to 6588 mg GAE/100 g dry matter, depending upon cultivars) remained in the pomace (Andrade et al., 2015). In addition, the pomace was also abundant in non-digestible carbohydrates (dietary fiber), reducing sugars and ascorbic acid (Matias et al., 2005). Dried pomace, rich in fiber, was also used for manufacturing fiber rich cookies (Matias et al., 2005). Moure et al. proved that considerable antioxidants could be extracted from cashew apple pomace and those could be applied in the dairy, meat, and bakery industries (Moure et al., 2001). Kuila et al. optimized process parameters (liquid to solid ratio, pH, incubation time, and temperature) for aqueous extraction of reducing sugars from cashew apple pomace to improve the yield. Fortunately, the yield of reducing sugar reached up to 56.89 g per 100 g of dry material under optimal extraction conditions (3.26 mL/g, pH 6.42, 6.3 h and 52.27°C) (Kuila et al., 2011).

In addition, cashew apple pomace can be utilized for preparing multiple value-added prebiotics, nutraceutical food, and animal feed products. It is also applied in manufacturing biofuels among several others such as bio-based chemicals. Thus, extra economic profits could be made available to both the cashew growers and the manufacturers (Das & Arora, 2017). Fiber in the cashew apple without low molecular weight compounds may be utilized as a preventive effect on obesity. Fiber in the cashew apple without low molecular weight compounds promoted satiety in mice fed a high fat diet, improving the metabolism of glucose and lipids. Positive effects of obesity prevention may be related to short-chain fatty acid production (D. V. Carvalho et al., 2019).

4.1.5 | Functional extract from cashew nut kernel

After cashew nut kernel oil extraction, the residues formed a cake with nutritional value. The cake can be utilized as a peanut substitute of a candy known in Brazil called Pacoca, which used the mixture of peanut with other ingredients such as corn flour, wheat flour, honey, sugar, and oil. Venkatachalam's study provided an alternative use to the byproduct of the cashew kernel oil production (Venkatachalam et al., 2020).

4.2 | Application in industry

CNSL, accounting for 32% of the cashew nutshell, was acquired as a byproduct of the industrial processing of cashew nuts in tropical countries as follows: Brazil, Tanzania, India, Kenya, and Mozambique. CNSL had considerable industrial applications and was exploited as a raw material for products such as brake linings, coatings, and paints (Akinwale, 2000).

CNSL-derived products can be utilized as chemical intermediates or additives: low budget side products/renewable natural resources or their derivatives may be applied as organo-modifiers for kaolin to impart excellent compatibility with non-polar rubbers with requisite physico-mechanical characteristics for different application (Peter et al., 2015). Distilled technical cashew nut shell liquid was applied as an additive to convert triglycerides to biofuel, and there was no need for methyl esters formation (Sanjeeva et al., 2014). CNSL was composed almost entirely of phenolic compounds including 15-carbon chains with variable unsaturation degree, meta-substituted in the aromatic ring. The homogeneity of these compounds with the structures represented as effective peptizing agents for asphaltenes. CNSL and its derivates, cardanol, and polycardanol were evaluated and confirmed as asphaltene stabilizing agents (Moreira et al., 1999). Cardanol has been developed as a potential substitute fuel for diesel engine (Velmurugan et al., 2014). Antioxidants CNSL contains alkyl-substituted phenolic compounds, and molecules show antioxidants properties because of their structures, which can be utilized as sources of eco-friendly antioxidants for lubricants (Mazzetto & Rios, 2009). Sodium cardanol sulfate surfactant was derived from cardanol, which can be utilized as a substitute of anionic surfactant (Peungjitton et al., 2009). In the coatings industry, the substitution of petroleum-derived materials by bio-based materials has been in trend because the latter are renewable, abundantly available, inexpensive, non-toxic, and biodegradable. CNSL was considered an adaptable and valuable crude material for thermally stable polymeric coatings manufacturing (Zafar et al., 2019). CNSL formaldehyde resins are used for brake liner binding preparation. Resins obtained from CNSL can be utilized as binders for agglomerates. Moreover, the resin derived from heating CNSL, phenol, and hexamethylenetetramine demonstrated proper characteristics of tensile strength, strength, and compressibility perpendicular traction (Telascrêa et al., 2014). Although there are plenty of applications of CNSL and its components, anacardic acid, and cardanol, there are very few examples of the transformation of cashew nut shell liquid and its components into small value-added molecules.

4.3 | Application in pharmacy

Many sections of the cashew tree are utilized in traditional medicine for curing disease. For example, the kernels were ground into poultice and applied in treating snakebites. Cashew fruits, barks, and leaves were also applied as antifungal, antipyretic, and antidiarrhea agents (Dahake et al., 2009). In addition, Tédong et al. (2005) proved that cashew kernels can reduce diabetes caused functional and histological change in the kidneys. And the hypoglycaemic function of cashew plant was mainly reported in type I diabetes. Streptozotocin-caused diabetes in rats has been demonstrated to be related to kidney functional and morphological alterations. Ingested gradient doses of cashew plant extract (150 and 300 mg/kg/day), the blood glucose level, total secreted protein, glycosuria and urea of diabetic rats were shown an obvious decline.

Relatively inexpensive cardanol is an inedible component of CNSL. It has been successfully converted to important and high-value medicinal drugs, such as norfenefrine, phenylephrine, etilefrine, and fenoprofen in desirable yields by mainly catalytic reactions. For fenoprofen, the key methoxy-carbonylation step has been demonstrated with good enantioselectivity. The greener solvent, 2-methyl THF, gave very good results for the metathesis of cardanol (Shi et al., 2019).

5 | SAFETY ASPECTS OF CASHEW NUT

5.1 | Microbes in cashew nut and its derived products

Cashew nut intake is highly recommended as a natural dietary supplement because of its outstanding nourishing and healthy nutrients; however, few risks are also associated with its intake due to the presence of potential contaminants such as bacterial toxins (chloramphenicol) (Adetunji et al., 2019) and fungal toxins such as aflatoxins, fumonisins, and deoxynivalenol (S. C. Cunha et al., 2018), heavy metals, pesticides, and allergic response (Table 5). The poor and unhygienic production and storage conditions of cashew nuts may favor the microbial spoilage due to molds, lactic acid bacteria, and Enterobacteriaceae, which grow optimally at moderate temperatures. This increases the health risk linked to the intake of fresh cashew apple and kernels, whereas the cashew kernels after drying are reported as microbiologically safe (Lima et al., 2012).

5.2 | Pesticide residues and allergic reactions

Residues of pesticide in cashew and its derived products have already raised a global concern. Jardim et al.'s research aimed at completely verifying a multi-residues method to analyze 46 pesticides and its metabolites in cashew apple and other fruits by gas chromatography-micro electron capture detectors, gas chromatography-flame photometric detectors, and liquid chromatography coupled to tandem mass spectrometry, and the data demonstrated that none of the pesticides was detected in cashew apple (Jardim et al., 2014).

In addition, cashew nut is a forceful allergen causing severe and sometime near fatal allergic reactions often requiring epinephrine cure and hospitalization, especially in children. To date, three kinds of seed storage allergenic proteins (Ana o 1-vicilin, Ana o 2-legumin, and Ana o 3-2S albumin) in cashew nut have been identified and described, which have been categorized as main allergens, being embraced in the WHO/IUIS authorized list of allergens. Tiny amounts of cashew nut protein (1 mg) can cause a harmful immunological reaction in allergic individuals (Mendes et al., 2019).

Since the prevalence of cashew nut allergy is rising with increasing consumption, the allergenic potential of cashew nuts is an underestimated essential healthcare issue, and it should be given more attention. Based on the Codex Alimentarius Commission and/or the European Union standards, several countries have adopted allergen labeling regulatory frameworks (Gendel, 2012). Tree nuts (cashew nut) are one of eight groups causing allergic reactions; consequently, they are embraced in the allergenic food list with mandatory labeling in many countries/regions like the United States, Canada, the European Union, Japan, and Korea (Gendel, 2012).

6 | CONCLUSIONS AND FUTURE PERSPECTIVES

Cashew nut provides not only delicious delicacy but also a great source of bioactive phytochemicals that provide health and economic benefits to human. Different organs of cashew nut have different uses and effects. However, the degree of development and utilization of each part differs greatly at present. The cashew nut kernel is found to have a higher grouping of fatty acids, proteins, B-vitamins, phenolic acids, flavonoids, and other bioactive constituents. The cashew apple possesses plenty of dietary fibers, reducing sugars, ascorbic acid, carotenoids, polysaccharides, and a wide range of phenolics. The CNSL is a good source of unique phenols with 15 carbon atoms aliphatic sidechain. Cashews have a broad range of functional activities including brain health, cardiovascular and cerebrovascular protection, anti-tumor, antioxidant, anti-diabetic, anti-inflammatory, and anti-microbial activities.

Cashews are pillar industry in some countries. They have wide market prospect. With people's continuous attention to a healthy diet, cashew nuts are becoming better every day in the traditional food industry and the functional food industry. Cashew apples, a byproduct of cashew nut, will be fully utilized through fermentation or processing into functional food. CNSL, a byproduct of processing and separating cashew nuts, is one of the important natural phenol sources with economic value. The industrial application of CNSL is based on the fact that phenolic substances can be polymerized by physical or chemical means. It can replace some chemical raw materials. Advantages of renewable, inexpensive, and abundant in resources will make CNSL more promising utilization.

With the development and application of efficient shell breaking and peeling equipment, the traditional cashew processing industry will be welcomed to improve the quality and efficiency and reduce the cost. Cashew, especially cashew nuts and cashew apples, will be widely used in snack food, functional food, personal care products, and cosmetics that have high added value and a huge number of consumer groups. Cashew nutshell liquid, as an important strategic material, will play a crucial part in advanced coatings and polymer materials along with the development of extraction and purification technology.

ACKNOWLEDGMENTS

This study was supported by the National Key R&D Program of China (No. 2021YFE0109200); the Natural Science Foundation of Shandong, China (No. ZR2020MH401, ZR2021QH351); the National Natural Science Foundation of China (No. 82003632); the Province Agricultural Major Application Technology Innovation Project of Shandong, China (No. 2021SFGC0904); the Provincial Agricultural Science and Technology Fund for Park Promotion Project of Shandong, China (No. 2019YQ026); the Agriculture Scientific and Technological Innovation Program of Shandong Academy of Agriculture Sciences (No. CXGC 2022B07); the Taishan Scholars's Program of Shandong for Jinyue Sun.

CONFLICT OF INTEREST STATEMENT

The authors confirm that they have no conflict of interest to declare for this publication.

ORCID

M. A. Prieto https://orcid.org/0000-0002-3513-0054

REFERENCES

Adetunji, M. C., Aroyeun, S. O., Osho, M. B., Sulyok, M., Krska, R., & Mwanza, M. (2019). Fungal metabolite and mycotoxins profile of cashew nut from selected locations in two African countries. *Food Additives and Contaminants—Part A Chemistry, Analysis, Control, Exposure and Risk Assessment*, *36*(12), 1847–1859. https://doi.org/10.1080/19440049.2019.1662951

Akinwale, T. O. (2000). Cashew apple juice: Its use in fortifying the nutritional quality of some tropical fruits. *European Food Research and Technology*, *211*(3), 205–207. https://doi.org/10.1007/s002170050024

Alasalvar, C., & Pelvan, E. (2011). Fat-soluble bioactives in nuts. *European Journal of Lipid Science and Technology*, *113*(8), 943–949. https://doi.org/10.1002/EJLT.201100066

Andrade, R. A. M. d. S., Maciel, M. I. S., Santos, A. M. P., & Melo, E. de A. (2015). Optimization of the extraction process of polyphenols from cashew apple agro-industrial residues. *Food Science and Technology (Brazil)*, *35*(2), 354–360. https://doi.org/10.1590/1678-457X.6585

Caillol, S. (2018). Cardanol: A promising building block for biobased polymers and additives. *Current Opinion in Green and Sustainable Chemistry*, *14*, 26–32. https://doi.org/10.1016/J.COGSC.2018.05.002

Carvalho, A. L. N., Annoni, R., Silva, P. R. P., Borelli, P., Fock, R. A., Trevisan, M. T. S., & Mauad, T. (2011). Acute, subacute toxicity and mutagenic effects of anacardic acids from cashew (*Anacardium occidentale* Linn.) in mice. *Journal of Ethnopharmacology*, *135*(3), 730–736. https://doi.org/10.1016/J.JEP.2011.04.002

Carvalho, D. V., Silva, L. M. A., Alves Filho, E. G., Santos, F. A., De Lima, R. P., Viana, A. F. S. C., Nunes, P. I. G., Fonseca, S. G. D. C., De Melo, T. S., Viana, D. D. A., Gallão, M. I., & De Brito, E. S. (2019). Cashew apple fiber prevents high fat diet-induced obesity in mice: An NMR metabolomic evaluation. *Food and Function*, *10*(3), 1671–1683. https://doi.org/10.1039/c8fo01575a

Chandrasekara, N., & Shahidi, F. (2011). Effect of roasting on phenolic content and antioxidant activities of whole cashew nuts, kernels, and testa. *Journal of Agricultural and Food Chemistry*, *59*(9), 5006–5014. https://doi.org/10.1021/JF2000772/ASSET/IMAGES/LARGE/JF-2011-000772_0001.JPEG

Cunha, A. G., Brito, E. S., Moura, C. F. H., Ribeiro, P. R. V., & Miranda, M. R. A. (2017). UPLC–qTOF-MS/MS-based phenolic profile and their biosynthetic enzyme activity used to discriminate between cashew apple (*Anacardium occidentale* L.) maturation stages. *Journal of Chromatography B*, *1051*, 24–32. https://doi.org/10.1016/J.JCHROMB.2017.02.022

Cunha, S. C., Sá, S. V. M., & Fernandes, J. O. (2018). Multiple mycotoxin analysis in nut products: Occurrence and risk characterization. *Food and Chemical Toxicology*, *114*, 260–269. https://doi.org/10.1016/j.fct.2018.02.039

Da Silva, K. D. P., Collares, F. P., & Finzer, J. R. D. (2000). A simple and rapid method for estimating the content of solids in industrialized cashew juice. *Food Chemistry*, *70*(2), 247–250. https://doi.org/10.1016/S0308-8146(00)00043-1

Dahake, A. P., Joshi, V. D., & Joshi, A. B. (2009). Antimicrobial screening of different extract of *Anacardium occidentale* Linn. leaves. *International Journal of ChemTech Research*, *1*(4), 856–858.

Das, I., & Arora, A. (2017). Post-harvest processing technology for cashew apple—A review. *Journal of Food Engineering*, *194*, 87–98. https://doi.org/10.1016/j.jfoodeng.2016.09.011

Das, I., Sasmal, S., & Arora, A. (2021). Effect of thermal and non-thermal processing on astringency reduction and nutrient retention in cashew apple fruit and its juice. *Journal of Food Science and Technology*, *58*(6), 2337–2348. https://doi.org/10.1007/S13197-020-04744-4/FIGURES/3

Das, I., Shah, N. G., & Kumar, G. (2014). Cashew nut quality as influenced by microwave heating used for stored grain insect control. *International Journal of Food Science*, *2014*, 516702. https://doi.org/10.1155/2014/516702

Davis, P. A., Jenab, M., Vanden Heuvel, J. P., Furlong, T., & Taylor, S. (2008). Tree nut and peanut consumption in relation to chronic and metabolic diseases including allergy. *The Journal of Nutrition*, *138*(9), 1757S–1762S. https://doi.org/10.1093/JN/138.9.1757S

De Abreu, F. P., Dornier, M., Dionisio, A. P., Carail, M., Caris-Veyrat, C., & Dhuique-Mayer, C. (2013). Cashew apple (*Anacardium occidentale* L.) extract from by-product of juice processing: A focus on carotenoids. *Food Chemistry*, *138*(1), 25–31. https://doi.org/10.1016/j.foodchem.2012.10.028

de Albuquerque, T. L., Gomes, S. D. L., Marques, J. E., da Silva, I. J., & Rocha, M. V. P. (2015). Xylitol production from cashew apple bagasse by Kluyveromyces marxianus CCA510. *Catalysis Today*, *255*, 33–40. https://doi.org/10.1016/j.cattod.2014.10.054

de Carvalho, J. M., Maia, G. A., de Figueiredo, R. W., Sousa de Brito, E., & Sueli, R. (2007). Development of a blended nonalcoholic beverage composed of coconut water and cashew apple juice containing caffeine. *Journal of Food Quality*, *30*(2007), 664–681.

de Lopes, M. M. A., de Miranda, M. R. A., Moura, C. F. H., & Filho, J. E. (2012). Compostos bioativos e atividade antioxidante total de pedúnculos de caju (*Anacardium occidentale* L.) durante o amadurecimento de clones de cajueiro anão-precoce. *Ciencia e Agrotecnologia*, *36*(3), 325–332. https://doi.org/10.1590/S1413-70542012000300008

Deenanath, E. D., Rumbold, K., Daramola, M., Falcon, R., & Iyuke, S. (2015). Evaluation of physicochemical properties of south african cashew apple juice as a biofuel feedstock. *Scientifica*, *2015*, 1–9. https://doi.org/10.1155/2015/764196

Delgado-Zamarreño, M. M., Fernández-Prieto, C., Bustamante-Rangel, M., & Pérez-Martín, L. (2016). Determination of tocopherols and sitosterols in seeds and nuts by QuEChERS-liquid chromatography. *Food Chemistry*, *192*, 825–830. https://doi.org/10.1016/J.FOODCHEM.2015.07.083

Dos Santos, T. D. J. A. D. S., Araújo, B. Q., Citó, A. M. D. G. L., Da Silva, J., Saffi, J., Richter, M. F., & Ferraz, A. D. B. F. (2011). Antioxidant properties and chemical composition of technical Cashew Nut Shell Liquid (tCNSL). *Food Chemistry*, *126*(3), 1044–1048. https://doi.org/10.1016/J.FOODCHEM.2010.11.122

Esche, R., Müller, L., & Engel, K. H. (2013). Online LC-GC-based analysis of minor lipids in various tree nuts and peanuts. *Journal of Agricultural and Food Chemistry*, *61*(47), 11636–11644. https://doi.org/10.1021/JF403900Q/ASSET/IMAGES/LARGE/JF-2013-03900Q_0004.JPEG

Fonteles, T. V., Leite, A. K. F., da Silva, A. R. A., Fernandes, F. A. N., & Rodrigues, S. (2017). Sonication effect on bioactive compounds of cashew apple bagasse. *Food and Bioprocess Technology*, *10*(10), 1854–1864. https://doi.org/10.1007/S11947-017-1960-X/TABLES/4

Gamero, A., Ren, X., Lamboni, Y., de Jong, C., Smid, E. J., & Linnemann, A. R. (2019). Development of a low-alcoholic fermented beverage employing cashew apple juice and non-conventional yeasts. *Fermentation*, *5*(3), 1–16. https://doi.org/10.3390/fermentation5030071

Gan, L., Zhao, Y., Mahmood, T., & Guo, Y. (2020). Effects of dietary vitamins supplementation level on the production performance and intestinal microbiota of aged laying hens. *Poultry Science*, *99*(7), 3594–3605. https://doi.org/10.1016/j.psj.2020.04.007

Gendel, S. M. (2012). Comparison of international food allergen labeling regulations. *Regulatory Toxicology and Pharmacology*, *63*(2), 279–285. https://doi.org/10.1016/j.yrtph.2012.04.007

Gibson, G. R., Probert, H. M., Van Loo, J., Rastall, R. A., & Roberfroid, M. B. (2004). Dietary modulation of the human colonic microbiota: Updating the concept of prebiotics. *Nutrition Research Reviews*, *17*(2), 259–275. https://doi.org/10.1079/nrr200479

González, C. A., & Salas-Salvadó, J. (2006). The potential of nuts in the prevention of cancer. *British Journal of Nutrition*, *96*(S2), S87–S94. https://doi.org/10.1017/BJN20061868

Griel, A. E., & Kris-Etherton, P. M. (2006). Tree nuts and the lipid profile: A review of clinical studies. *British Journal of Nutrition*, *96*(S2), S68–S78. https://doi.org/10.1017/BJN20061866

Himejima, M., & Kubo, I. (1991). Antibacterial Agents from the cashew *Anacardium occidentale* (Anacardiaceae) nut shell oil. *Journal of Agricultural and Food Chemistry*, *39*(2), 418–421. https://doi.org/10.1021/jf00002a039

Hollands, A., Corriden, R., Gysler, G., Dahesh, S., Olson, J., Ali, S. R., Kunkel, M. T., Lin, A. E., Forli, S., Newton, A. C., Kumar, G. B., Nair, B. G., Perry, J. J. P., & Nizet, V. (2016). Natural product anacardic acid from cashew nut shells stimulates neutrophil extracellular trap production and bactericidal activity. *Journal of Biological Chemistry*, *291*(27), 13964–13973. https://doi.org/10.1074/jbc.M115.695866

Ileke, K. D., & Olotuah, O. F. (2011). Bioactivity of *Anacardium occidentale* (L) and *Allium sativum* (L) powders and oils extracts against cowpea bruchid, *Callosobruchus maculatus* (Fab.) [Coleoptera: Chrysomelidae]. *International Journal of Biology*, *4*(1), 96–103. https://doi.org/10.5539/ijb.v4n1p96

Jardim, A. N. O., Mello, D. C., Goes, F. C. S., Frota, E. F., & Caldas, E. D. (2014). Pesticide residues in cashew apple, guava, kaki and peach: GC-μECD, GC-FPD and LC-MS/MS multiresidue method validation, analysis and cumulative acute risk assessment. *Food Chemistry*, *164*, 195–204. https://doi.org/10.1016/j.foodchem.2014.05.030

Jenkins, D. J. A., Hu, F. B., Tapsell, L. C., Josse, A. R., & Kendall, C. W. C. (2008). Possible benefit of nuts in type 2 diabetes. *The Journal of Nutrition*, *138*(9), 1752S–1756S. https://doi.org/10.1093/JN/138.9.1752S

Jiang, R., Manson, J. A. E., Stampfer, M. J., Liu, S., Willett, W. C., & Hu, F. B. (2002). Nut and peanut butter consumption and risk of type 2 diabetes in women. *JAMA*, *288*(20), 2554–2560. https://doi.org/10.1001/JAMA.288.20.2554

Kelly, J. H., & Sabaté, J. (2006). Nuts and coronary heart disease: An epidemiological perspective. *British Journal of Nutrition*, *96*(S2), S61–S67. https://doi.org/10.1017/BJN20061865

Kendall, C. W. C., Esfahani, A., Truan, J., Srichaikul, K., & Jenkins, D. J. A. (2010). Health benefits of nuts in prevention and management of diabetes. *Asia Pacific Journal of Clinical Nutrition*, *19*, 110–116.

King, J. C., Blumberg, J., Ingwersen, L., Jenab, M., & Tucker, K. L. (2008). Tree nuts and peanuts as components of a healthy diet. *The Journal of Nutrition*, *138*(9), 1736S–1740S. https://doi.org/10.1093/JN/138.9.1736S

Kris-Etherton, P. M., Hu, F. B., Ros, E., & Sabaté, J. (2008). The role of tree nuts and peanuts in the prevention of coronary heart disease: Multiple potential mechanisms. *The Journal of Nutrition*, *138*(9), 1746S–1751S. https://doi.org/10.1093/JN/138.9.1746S

Kubo, I., Kinst-Hori, I., & Yokokawa, Y. (1994). Tyrosinase inhibitors from anacardium occidentale fruits. *Journal of Natural Products*, *57*(4), 545–551. https://doi.org/10.1021/np50106a021

Kubo, I., Komatsu, S., & Ochi, M. (1986). Molluscicides from the cashew *Anacardium occidentale* and their large-scale isolation. *Journal of Agricultural and Food Chemistry*, *34*(6), 970–973. https://doi.org/10.1021/jf00072a010

Kubo, I., Masuoka, N., Ha, T. J., & Tsujimoto, K. (2006). Antioxidant activity of anacardic acids. *Food Chemistry*, *99*(3), 555–562. https://doi.org/10.1016/J.FOODCHEM.2005.08.023

Kubo, I., Muroi, H., & Kubo, A. (1993). Antibacterial activity of long-chain alcohols against *Streptococcus mutans*. *Journal of Agricultural and Food Chemistry*, *41*(12), 2447–2450. https://doi.org/10.1021/jf00036a045

Kubo, I., Ochi, M., Vieira, P. C., & Komatsu, S. (1993). Antitumor agents from the cashew (*Anacardium occidentale*) apple juice. *Journal of Agricultural and Food Chemistry*, *41*(6), 1012–1015. https://doi.org/10.1021/jf00030a035

Kuila, A., Singh, A., Mukhopadhyay, M., & Banerjee, R. (2011). Process optimization for aqueous extraction of reducing sugar from cashew apple bagasse: A potential, low cost substrate. *LWT*, *44*(1), 62–66. https://doi.org/10.1016/j.lwt.2010.06.005

Li, T. Y., Brennan, A. M., Wedick, N. M., Mantzoros, C., Rifai, N., & Hu, F. B. (2009). Regular consumption of nuts is associated with a lower risk of cardiovascular disease in women with type 2 diabetes. *The Journal of Nutrition*, *139*(7), 1333–1338. https://doi.org/10.3945/JN.108.103622

Lima, J. R., Garruti, D. S., & Bruno, L. M. (2012). Physicochemical, microbiological and sensory characteristics of cashew nut butter made from different kernel grades-quality. *LWT—Food Science and Technology*, *45*(2), 180–185. https://doi.org/10.1016/j.lwt.2011.08.018

Liu, H., Zhang, J., Zhang, S., Yang, F., Thacker, P. A., Zhang, G., Qiao, S., & Ma, X. (2014). Oral administration of lactobacillus fermentum I5007 favors intestinal development and alters the intestinal microbiota in formula-fed piglets. *Journal of Agricultural and Food Chemistry*, *62*(4), 860–866. https://doi.org/10.1021/jf403288r

Lomonaco, D., Santiago, G. M. P., Ferreira, Y. S., Arriaga, Â. M. C., Mazzetto, S. E., Mele, G., & Vasapollo, G. (2009). Study of technical CNSL and its main components as new green larvicides. *Green Chemistry*, *11*(1), 31–33. https://doi.org/10.1039/b811504d

Matias, M. D. F. O., De Oliveira, E. L., Gertrudes, E., & Dos Anjos Magalhães, M. M. (2005). Use of fibres obtained from the cashew (*Anacardium ocidentale*, L) and guava (*Psidium guayava*) fruits for enrichment of food products. *Brazilian Archives of Biology and Technology*, *48*(Spec. Iss.), 143–150. https://doi.org/10.1590/s1516-89132005000400018

Mattison, C. P., Malveira Cavalcante, J., Izabel Gallão, M., & Sousa de Brito, E. (2018). Effects of industrial cashew nut processing on anacardic acid content and allergen recognition by IgE. *Food Chemistry*, *240*, 370–376. https://doi.org/10.1016/J.FOODCHEM.2017.07.146

Mazzetto, S., & Rios, M. (2009). Cashew nut shell liquid (Cnsl) as source of eco-friendly antioxidants for lubricants. *Proceedings of The 13th International Electronic Conference on Synthetic Organic Chemistry*.

Mendes, C., Costa, J., Vicente, A. A., Oliveira, M. B. P. P., & Mafra, I. (2019). Cashew nut allergy: Clinical relevance and allergen characterisation. *Clinical Reviews in Allergy and Immunology*, *57*(1), 1–22. https://doi.org/10.1007/s12016-016-8580-5

Mohanty, S., Ray, P., Swain, M. R., & Ray, R. C. (2006). Fermentation of cashew (*anacardium occidentale* L.) “apple” into wine. *Journal of Food Processing and Preservation*, *30*(3), 314–322. https://doi.org/10.1111/j.1745-4549.2006.00067.x

Moo-Huchin, V. M., Estrada-Mota, I., Estrada-León, R., Cuevas-Glory, L., Ortiz-Vázquez, E., De Lourdes Vargas Y Vargas, M., Betancur-Ancona, D., & Sauri-Duch, E. (2014). Determination of some physicochemical characteristics, bioactive compounds and antioxidant activity of tropical fruits from Yucatan, Mexico. *Food Chemistry*, *152*, 508–515. https://doi.org/10.1016/J.FOODCHEM.2013.12.013

Morais, T. C., Pinto, N. B., Carvalho, K. M. M. B., Rios, J. B., Ricardo, N. M. P. S., Trevisan, M. T. S., Rao, V. S., & Santos, F. A. (2010). Protective effect of anacardic acids from cashew (*Anacardium occidentale*) on ethanol-induced gastric damage in mice. *Chemico-Biological Interactions*, *183*(1), 264–269. https://doi.org/10.1016/J.CBI.2009.10.008

Moreira, L. F. B., Lucas, E. F., & González, G. (1999). Stabilization of asphaltenes by phenolic compounds extracted from cashew-nut shell liquid. *Journal of Applied Polymer Science*, *73*(1), 29–34. https://doi.org/10.1002/(SICI)1097-4628(19990705)73:1⟨29::AID-APP3⟩3.0.CO;2-O

Moure, A., Cruz, J. M., Franco, D., Manuel Domínguez, J., Sineiro, J., Domínguez, H., Núñez, M. J., & Carlos Parajó, J. (2001). Natural antioxidants from residual sources. *Food Chemistry*, *72*(2), 145–171. https://doi.org/10.1016/S0308-8146(00)00223-5

Muroi, H. (1996). Antibacterial activity of anacardic acid and totarol, alone and in combination with methicillin, against methicillin-resist ant *Staphylococcus aureus*. *Journal of Applied Sacteriology*, *80*(1), 387–394.

Neelakandan, T., & Usharani, G. (2009). Optimization and production of bioethanol from cashew apple juice using immobilized yeast cells by *Saccharomyces cerevisiae*. *American-Eurasian Journal of Scientific Research*, *4*(2), 85–88.

Nkwocha, C. C., Uchendu, N. O., & Amujiri, A. N. (2020). Phytochemicals and chemical compositions of raw cashew (*Anarcardium occidantale*) nuts sourced from Enugu State, South Eastern Nigeria. *Tropical Journal of Natural Product Research (TJNPR)*, *4*(12), 1124–1130. https://doi.org/10.26538/TJNPR/V4I12.3

Nwosu, C., Adejumo, O. A., & Udoha, W. N. (2016). Cashew apple utilization in Nigeria : Challenges and prospects. *Journal of Stored Products and Postharvest Research*, *7*(February), 29–31. https://doi.org/10.5897/JSPPR2015.0190

Oliveira, M. S. C., de Morais, S. M., Magalhães, D. V., Batista, W. P., Vieira, Í. G. P., Craveiro, A. A., de Manezes, J. E. S. A., Carvalho, A. F. U., & de Lima, G. P. G. (2011). Antioxidant, larvicidal and antiacetylcholinesterase activities of cashew nut shell liquid constituents. *Acta Tropica*, *117*(3), 165–170. https://doi.org/10.1016/J.ACTATROPICA.2010.08.003

Olotuah, O. F., & Ofuya, T. I. (2010). Comparative protection of Cowpea, *Vigna unguiculata* (L.) Walpers against field insect pests using cashew nut shell liquid and cypermethrin (Cymbush). *Pakistan Journal of Nutrition*, *9*(2), 158–161. https://doi.org/10.3923/pjn.2010.158.161

Paramasivam, S. (2010). Characterisation of cashew apple (*Anacardium occidentale* L.) fruits collected from Ariyalur district characterisation of cashew apple (*Anacardium occidentale* L.) fruits collected from Ariyalur district. *Journal of Biosciences Research*, *1*(2), 101–107.

Peter, R., Vijay, V. R., Ramakrishnan, S., Sukumar, R., & Menon, A. R. R. (2015). Phosphorylated cashew nut shell liquid prepolymer modified kaolin as a reinforcing filler for natural rubber. *Applied Clay Science*, *105–106*, 186–191. https://doi.org/10.1016/j.clay.2014.12.011

Peungjitton, P., Sangvanich, P., Pornpakakul, S., Petsom, A., & Roengsumran, S. (2009). Sodium cardanol sulfonate surfactant from cashew nut shell liquid. *Journal of Surfactants and Detergents*, *12*(2), 85–89. https://doi.org/10.1007/S11743-008-1082-6/TABLES/2

Piccioni, A., Covino, M., Candelli, M., Ojetti, V., Capacci, A., Gasbarrini, A., Franceschi, F., & Merra, G. (2023). How do diet patterns, single foods, prebiotics and probiotics impact gut microbiota? *Microbiology Research*, *14*(1), 390–408. https://doi.org/10.3390/microbiolres14010030

Poornakala, S. J., Indumathi, V., & Shanthi, K. (2020). Value addition in cashew apple: A review. *International Journal of Chemical Studies*, *8*(6), 819–825. https://doi.org/10.22271/chemi.2020.v8.i6l.10871

Preethi, P., Mangalassery, S., Shradha, K., Pandiselvam, R., Manikantan, M. R., Reddy, S. V. R., Devi, S. R., & Nayak, M. G. (2021). Cashew apple pomace powder enriched the proximate, mineral, functional and structural properties of cereal based extrudates. *LWT*, *139*, 110539. https://doi.org/10.1016/J.LWT.2020.110539

Prommajak, T., Leksawasdi, N., & Rattanapanone, N. (2014). Biotechnological valorization of cashew apple: A review. *Chiang Mai University Journal of Natural Sciences*, *13*(2), 159–182. https://doi.org/10.12982/CMUJNS.2014.0029

Robotham, J. M., Wang, F., Seamon, V., Teuber, S. S., Sathe, S. K., Sampson, H. A., Beyer, K., Seavy, M., & Roux, K. H. (2005). Ana o 3, an important cashew nut (*Anacardium occidentale* L.) allergen of the 2S albumin family. *Journal of Allergy and Clinical Immunology*, *115*(6), 1284–1290. https://doi.org/10.1016/J.JACI.2005.02.028

Rodrigues, T. H. S., Pinto, G. A. S., & Gonçalves, L. R. B. (2008). Effects of inoculum concentration, temperature, and carbon sources on tannase production during solid state fermentation of cashew apple bagasse. *Biotechnology and Bioprocess Engineering*, *13*(5), 571–576. https://doi.org/10.1007/s12257-008-0014-7

Rodríguez, Ó., Gomes, W. F., Rodrigues, S., & Fernandes, F. A. N. (2017). Effect of indirect cold plasma treatment on cashew apple juice (*Anacardium occidentale* L.). *LWT*, *84*, 457–463. https://doi.org/10.1016/J.LWT.2017.06.010

Ros, E., Tapsell, L. C., & Sabaté, J. (2010). Nuts and berries for heart health. *Current Atherosclerosis Reports*, *12*(6), 397–406. https://doi.org/10.1007/S11883-010-0132-5/TABLES/2

Roy, A., Fajardie, P., Lepoittevin, B., Baudoux, J., Lapinte, V., Caillol, S., & Briou, B. (2022). CNSL, a promising building blocks for sustainable molecular design of surfactants: A critical review. *Molecules*, *27*(4), 1–51. https://doi.org/10.3390/molecules27041443

Rufino, M. d. S. M., Alves, R. E., de Brito, E. S., Pérez-Jiménez, J., Saura-Calixto, F., & Mancini-Filho, J. (2010). Bioactive compounds and antioxidant capacities of 18 non-traditional tropical fruits from Brazil. *Food Chemistry*, *121*(4), 996–1002. https://doi.org/10.1016/J.FOODCHEM.2010.01.037

Sabaté, J., & Wien, M. (2010). Vegetarian diets and childhood obesity prevention. *The American Journal of Clinical Nutrition*, *91*(5), 1525S–1529S. https://doi.org/10.3945/AJCN.2010.28701F

Sajilata, M. G., & Singhal, R. S. (2006). Effect of irradiation and storage on the antioxidative activity of cashew nuts. *Radiation Physics and Chemistry*, *75*(2), 297–300. https://doi.org/10.1016/J.RADPHYSCHEM.2005.07.004

Sanjeeva, S. K., Pinto, M. P., Narayanan, M. M., Kini, G. M., Nair, C. B., SubbaRao, P. V., Pullela, P. K., Ramamoorthy, S., & Barrow, C. J. (2014). Distilled technical cashew nut shell liquid (DT-CNSL) as an effective biofuel and additive to stabilize triglyceride biofuels in diesel. *Renewable Energy*, *71*, 81–88. https://doi.org/10.1016/j.renene.2014.05.024

Schweiggert, R. M., Vargas, E., Conrad, J., Hempel, J., Gras, C. C., Ziegler, J. U., Mayer, A., Jiménez, V., Esquivel, P., & Carle, R. (2016). Carotenoids, carotenoid esters, and anthocyanins of yellow-, orange-, and red-peeled cashew apples (*Anacardium occidentale* L.). *Food Chemistry*, *200*, 274–282. https://doi.org/10.1016/J.FOODCHEM.2016.01.038

Seong, Y. A., Shin, P. G., & Kim, G. D. (2013). Anacardic acid induces mitochondrial-mediated apoptosis in the A549 human lung adenocarcinoma cells. *International Journal of Oncology*, *42*(3), 1045–1051. https://doi.org/10.3892/ijo.2013.1763

Setianto, W. B., Yoshikawa, S., Smith, R. L., Inomata, H., Florusse, L. J., & Peters, C. J. (2009). Pressure profile separation of phenolic liquid compounds from cashew (*Anacardium occidentale*) shell with supercritical carbon dioxide and aspects of its phase equilibria. *The Journal of Supercritical Fluids*, *48*(3), 203–210. https://doi.org/10.1016/J.SUPFLU.2008.11.018

Shi, Y., Kamer, P. C. J., & Cole-Hamilton, D. J. (2019). Synthesis of pharmaceutical drugs from cardanol derived from cashew nut shell liquid. *Green Chemistry*, *21*(5), 1043–1053. https://doi.org/10.1039/C8GC03823F

Silva, M. I. G., De Melo, C. T. V., Vasconcelos, L. F., De Carvalho, A. M. R., & Sousa, F. C. F. (2005). Bioactivity and potential therapeutic benefits of some medicinal plants from the Caatinga (semi-arid) vegetation of Northeast Brazil: A review of the literature. *Brazilian Journal of Pharmacognosy*, *22*(1), 193–207.

So, O., Fo, H., Hp, M., Matros, A., & Ogunwolu, S. (2010). Production of protein concentrate and isolate from cashew (*Anacardium occidentale L.*) nut. *African Journal of Food, Agriculture, Nutrition and Development*, *10*(5), 2501–2514. https://doi.org/10.4314/ajfand.v10i5.56334

Sreenivas, K. M., & Lele, S. S. (2013). Prebiotic activity of gourd family vegetable fibres using in vitro fermentation. *Food Bioscience*, *1*, 26–30. https://doi.org/10.1016/j.fbio.2013.01.002

Stasiuk, M., Janiszewska, A., & Kozubek, A. (2014). Phenolic lipids affect the activity and conformation of acetylcholinesterase from *Electrophorus electricus* (Electric eel). 1823–1831. https://doi.org/10.3390/nu6051823

Stuetz, W., Schlörmann, W., & Glei, M. (2017). B-vitamins, carotenoids and α-/γ-tocopherol in raw and roasted nuts. *Food Chemistry*, *221*, 222–227. https://doi.org/10.1016/J.FOODCHEM.2016.10.065

Suo, M., Isao, H., Ishida, Y., Shimano, Y., Bi, C., Kato, H., Takano, F., & Ohta, T. (2012). Phenolic lipid ingredients from cashew nuts. *Journal of Natural Medicines*, *66*(1), 133–139. https://doi.org/10.1007/S11418-011-0564-4/TABLES/1

Tamiello-Rosa, C. S., Cantu-Jungles, T. M., Iacomini, M., & Cordeiro, L. M. C. (2019). Pectins from cashew apple fruit (*Anacardium occidentale*): Extraction and chemical characterization. *Carbohydrate Research*, *483*, 107752. https://doi.org/10.1016/J.CARRES.2019.107752

Tedong, L., Madiraju, P., Martineau, L. C., Vallerand, D., Arnason, J. T., Desire, D. D. P., Lavoie, L., Kamtchouing, P., & Haddad, P. S. (2010). Hydro-ethanolic extract of cashew tree (*Anacardium occidentale*) nut and its principal compound, anacardic acid, stimulate glucose uptake in C2C12 muscle cells. *Molecular Nutrition & Food Research*, *54*(12), 1753–1762. https://doi.org/10.1002/MNFR.201000045

Tédong, L., Théophile, D., Dzeufiet, P., Asongalem, A., Sokeng, S., Callard, P., & Kamtchouing, P. (2005). Antihyperglycemic and renal protective activities of Anacardium occidentale (Anacardiaceae) leaves in streptozotocin induced diabetic rats. *African Journal of Traditional, Complementary and Alternative Medicines*, *3*, 23–35. https://doi.org/10.4314/ajtcam.v3i1.31136

Telascrêa, M., Leão, A. L., Ferreira, M. Z., Pupo, H. F. F., Cherian, B. M., & Narine, S. (2014). Use of a Cashew Nut Shell Liquid resin as a potential replacement for phenolic resins in the preparation of panels—A review. *Molecular Crystals and Liquid Crystals*, *604*(1), 222–232. https://doi.org/10.1080/15421406.2014.968509

Trox, J., Vadivel, V., Vetter, W., Stuetz, W., Kammerer, D. R., Carle, R., Scherbaum, V., Gola, U., Nohr, D., & Biesalski, H. K. (2011). Catechin and epicatechin in testa and their association with bioactive compounds in kernels of cashew nut (*Anacardium occidentale* L.). *Food Chemistry*, *128*(4), 1094–1099. https://doi.org/10.1016/J.FOODCHEM.2011.04.018

Velmurugan, A., Loganathan, M., & Gunasekaran, E. J. (2014). Experimental investigations on combustion, performance and emission characteristics of thermal cracked cashew nut shell liquid (TC-CNSL)-diesel blends in a diesel engine. *Fuel*, *132*(May), 236–245. https://doi.org/10.1016/j.fuel.2014.04.060

Venkatachalam, C. D., Sengottian, M., Lakshmanan, S., Thilagarajan, R. R. A., & Pugazanthi, S. (2020). Extraction of polyphenols from cashew nut (*Anacardium occidentale*) shells using rotocel extractor. *AIP Conference Proceedings*, *2240*(May), 030001. https://doi.org/10.1063/5.0010999

Wang, F., Robotham, J. M., Teuber, S. S., Sathe, S. K., & Roux, K. H. (2003). Ana o 2, a major cashew (*Anacardium occidentale* L.) nut allergen of the legumin family. *International Archives of Allergy and Immunology*, *132*(1), 27–39. https://doi.org/10.1159/000073262

Wattanathorn, J., Thukham-Mee, W., Muchimapura, S., Wannanon, P., Tong-Un, T., & Tiamkao, S. (2017). Preventive effect of cashew-derived protein hydrolysate with high fiber on cerebral ischemia. *BioMed Research International*, *2017*, 6135023. https://doi.org/10.1155/2017/6135023

Zafar, F., Ghosal, A., Sharmin, E., & Nishat, N. (2019). Cashew nut shell liquid (phenolic lipid) based coatings: Polymers to nanocomposites. In S. ul-Islam (Ed.), *Integrating* green chemistry and sustainable engineering (pp. 255–289). Wiley-Scrivener. https://doi.org/10.1002/9781119509868.ch9

Zeitoun, H., Khan, Z., Banerjee, K., Salameh, D., & Lteif, R. (2020). Antityrosinase activity of *Combretum micranthum*, *Euphorbia hirta* and *Anacardium occidentale* Plants: Ultrasound assisted extraction optimization and profiling of associated predominant metabolites. *Molecules*, *25*(11), 2684. https://doi.org/10.3390/MOLECULES25112684

Zheng, J., Zhang, J., Guo, Y., Yang, H., Lin, A., Hu, B., Gao, Q., Chen, Y., & Liu, H. (2020). Improvement on metabolic syndrome in high fat diet-induced obese mice through modulation of gut microbiota by sangguayin decoction. *Journal of Ethnopharmacology*, *246*, 112225. https://doi.org/10.1016/J.JEP.2019.112225

Zhong, Q., & Li, Y. (2012). Antioxidant properties of cashew apple wine (CAW). *Advanced Materials Research*, *396–398*, 1645–1651. https://doi.org/10.4028/WWW.SCIENTIFIC.NET/AMR.396-398.1645

Zhuang, J. X., Hu, Y. H., Yang, M. H., Liu, F. J., Qiu, L., Zhou, X. W., & Chen, Q. X. (2010). Irreversible competitive inhibitory kinetics of cardol triene on mushroom tyrosinase. *Journal of Agricultural and Food Chemistry*, *58*(24), 12993–12998. https://doi.org/10.1021/jf103723k

Zielinski, A. A. F., Ávila, S., Ito, V., Nogueira, A., Wosiacki, G., & Haminiuk, C. W. I. (2014). The association between chromaticity, phenolics, carotenoids, and in vitro antioxidant activity of frozen fruit pulp in Brazil: An application of chemometrics. *Journal of Food Science*, *79*(4), C510–C516. https://doi.org/10.1111/1750-3841.12389

How to cite this article: Chen, Y.-Y., Li, N.-y., Guo, X., Huang, H.-j., Garcia-Oliveira, P., Sun, J.-y., Zhang, J.-d., Prieto, M. A., Guo, Z.-q., & Liu, C. (2023). The nutritional and bio-active constituents, functional activities, and industrial applications of cashew (*Anacardium occidentale*): A review. *Food Frontiers*, 1–16. https://doi.org/10.1002/fft2.250