GC-MS based Identification of Bioactive Compounds in Freeze-dried Cashew Apple

B. Ameena Beebi[1,2], R. Balasasirekha[1]

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ABSTRACT

Background: Cashew apple is a rich source of essential nutrients, including vitamin C, natural sugars (fructose and sucrose), dietary fiber, flavonoids, carotenoids, total polyphenols, volatile compounds, flavanols, amino acids and vital minerals such as potassium, magnesium, sodium and iron. These components contribute to strong immunity, antioxidant activity, proper nerve and heart function and the maintenance of healthy skin and overall bodily health. Although highly perishable, the cashew apple possesses a rich phytochemical profile. Considering this, the present study aims to identify its bioactive compounds to explore its therapeutic potential.

Methods: The study evaluated various drying methods, including sun drying, solar drying, cabinet drying, microwave drying and freeze drying, to determine the best technique for retaining the nutritional quality and sensory attributes of cashew apple products. Freeze drying was found to be the most preferred method. The freeze-dried cashew apple samples were then analyzed using Gas chromatography-mass spectrometry (GC-MS) with methanol, ethanol and acetone as solvents to identify the bioactive compounds present.

Result: Among the drying techniques, freeze drying was found to preserve the highest nutritional value and sensory quality. GC-MS analysis revealed (Z)-3-(pentadec-8-en-1-yl) phenol as the dominant compound, known for its antioxidant, antimicrobial and anti-inflammatory activities. β-Sitosterol, which aids in cholesterol reduction and cardiovascular support, was also identified. Siloxane compounds and glyceraldehyde, contributing to metabolic function and product stability, were detected primarily in ethanol and acetone extracts. Methanol and acetone were the most effective solvents for extracting a broad spectrum of phytochemicals.

Key words: Anacardium occidentale, Antioxidant, Bioactive compounds, Cashew apple, Freeze drying, Functional food, GC-MS, Methanol extract, Phytochemicals, β-sitosterol.

INTRODUCTION

The cashew (*Anacardium occidentale* L.) has become one of the most commercially important cash crops in the tropics of India. It's economically and nutritionally rich and even through its exports-oriented crop. However, peoples are significantly engaged with production to processing and also provides livelihood to millions of farmers. India has become one of the world's largest producers of cashew traditionally. Further, cultivation occurs mainly in the states of Kerala, Maharashtra, Odisha, Andhra Pradesh, Jharkhand, West Bengal and the north-eastern states, including Meghalaya (Dey *et al*., 2025). For thousands of years, human have used various plant species found in its natural environment to treat and cure different diseases (Derradjia *et al.,* 2026).

India is the world largest producer of fruits and vegetables, however, the fruits and vegetables of worth ` 13300 crores get spoiled every year due to unavailability of appropriate refrigerated transportation and cold storage facilities (Yadav and Dhankhar, 2025).

Cashew apple is a rich source of essential nutrients, including vitamin C, natural sugars (fructose and sucrose), dietary fiber, flavonoids, carotenoids, total polyphenols, volatile compounds, flavanols, amino acids and vital minerals such as potassium, magnesium, sodium and iron. These components support strong immunity, free radical scavenging, proper nerve and heart function and contribute to the maintenance of healthy skin and overall body integrity. The high content of flavonoids, particularly myricetin and quercetin, makes cashew apple beneficial for weight management and diabetes control. Regular consumption of cashew apple and its value-added products offers significant therapeutic benefits, aids in the management of diabetes and cardiovascular diseases and contributes to overall food and nutrition security (Akyereko *et al.,* 2023).

Bioactive compounds are usually derived from plants these includes alkaloids, terpenoids, flavonoids, nitrogen-containing compounds, phenolics. These have been researched as to be antioxidant, anti-inflammatory, immunost-imulatory, anticancer, antimicrobial in nature thereby its consumption prevents the occurrence of degenerative diseases such

[1]Department of Food Science and Nutrition, Avinashilingam Institute for Home Science and Higher Education for Women, Coimbatore-641 043, Tamil Nadu, India.

[2]Department of Home Science, Department of Home Science, V.V. Vanniaperumal College for Women, Virudhunagar- 626 001, Tamil Nadu, India.

Corresponding Author: B. Ameena Beebi and R. Balasasirekha, Department of Food Science and Nutrition, Avinashilingam Institute for Home Science and Higher Education for Women, Coimbatore-641 043, Tamil Nadu, India. Email: ameenabeebib@gmail.com

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as cardiovascular diseases, hypertension, diabetics *etc*. and it helps to promote a healthy life style.

Antioxidants are compounds that delay or neutralize free radicals in the body system. They offer resistance against oxidative stress by scavenging free radicals, inhibiting lipid peroxidation and by many other mechanisms to prevent disease progression. Natural sources of antioxidant are found in fruits and vegetables with the highest percentage of antioxidant concentrated in the kernel of nuts, peels of fruit, juice of fruits and vegetables (Oloniyo *et al.,* 2024).

Cashew apple extract was analyzed for its phytochemical content and antibacterial activity. It was found to be rich in phenolic compounds, including polyphenols, flavonoids and tannins, which likely contribute to its strong antibacterial effects. These compounds act by disrupting microbial membranes, inhibiting growth, coagulating cell contents and interfering with signal transduction. Flavonoids may form complexes with bacterial cell walls, while tannins can inactivate microbial enzymes and transport proteins, leading to bacterial stasis. These findings align with previous studies and support the traditional use of cashew apple extract in folk medicine for combating bacterial infections. The presence of various bioactive components in cashew apple extract have been attributed to its potent antibacterial activity (Costa *et al.,* 2020).

The functional beverage of yacon and cashew-apple have considerable concentrations of bioactive compounds, such as Fructo Oligosaccharides FOS and phenolic compounds, which may be directly or indirectly responsible for its hypoglycemic and antiproliferative activity properties. Therefore, this beverage should be considered as a potential applicant for future studies on diabetes (Dionísio *et al.,* 2015).

Cashew shoot extract contained 38 compounds from GCMS such as sitosterol, tannin, pyrogallol, phenol and 20 compounds from LCMS such as citric acid, gallic acid, myricetin and hinokiflavone that may give rise to its anti-cancer effect. Cashew shoot extract demonstrated potential anti-cancer properties thus further study is required to investigate its mechanism as anti-cancer agent (Chan *et al*., 2023).

Therapeutic and nutritional potential of cashew (*Anacardium occidentale* L.)*,* with a particular focus on the cashew apple fruit, which are rich sources of bioactive compounds. Cashew apple is known to contain high levels of vitamin C, polyphenols, flavonoids (such as myricetin and quercetin), carotenoids, tannins, dietary fiber and essential minerals, all of which contribute to immune enhancement, antioxidant defence, glycemic control and cardiovascular health. Despite its high nutritional and medicinal value, the cashew apple is often discarded as a by-product of nut extraction, representing a missed opportunity for value addition and public health benefits.

This study highlights the therapeutic and nutritional value of cashew plant parts, especially the cashew apple, which is rich in bioactive compounds with antioxidant, antibacterial, anticancer and antidiabetic properties. Despite its benefits, cashew apple remains underutilized. Phytochemical analyses (GC-MS, LC-MS) confirmed the presence of compounds like myricetin, sitosterol and tannins, supporting its traditional medicinal use. Given the rising demand for plant-based therapies and functional foods, valorizing cashew apple offers a sustainable strategy for disease prevention and improved public health.

Objectives

1. To optimize processing methods for removing the astringent and acrid properties of cashew apple.
2. To develop dried cashew apple products using the freeze drying method
3. To evaluate the sensorial attributes of freeze-dried cashew apple.
4. To identify bioactive compounds in freeze-dried cashew apple.

MATERIALS AND METHODS

Optimization of processing methods for removing the astringent and acrid properties of cashew apple

Selection and procurement of cashew apple

Cashew apples in the fresh form were obtained from Thirupuvanam, Ramnad District. Yellow variety was chosen because of high nutrients. Fully matured, ripe and undamaged cashew apples were carefully handpicked from the trees. They were then placed in a thermocol box and promptly transported to the processing area within six hours for further preparation. Upon arrival, the collected cashew apples underwent sorting and were washed with tap water to diminish microbial presence and remove soil debris, followed by a wash with chlorinated water.

Minimal processing of cashew apple

Minimally processed fruits and vegetables are fresh produce that undergo limited processing to improve functionality while maintaining their natural, fresh-like characteristics (Siddiqui *et al*., 2011). Collected cashew apples were first washed with chlorinated water at a concentration of 50 ppm. Due to the presence of tannins, cashew apples have an astringent taste. To reduce this astringency, the apples were blanched in hot water at 55°C for 2 minutes using a thermostatic water bath.

In addition to the blanched samples, a control batch of unblanched cashew apples was included to assess the direct impact of blanching on astringency reduction and bioactive compound retention. For this control treatment, the cashew apples were subjected only to washing with chlorinated water (50 ppm) and were not exposed to the 55°C hot-water blanching step. These unblanched apples retained their natural tannin content and original astringent characteristics. The control samples were sliced and freeze-dried under the same conditions as the blanched apples to ensure uniformity in processing. This comparison allowed for evaluating how blanching influenced the chemical composition, sensory attributes and overall quality of the freeze-dried cashew apple product.

Evaluation of sensorial attributes of freeze-dried cashew apple

Evaluation of sensory attributes of freeze dried cashew apple

The organoleptic study was carried out to determine the acceptability of the developed dehydrated cashew apple using freeze dring methods. The sensory examination was conducted with a total of thirty semi trained panel members. The freeze-dried cashew apple was prepared and the sensory evaluation was carried out in the Foods Laboratory, Department of Food Science and Nutrition, Avinashilingam Institute for Home Science and Higher Education for Women. The freeze-dried cashew apple product was evaluated by the panellists. To eliminate prejudice in taste, the panelists were given a glass of water. They were asked not to consume any other highly flavored meal for at least 1 hour before the test to avoid taste interaction that might impact the evaluation choice. It was labeled as cashew apple freeze dried (CA-FD). The indicated quality parameters such as appearance, colour, taste, texture flavor and overall acceptability were assessed using a 5-point hedonic scale. The five-point hedonic scale ranged from 1= poor and 5= excellent. It is also known as the grade or taste scale. The thirty semi-trained panelists were permitted to evaluate the products on their own time. The panel members were provided with a pen, an evaluation score card and a glass of water to rinse their mouth throughout the evaluation. The variation with the highest overall score was considered the best-accepted variation and it was chosen for further analysis.

Appearance

The product's appearance encompasses its comprehensive visual qualities, encompassing elements like appealing, uniform, uneven, visual defects and not appealing. Not appealing panelists assess this aspect by relying on their visual observations and by evaluating attributes in comparison to the anticipated visual presentation ranged from the scores 5 to 1, where 5 indicating Excellent, 4 indicating Very good, 3 indicating Good, 2 Fair and 1 indicating Poor.

Colour

In sensory evaluation, color plays a pivotal role as it has the potential to shape expectations and preferences. During assessment, panelists carefully analyze the product's color, identifying attributes such as shades of yellow, brown, yellowish-brown, black and any indications of discoloration.

Texture

Texture pertains to a product's tangible attributes discernible through touch or mouth sensation. It encompasses qualities like crispness, hardness, brittleness, leathery feel and stickiness. Evaluating texture involves panelists either physically examining it through touch or experiencing it *via* consumption, assessing how it feels in the mouth. They seek out specific textural attributes that correspond to the product's nature and anticipated qualities.

Taste

Taste encompasses the fundamental sensations detected by the taste buds on the tongue. The five key tastes include sweet, sour, sweet and sour, bitter and acrid. When assessing a product's taste attributes, panelists consume small bites or sips, concentrating on these taste sensations. They assess the intensity of each taste and how they interact with each other.

Flavour

Flavor encompasses the holistic sensory impression of a product, encompassing both taste and aroma. It amalgamates the taste sensations experienced on the tongue with the aromatic compounds sensed by the nose. Panelists evaluate the flavor by consuming the product. They focus on attributes such as balance of flavors, complexity after taste, astringent and any off-flavors.

Overall acceptability

Based on the appearance, colour, flavour, texture and taste the overall acceptability of the product is determined. The overall acceptability of a food is an important factor that is influenced by the sensory quality of the product together with the consumer's attitude towards the food (Mela, 2001).

The overall acceptability of the dehydrated products ranged from the scores 5 to 1, where 5 indicating Excellent, 4 indicating Very good, 3 indicating Good, 2 Fair and 1 indicating Poor.

Dehydration of cashew apple using freeze dryer

The Lyo 3PRD tray freeze dryer was employed for drying the cashew apple. The dehydration of cashew apple was carried out in PC Lyophlize India Private Limited, Vandiyur, Madurai. The drier tray boasts 3 kg capacity, specially crafted for the meticulous dehydration of diverse materials. Its innovative design incorporates an advanced freeze-drying process. During the initial freezing stage, materials are carefully arranged on the trays within the dryer and the temperature is systematically lowered to induce the freezing process. Subsequently, the primary drying phase utilizes a powerful vacuum system, allowing the frozen water to sublime directly into vapour. This is followed by a secondary drying phase, raising the temperature slightly to remove any lingering bound water molecules. The Lyo 3PRD is equipped with a cutting-edge condenser, ensuring efficient capture and removal of the vaporized water. Its features include precise temperature control, programmable functionalities and observation windows, providing users with a sophisticated tool for controlled and efficient drying processes.

Following the initial processing of cashew apples, the fruits were meticulously transversely sliced into 10 mm thickness manually using a sharp stainless-steel knife and their weight was recorded. Subsequently, to reduce moisture content significantly, the sliced cashew apples underwent a 15-hour drying process in a freeze dryer set at a temperature of -14.2°C. The dried cashew apples were then allowed to naturally reach room temperature before being carefully packed into an airtight container. These preserved cashew apples were stored at a consistent room temperature of 26±1°C. This comprehensive approach ensures the preservation of the cashew apples while maintaining their quality for future use.

The dehydration methods were standardized by adjusting the time and temperature and the experiments were conducted in triplicates to ensure acceptability of the dried product in terms of sensory attributes.

Identification of bioactive compounds in freeze-dried cashew apple using GCMS

Identification of bioactive compounds in freeze dried cashew apple powder was done by using Gas Chromatography Mass Spectrometry GC-MS. Cashew apple extract was centrifuged at 10,000 rpm for 15-20 min. Then, the supernatant was transferred to a fresh microcentrifuge tube. 2 ml of the supernatant was mixed with 2 ml of methanol. This was mixed well and kept for some time at room temperature for separation. Cashew apple juice was extracted with methanol and the extract was analyzed using GC–MS for different bioactive components. A gas chromato-graphy equipped with a "RawMode" in which the mass spectrometer was operated during data acquisition. Averaged 47.408-47.412 (25446-25448): This indicates a mass spectral range that was averaged. The base peak is the most intense peak observed in a mass spectrum. In this case, the base peak has a value of 73.05 and is observed at m/z 41327.

Sample preparation was done as follows, 2 g sample was taken in a test tube along with 20 ml solvent (Ethanol/ Methanol/ Acetone) and sonicated in heated water bath at 60°C for 1 hr and then supernatant was filtered with 0.45 um syringe filter and taken for GCMS Profiling.

RESULTS AND DISCUSSION

Table 1 presents the sensory evaluation scores of dehydrated cashew apple products, comparing the standard sample with the freeze-dried (FD) sample. Sensory attributes including appearance, color, flavor, taste, texture and overall acceptability were assessed using a hedonic scale. The results show that both samples received high scores, ranging from 4.73 to 4.93, indicating very good acceptability. For all attributes, the standard product recorded slightly higher mean scores compared to the freeze-dried sample, although the differences were minimal. The freeze-dried cashew apple showed good retention of color, texture and overall sensory quality, reflecting the effectiveness of the freeze-drying method in preserving the natural characteristics of the fruit.

The ANOVA results reveal that the sensory differences between the treatments were statistically significant at the 1% level ($p<0.01$). This indicates that even small variations in sensory attributes were meaningful. Additionally, the t-test comparing the standard and dehydrated products showed a significant difference, reinforcing the statistical reliability of the findings.

Overall, the table demonstrates that freeze-dried cashew apple maintains excellent sensory quality, closely comparable to the standard sample, making it a suitable processing method for retaining desirable sensory properties.

Table 2 depicts, the identification of Bioactive compounds in freeze-dried cashew apple using methanol. The peak report presents a detailed profile of identified peaks. Each peak is assigned a unique number and is characterized by its corresponding retention time (R. Time) in the chromatographic process. These peaks are linked to distinct compounds, each accompanied by a specific name and the relevant CAS number. The area and area% values quantify the relative abundance and composition of the compounds within the sample, while the Height parameter indicates the intensity of the respective peak.

Among the highlighted peaks, notable compounds include 2,4-Dihydroxy-2,5-dimethyl-3(2H)-furan-3-one, Pentanoic acid, 4-oxo- and Acetic acid, 1-(2-methyltetrazol-5-yl)ethenyl ester, each showcasing distinct spectral attributes. Additionally, the presence of 4H-Pyran-4-one, 2,3-dihydro-3,5-dihydroxy-6-m, 5-Hydroxymethylfurfural and 1,2,3-Propanetriol, 1-acetate.

The report also highlights compounds such as Mevalonic lactone-TMS, 3-Isopropoxy-1,1,1,7,7,7-hexamethyl-3, 5, 5-tris (and 1, 1, 1, 3, 5, 7, 7, 7-Octamethyl-3, 5-bis

Table 1: Depicts the sensory scores of dehydrated cashew apple.

Sensory Attributes	Standard	FD	ANOVA	
			F Value	P Value
Appearance	4.87±0.1	4.80±0.2	4.87±0.1	<0.00*
Color	4.93±0.1	4.87±0.1	4.93±0.1	<0.00*
Flavor	4.80±0.2	4.77±0.2	4.80±0.2	<0.00*
Taste	4.83±0.1	4.73±0.2	4.83±0.1	<0.00*
Texture	4.90±0.1	4.83±0.1	4.90±0.1	<0.00*
Overall acceptability	4.87±0.1	4.80±0.2	4.87±0.1	<0.00*
t Test - Standard vs dehydrated products		1.64*		

*Significant at 1% level.

*FD- Freeze drying.

(trimethylsilo, indicating the diverse nature of the identified chemicals. Particularly of (Z)-3-(pentadec-8-en-1-yl) phenol and β-Sitosterol, which contribute to the overall complexity of the sample's composition.

Table 3 depicts, the identification of bioactive compounds in freeze-dried cashew apple using ethanol. Among the identified peaks, several compounds are of particularly Glyceraldehyde, Cyclohexasiloxane, dodecamethyl- and 1,3-Propanediol, 2-ethyl-2-(hydroxymethyl)- are the compounds, each contributing to the diverse chemical composition present in the freeze-dried cashew apple. Additionally, the presence of 3-Isopropoxy-1,1,1,7,7,7-hexamethyl-3,5,5-tris and 1,1,1,3,5,7,7,7-Octamethyl-3,5-bis (trimethylsilo and Octasiloxane compounds, such as Octasiloxane, 1,1,3,3,5,5,7,7,9,9,11,11,13,13,15 and Octasiloxane, 1,1,3,3,5,5,7,7,9,9,11,11,13,13,15,, are the compounds variations in their abundances within the freeze dried cashew apple, indicating the presence of distinct chemical isomers.

Pentadecanoic acid, Hexasiloxane, tetradecamethyl- and Heptasiloxane, hexadecamethyl-, among others, contribute to the diverse array of identified compounds, of particular note is the dominant presence of (Z)-3-(pentadec-8-en-1-yl)phenol, which stands out with a significant area percentage, highlighting its abundance within the sample. Furthermore, the report identifies other compounds such as β-Sitosterol and Docosahexaenoic acid-TMS, adding to the overall richness of the chemical compounds was present.

Table 4 depicts, the identification of bioactive compounds in freeze-dried cashew apple using acetone. The peak of bioactive components presence in the solvent acetone. identified peaks resulting from the analysis. Each peak corresponds to a specific retention time (R.Time), denoting the time at which a compound elutes from the chromatographic column. These peaks are associated with distinct compounds, each designated by a unique name and corresponding CAS number. The Area and Area% values provide the abundance and relative composition of the compounds within the sample, while the Height indicates the peak's intensity. Among the notable peaks are compounds like Glyceraldehyde, Cyclohexasiloxane, dodecamethyl, 2-(Isobutoxymethyl) oxirane and 3-Isopropoxy-1,1,1,7,7,7-hexamethyl-3,5,5-tris, each exhibiting distinct spectral characteristics and the presence of various siloxane compounds, such as Octasiloxane and Heptasiloxane derivatives was present in freeze dried cashew apple.

The report further identifies compounds like (Z)-3-(pentadec-8-en-1-yl)phenol, Phenol, 3-pentadecyl, (Z)-3-(Heptadec-10-en-1-yl)phenol and β-Sitosterol, showcasing

Table 2: Bioactive compounds in freeze-dried cashew apple using methanol.

Peak report							
Peak#	R. Time	Similarity	Name	CAS#	Area	Area%	Height
1	5.363	94	2,4-Dihydroxy-2,5-dimethyl-3(2H)-furan-3-one	10230-62-3	2102099	3.47	412073
2	6.725	87	Pentanoic acid, 4-oxo-	123-76-2	789045	1.30	190412
3	7.519	83	Acetic acid, 1-(2-methyltetrazol-5-yl)ethenyl este1r	52028-15-4	3699247	6.10	661985
4	9.202	95	4H-Pyran-4-one, 2,3-dihydro-3,5-dihydroxy-6-m	28564-83-2	7149903	11.80	1390108
5	11.372	92	5-Hydroxymethylfurfural	67-47-0	18973292	31.31	2699635
6	11.818	93	1,2,3-Propanetriol, 1-acetate	106-61-6	9326842	15.39	1170246
7	13.031	78	1,3-Cyclopentanediol, O, O'-bis(acetyl)-, trans-	0-0-0	2603883	4.30	234623
8	13.623	73	1,3,2-Dioxaborolane, 4, 4-dimethyl-5-oxo-, 2-eth	0-0-0	1526262	2.52	213543
9	15.769	60	Mevalonic lactone-TMS	503-48-0	703348	1.16	123871
10	17.559	85	3-Isopropoxy-1,1,1,7,7,7-hexamethyl-3,5,5-tris(	71579-69-6	793925	1.31	187470
11	21.396	76	1,1,1,3,5,7,7,7-Octamethyl-3, 5-bis(trimethylsilo	2003-92-1	570158	0.94	140158
12	24.729	80	Octasiloxane, 1,1,3,3,5,5,7,7,9, 9,11,11,13,13,15,	19095-24-0	527356	0.87	120341
13	28.273	93	Pentadecanoic acid	1002-84-2	714093	1.18	146207
14	31.567	91	Oleic Acid	112-80-1	1510260	2.49	268114
15	38.762	94	(Z)-3-(pentadec-8-en-1-yl)phenol	501-26-8	6607896	10.90	1010273
16	38.960	77	Heptasiloxane, hexadecamethyl-	541-1-5	803783	1.33	138275
17	41.460	82	Heptasiloxane, hexadecamethyl-	541-1-5	490809	0.81	106240
18	43.668	80	Heptasiloxane, hexadecamethyl-	541-1-5	468386	0.77	102878
19	45.634	80	Heptasiloxane, hexadecamethyl-	541-1-5	461774	0.76	98748
20	51.661	85	beta.-Sitosterol	83-46-5	783393	1.29	140750

a diverse range of identified chemicals. Additionally, 9,19-Cyclolanostan-3-ol, 24-methylene-, (3.beta.component also present in freeze dried cashew apple. This comprehensive peak report serves as a valuable resource for identifying and characterizing the compounds within the analyzed sample, aiding in the understanding of its chemical compounds and potential applications.

The identified chemical compounds have the biological activities associated with various compounds identified in methanol, ethanol and acetone extracts of the freeze-dried cashew apple. One of the compounds identified is 5-Hydroxymethylfurfural, which exhibits diverse biological properties. It is recognized for its potential as an anti-cancer agent and anti-inflammatory effects and antimicrobial activity. Additionally, it showcases antioxidant properties, making it potentially valuable for combating oxidative stress-related conditions.

The presence of 4h-Pyran-4-One, 2,3-Dihydro-3,5-Dihydroxy-6-M further enriches the potential benefits of the cashew apple. This compound is associated with anti-cancer, anti-microbial and anti-diabetic properties. Moreover, it exhibits antioxidant and anti-inflammatory effects, which are attributes often linked to compounds with potential health benefits.

(Z)-3-(Pentadec-8-En-1-Yl) Phenol has antioxidant, anti-inflammatory and antimicrobial properties and also has dermatological properties, indicating its potential application in skincare and related products. Glyceraldehyde, another identified compound, holds relevance in biomolecule synthesis and glycation reactions. These properties render it significant in treating degenerative diseases such as diabetes, Alzheimer's disease and cardiovascular complications.

1,3-Propanediol, 2-Ethyl-2-(Hydroxymethyl)- exhibits a multifaceted role as a biomarker for disease detection, as well as a versatile component in food additives, pharmaceutical applications, cosmetics and personal care products. The presence of 1,2,3-Propanetriol, 1-Acetate contributes to its utilization across diverse industries. It finds applications in bio preservation, the food and beverage industry, pharmaceutical formulations, cosmetics and personal care products. Moreover, it serves as a microbial growth medium and a solvent for drug delivery systems. Acetic Acid, 1-(2-Methyltetrazol-5-Yl) Ethenyl is recognized for its role as a food preservative, disinfectant, pH adjuster and laboratory reagent. Its versatile applications highlight its importance in maintaining hygiene and controlling microbial growth.

Table 3: Bioactive compounds in freeze-dried cashew apple using ethanol.

Peak report							
Peak#	R.time	Similarity	Name	CAS#	Area	Area%	Height
1	9.236	84	Glyceraldehyde	56-82-6	910274	22.83	353379
2	13.314	88	Cyclohexasiloxane, dodecamethyl-	540-97-6	297305	1.38	68932
3	16.800	82	1,3-Propanediol, 2-ethyl-2-(hydroxymethyl)-	77-99-6	755914	8.16	155455
4	17.551	83	3-Isopropoxy-1,1,1,7,7,7-hexamethyl-3,5,5-tris(	71579-69-6	467757	2.17	110834
5	21.386	78	1,1,1,3,5,7,7,7-Octamethyl-3,5-bis(trimethylsilo	2003-92-1	467438	2.17	92087
6	24.712	81	Octasiloxane, 1,1,3,3,5,5,7,7,9,9,11,11,13,13,15,	19095-24-0	318393	1.48	70946
7	27.681	80	Octasiloxane, 1,1,3,3,5,5,7,7,9,9,11,11,13,13,15,	19095-24-0	240157	1.12	55140
8	28.274	87	Pentadecanoic acid	1002-84-2	235819	1.10	42697
9	30.393	77	Hexasiloxane, tetradecamethyl-	107-52-8	23761	1.04	50390
10	32.915	77	Heptasiloxane, hexadecamethyl-	541-1-5	232875	1.08	48279
11	36.007	79	Heptasiloxane, hexadecamethyl-	541-1-5	228336	1.06	44166
12	38.776	94	(Z)-3-(pentadec-8-en-1-yl)phenol	501-26-8	608960	44.68	1000970
13	39.202	87	Phenol, 3-pentadecyl-	501-24-6	16676	1.01	40128
14	41.452	80	Heptasiloxane, hexadecamethyl-	541-1-5	323194	1.50	64391
15	43.657	79	Heptasiloxane, hexadecamethyl-	541-1-5	314933	1.46	66050
16	45.625	77	Heptasiloxane, hexadecamethyl-	541-1-5	302220	1.41	62330
17	47.413	75	Heptasiloxane, hexadecamethyl-	541-1-5	270362	1.26	52957
18	49.055	71	Heptasiloxane, hexadecamethyl-	541-1-5	223706	1.04	46175
19	51.659	72	Beta-sSitosterol	83-46-5	473775	2.20	77640
20	53.960	52	Docosahexaenoic acid-TMS	6217-54-5	95657	1.84	62034

Table 4: Bioactive compounds in freeze-dried cashew apple using acetone.

Peak report							
Peak#	R.time	Similarity	Name	CAS#	Area	Area%	Height
1	9.233	81	Glyceraldehyde	56-82-6	308249	6.86	192357
2	13.310	89	Cyclohexasiloxane, dodecamethyl-	540-97-6	563651	1.25	128497
3	16.763	81	2-(Isobutoxymethyl)oxirane	3814-55-9	101294	2.25	103674
4	17.550	87	3-Isopropoxy-1,1,1,7,7,7-hexam-ethyl-3,5,5-tris	71579-69-6	101738	2.26	230282
5	21.387	77	1,1,1,3,5,7,7,7-Octamethyl-3,5-bis(trimethylsilo	2003-92-1	804639	1.79	178331
6	24.718	81	Octasiloxane, 1,1,3,3,5,5,7,7,9, 9,11,11,13,13,15,	19095-24-0	666315	1.48	147550
7	27.684	84	Octasiloxane, 1,1,3,3,5,5,7,7,9, 9,11,11,13,13,15,	19095-24-0	559369	1.24	124414
8	30.395	81	Heptasiloxane, hexadecamethyl-	541-1-5	485540	1.08	109311
9	32.916	82	Heptasiloxane, hexadecamethyl-	541-1-5	546454	1.22	113600
10	36.010	80	Heptasiloxane, hexadecamethyl-	541-1-5	542831	1.21	107344
11	38.767	94	(Z)-3-(pentadec-8-en-1-yl)phenol	501-26-8	2873414	63.91	3632578
12	39.193	91	Phenol, 3-pentadecyl-	501-24-6	824965	1.83	150982
13	41.451	84	Heptasiloxane, hexadecamethyl-	541-1-5	694970	1.55	144561
14	42.677	88	(Z)-3-(Heptadec-10-en-1-yl)phenol	111047-33-7	845487	1.88	105313
15	43.658	83	Heptasiloxane, hexadecamethyl-	541-1-5	689231	1.53	145266
16	45.625	82	Heptasiloxane, hexadecamethyl-	541-1-5	669123	1.49	136678
17	47.410	82	Heptasiloxane, hexadecamethyl-	541-1-5	580431	1.29	117982
18	49.056	82	Heptasiloxane, hexadecamethyl-	541-1-5	497144	1.11	97404
19	51.658	84	.beta.-Sitosterol	83-46-5	118654	2.64	200865
20	53.956	80	9,19-Cyclolanostan-3-ol, 24-methylene-, (3.beta	1449-9-8	955080	2.12	152534

The compounds identified in the methanol, ethanol and acetone extracts of freeze-dried cashew apple exhibit a wide range of biological activities and potential applications across various industries, including healthcare, cosmetics and food production. These diverse attributes underline the significance of the cashew apple's chemical composition in terms of both its health-related benefits and industrial utility.

CONCLUSION

Freeze drying proved to be an effective technique for cashew apple dehydration, ensuring excellent sensory qualities and maximum retention of bioactive compounds. Methanol and acetone were the most effective solvents for broad-spectrum phytochemical extraction, followed by ethanol. The freeze-dried cashew apple demonstrated a rich array of bioactive compounds, particularly phenolic compounds, glyceraldehydes and phytosterols, with potential applications in health, cosmetics and food industries. Thus, freeze-dried cashew apple products hold great promise for value addition and functional food development.

Conflict of interest

All authors declare that they have no conflicts of interest.

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