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REVIEW PAPER

Cashew Apple and its Many Functional Components as Related to Human Health: A Review

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ABSTRACT

Effective utilization of food waste presents a significant challenge for the food industry. The transformation of food waste materials into useful products, and the production of healthy food products by the incorporation of food waste materials are a focus of many researchers these days. Cashew waste can be utilized in the confectionery, beverage, meat, and baking industry and to produce eco-friendly packaging materials. Vaporization or value addition is one of the approaches to improve the market horizon of cashew apple products and thereby the livelihood of cashew farmers and processors. Preparation of alcoholic and non-alcoholic beverages, pickles, candies, probiotics, enzymes, emulsan, surfactants and cattle feed from cashew apple pomace have already been standardised. Also, Cashew apple is associated with weight loss, and is good for diabetic patients due to its high content of flavonoids (myricetin and quercetin). Consumption of cashew apple and its value-added products confer good health, therapeutic effects in the management of diabetics and cardiovascular diseases, and also ensure food and nutrition security. It is hoped that this review will contribute significantly to the expanding body of knowledge aimed at promoting cashew apple utilization globally. This study determined different physical, thermal, mechanical, and physicochemical properties of the cashew apple fruit and the importance of processing, machine designing, product-development.

Keywords: Food industry, healthy food, Cashew, Vaporization, alcoholic, non-alcoholic

Cashew apple (*Anacardium occidental L.*), also named cashew fruit, is the fleshy and succulent part of the cashew fruit that is attached to the cashew nut. It is a fruit of peduncle, also called as pseudo-fruit Ogunmoyela (1983). Cashew apple plant is an important tropical plant which is grown mainly in West Africa, India, Brazil and Indonesia, Nigeria, Vietnam. India contributes to about 23% of total cashew apple production all over the world followed by Vietnam 15%, East Africa 5%, Brazil 5%, Cambodia 3%, Indonesia 2% and others 1%. The major contribution is from West Africa which is 46% (Priya and Setty, 2019).

Fruits play an important role in humans, especially as a source of vitamins and minerals. Cashew apple is rich source of minerals, vitamins especially vitamin C and sugars infused with water. Heavy toll of cashew apple is being wasted annually because the focus was on nuts alone. Cashew apple is about 6-7 times greater in weight than the raw nut. About 90% of the cashew apples production is lost in the field after removing the nut. Keeping the nutritional qualities in view,

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several approaches like low temperature storage, modified and control atmospheric storage, edible coating, use of botanicals and chemical have been attempted and optimized to increase the storage life and transportation. Valorisation or value addition is one of the approaches to improve the market horizon of cashew apple products and thereby the livelihood of cashew farmers and processors. Preparation of alcoholic and non-alcoholic beverages, pickles, candies, probiotics, enzymes, surfactants and cattle feed from cashew apple pomace have already been standardised (Preethi, 2019).

Cashew apple is edible, and has a strong "sweet" smell and a sweet taste. Cashew apple possesses anti-bacterial properties and have been proven to be effective in treating stomach ulcers and gastritis, which is usually caused by PH. Its juice is rich in vitamin C and has an anti-scurvy effect. It is widely utilized in the cosmetic industry due to the presence of antioxidants and used in the preparations of various creams and shampoos. Cashew apple extract contains anacardia acid which is an antioxidant and has been shown to limit the pigmentation effects of aging and to eradicate the cancer cells (Rajala and Kella, 2017).

The drying of cashew apple can be excellent alternative to increase its shelf life. It allows conversion of perishable materials into stabilized product by lowering the water activity to appropriate levels. It also prevents microbial spoilage and quality deterioration due to undesirable biochemical reactions. In addition, drying reduces waste and post-harvest losses. The development of dried cashew apple (cashew apple powder), which maintain the relevant sensory properties as unaltered as possible, can contribute to the development of some value-added products, which should be acceptable to the consumers (Ogunjobi and Gunwale, 2010).

Apart from the cashew kernel, the cashew apple is the most important fruit part which can also increase the income of the farmer. Cashew apple is a nutritive fruit that needs special attention during processing because its chemical composition and sensorial taste may be affected by physical, chemical, biochemical and microbiological factors. Then, the search for enzymes with special features such as low optimum temperature is very important to ensure a successful pectin hydrolysis without affecting the juice nutritional value (Silva, 2022).

Bakery products are an important part of a balanced diet and, today a wide variety of such value-added products can be found on supermarket shelves. This includes unsweetened goods (bread, rolls, buns, crumpets, muffins, and bagels), sweet goods (pancakes, doughnuts, waffles, and cookies), and filled goods (fruit and meat pies, sausage rolls, pastries, sandwiches, cream cakes, pizza and quiche). The challenge is to develop traditional cookies, a higher consumed bakery product, using cashew apple waste to increase functional ingredients for daily consumption intake. Consumer awareness of the functional characteristics of the food products is increasing, which is influencing their purchasing decisions, with the functional foods market increasing at above 10% a year (Uchoa, 2009).

Cashew apple powder which maintains the sensory properties and it also can contribute to the development of value- added products like cookies, muffins, breads, biscuits, buns, crackers, cakes, wheat rolls and scones. Therefore, the fruit powder addition in biscuit type cookies formulations seems to be better suited for cookie process and enriches, since it is possible to use them as partial ingredients for wheat flour substitution as well as functional ingredients in formulated foods. The excellent qualities of cashew apple offer immense opportunities for its processing to various value-added products. Commercial exploitation of cashew apple is the need of the hour considering its vast potential in enhancing the income from cashew plantations. It is one of the prime areas of utilizing the indigenous fruit and opens up wider market possibilities and hence tremendous scope for commercialization (Salvi, 2023).

Cashew apple residues from fruit juice processing industry were prepared as dehydrated fruit powders. Cashew apple powders may be useful in food industry

as high dietary "Fiber ingredients". Utilization of these residue as valuable food ingredients or as a resource for nutraceuticals. Recycling fruit industrial residue is to submit it to drying processes and transform into value added products as dehydrated fruit powder. In this way, this process contributes to diminish the problem and to recover valuable biomass and nutrients. The purpose of this study was the objective of finding alternatives to the exploitation of these residues as valuable sources of vitamin C, as ashes and lipid that should be regarded as potential nutraceutical resources in future or functional ingredients (COSTA, 2009).

BOTANY OF CASHEW APPLE

Botany

Cashew belongs to the family Anacardiaceous having drupe fruit type (Fig. 1). The drupaceous kidney-shaped fruit is exclusively surrounded by a greyish hard coat and attached outwardly to a swollen fruit stalk (cashew apple) which is mis conceptualized as fruit. Cashew apples are derived from a tissue called thalamus or receptacle or stalk present outside the ovary. Hence, the distinct layers like exocarp, mesocarp and endocarp are absent in cashew apple and therefore considered as pseudocarp or false fruit (Preethi, 2019). The fruits are oblong-shaped (5-10 cm long) and brightly coloured can be red, orange or yellow. The cashew apple is a swollen fruit stalk of the cashew tree (Sobhana, 2010).

Production Status of Cashew apple

Cashew is an important cash crop and foreign exchange earner for many countries in Asia and America. There is growing market for cashew for many countries in Asia and America. There is growing market for cashew in Europe and the U.S.A., with a new opening up in the other parts of the world, such as Russia and Japan (Gule Gudda, 2021).

There is a growing demand on the world market for cashew kernels and their by-products. Cashew is a fast-growing evergreen tree and is salt and drought tolerant, suitable for growing in the coastal saline areas of Bangladesh. Among the all nuts, cashew imports increase faster than almonds in Bangladesh the cashew nut production in Bangladesh was 1,323 tons in 2021-22, which was 32.3% higher than a year earlier, and the raw nut export earning was 3,57,000 USD in the 2021-22 year. The annual demand for cashew in Bangladesh is around 50,000 tons (Dewangan *et al.* 2021).

India is the leading country in the world in cashew production area (923,00 ha) and production (613,000 MT) Cultivation of cashew or cashew apple India is confined mainly to the peninsular areas. It grown in Maharashtra, Kerala, Karnataka, and Goa, along the

Fig. 1: Cashew Fruit

west cost of the country and in Tamil Nadu, Andhra Pradesh, Orrisa and West Bengal along the east cost of the country. To a limited extent it is being cultivated in such another states (Kumar, 2009). Today India is the largest producer, processor, consumer, and exporter of the cashew in the world and total production of raw nuts of 6.20 lakh MT with the productivity of 800 kg per hectare (Gawankar, 2022).

At present, Maharashtra ranks first in area (1.86 lakh ha), production (2.48 lakh tonnes), and productivity (1367kg ha^{-1}) in the country contributing 28% area and 31.49 percent total cashew nut production in the country. The average productivity in the state of Maharashtra is 1.5 t/ha. This is due to strong research backup from the State Agriculture University and efforts taken by the extension officers for the transfer of technologies and popularizing the high yielding bold type of hybrid varieties developed by Dr. B. S. Konkan Krishi Vidyapeeth, Dapoli (Gawankar, 2022).

Maharashtra produced 256.61 thousand metric tonnes (32.93% OF the total production) followed by Andhra Pradesh (111.39 thousand metric tonnes) and Odisha (93.9 thousand metric tonnes).

Proximate and chemical properties of cashew apple

Physicochemical properties of fruit are the major factors that highlight the different health constituents of the product as well as the maturity stage. The major proximate and physicochemical properties of the cashew apple fruit such as moisture content, dry mass, TDS, TSS, crude Fiber, pH, specific gravity, refractive index, ascorbic acid, titratable acidity, turbidity, protein, ash content, total fat, total sugar, and total phenolic content. The cashew apple fruit is a highly acidic fruit with an average pH value of 4.367. Microbial deterioration of this fruit by yeasts the high amount of moisture content (85.623% (w. b.) is a key factor for its faster microbial deterioration and physical damage due to highly softness (Singh, 2019).

A proper understanding of product's moisture content will help in predicting the stability and shelf life of the product in a particular environment. Moreover, the moisture content value is very helpful in finding out different physical, mechanical, and thermal properties of the cashew apple because of their correlation. The dry matter and total dissolved solid of cashew apple fruit were found to be 14.363% and 539.643 ppm, respectively. The total soluble solids content (8.193 brix) and crude Fiber content (3.593%) were found higher while comparing with different vary ties of cashew apple found in Brazil and Nigeria (Singh, 2019).

Composition of cashew apple

Cashew apple fruit includes two parts true and false fruit. The true fruit is surrounded by shell and nut, false fruit is developed from pedicel. False fruit contain 90% whole fruit weight. Table 1 shows the chemical and nutritional composition of cashew apple. The pulp of the cashew apple is very juicy with 85-90% water, 7-13% carbohydrate, 0.7-0.9% protein, 0.2% mineral, 0.1% lipid, vitamin C at high content (261.5 mg per edible part), five or six-fold compared to orange, eight-fold compared to mandarin, orange, other vitamins (B1, B2, etc), and minerals (Ca, P, Fe etc) (Nam, 2014).

Cashew apple is the peduncle of cashew fruit, which is rich in reducing sugars (fructose and glucose), vitamins, minerals, and some amino acids, carotenoids, phenolics, organic acids and antioxidants, and also consider as a source of energy. Astringency of cashew apple undertakes consumption, due to polyphenols, tannins (0.35% etc.) (Dedehou, 2015).

Table 1: Chemical and nutritional composition of the cashew apple

Sl. No.	Constituent	Amount (per 100 g)
1	Moisture	87.80%
2	Protein	0.20%
3	Fat	0.10%
4	Crude Fiber	0.90%
5	Carbohydrate	11.60%
6	Phosphorous	10 mg
7	Iron	0.2 mg

8	Vitamin	261 mg
9	Minerals	200 mg
10	Riboflavin	0.5 mg
11	Reducing Sugar	9.04 – 10.04 %w/v
12	Tannis	0.6 mg

Kannan, 2021.

Cashew apple is a source of polyphenols and other organic acid

The cashew apple is a significant source of polyphenols and other organic acids like flavonoids, carotenoids, anacardic acid, and tannins. Carotenoids are the natural (red, orange, and yellow) pigments in plants, algae, and microorganisms which play key role in physiological and developmental functions in plants, animal health and nutrition. The amount of carotenoids in a cashew apple is dependent on the type of variety, the red variety has a higher concentration than the yellow ones (Yaw, 2023).

Polyphenolic compounds, such as flavonoids (anthocyanins, myricetin, quercetin, Kaempferol) tannins, and phenolic acids (caffeic acid, coumaric acid, ferulic acid, and gallic acid) are prominent constituents of cashew apple. Tannins are polyphenols that have been classified as anti-nutrient due to their negative effect on nutrients absorption and bio availability. They are classified as hydrolysable and condensed tannins (also known as proanthocyanidins) Apart from its negative effects, tannins have been shown to exhibit antioxidant, anti-tumor, anti-inflammatory, and antimicrobial properties. Tannins also contribute to the astringent taste of cashew apples, one of the key reasons for its low utilization (Lowor, 2009).

Dietary fiber

Cashew apple is a good source of dietary fiber, with studies indicating that on a dry matter basis. Table 2 shows the composition of dietary fiber of cashew apple. It contain around 61.21% dietary fiber, of which 13.25% is soluble and 47.96 % is insoluble. The content and composition of dietary fiber in cashew apple, including neutral sugars, uronic acids, Klason lignin, resistant protein, ash and polyphenols. Cashew apple had a total DF content of 260 and 209 g kg)1 d.m., respectively, most of it insoluble DF (88% in cashew apple). his content is in the same range as the values reported for some common fruits such as apples, oranges or bananas, in which it ranges from 170 to 360 g kg^{-1} d.m (Saura, 2000). Total neutral sugars and uronic acids represent the major carbohydrate fraction of DF, reaching values of 76 and 57.5 g kg^{-1} d.m. for cashew apple, respectively (Rufino 2010). Table 3 shows the proximate composition of dried cashew apple flour.

Table 2: Composition of dietary fibre (g kg^{-1} d. m) of cashew apple

Names	Soluble Dietary Fibers	Insoluble Dietary Fibers
Total neutral sugars	9.3 ± 0.6	28.6 ± 1.0
Uronic acids	15.5 ± 0.8	4.1 ± 0.2
Klason lignin	—	99.0 ± 12.8
Resistant protein	—	41.2 ± 0.04
Ash	—	8.3± 0.0
Polyphenols	—	3.9 ± 0.3
DF (Total)	24.8 ± 0.1	185.1 ± 12.8

Rufino, 2010.

Table 3: Proximate composition of Dried Cashew apple flour

Sl. No.	Constituents	Amount (% dry matter)
1	Crude Fiber	6.250 ± 0.07
2	Protein	1.930 ± 0.1
3	Ash	2.700 ± 0.00
4	Fat	4.600 ± 0.14
5	Moisture	6.725 ± 0.03
6	Carbohydrate	77.795 ± 0.04

Offia-Olua, 2015.

Phytochemical profile and antimicrobial activity of cashew apple

Phytochemicals and its biological activities of a plant have been found to be affected by seasonal variation, maturity and environment factors. Although various studies have been carried out of a Phytochemicals

that appear in the different parts especially fruit of these plants. Therefore, the objective of this study was determining the phytochemical and antimicrobial properties of cashew apple extract. This will contribute to the knowledge based on the application of these extract as ingredients in developing nutraceuticals and functional foods for the potential treatment against pathogenic bacteria (Laxman, 2018). Table 4 shows the Quantification of phytochemicals in cashew leaf, bark and fruit extract presented by Onuh 2017. Table 5 shows the Phytochemicals and its activities available in cashew apples. Table 6 shows the Structures of Phytochemicals available in Cashew Apples.

The mechanism of antimicrobial action of phytochemicals may be by inhibiting microbial growth, inducing cellular membrane perturbation, disrupting the proton motive force, coagulation of cell composition and modulation of signal transduction pathways. Flavones are hydroxylated phenolic structures containing one's carbonyl group which occur as C6-C3 unit linked to an aromatic ring. Their activity is probably due to their ability to form complex with extracellular and soluble proteins as well as the complex bacterial cell walls, there by inducing microbial cell membrane perturbation (Laxman, 2018).

Table 4: Quantification of phytochemicals in cashew leaf, bark and fruit extracts (mg/g)

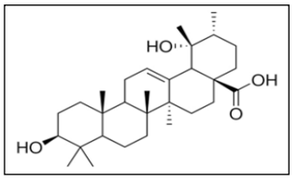
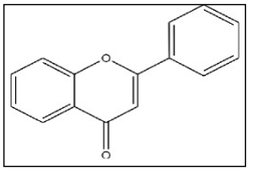
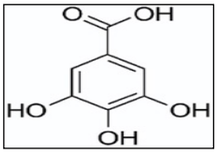
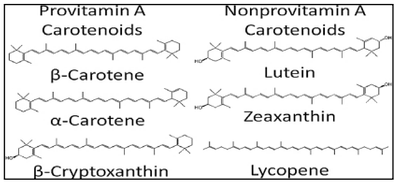
Phytochemical	Cashew leaf	Cashew bark	Cashew fruit
Saponin	0.74 ± 0.02	1.35 ± 0.03	1.35 ± 0.03
Tanin	1.19 ± 0.25	2.01 ± 0.02	2.01 ± 0.02
Flavonoid	2.73 ± 0.03	3.70 ± 0.02	3.70 ± 0.02
Alkaloid	0.57 ± 0.06	0.40 ± 0.00	0.40 ± 0.00
Carotenoid	88.86 ± 0.18	125.93 ± 0.10	125.93 ± 0.10

Onuh, 2017.

Table 5: Phytochemicals and its activities available in cashew apples

Phytochemicals	About Phytochemicals activities	References
Saponin	The result of the saponin in cashew apple fruit ranges from 0.69 mg/100 g to 0.90 mg/100 g. Saponin are practically non-toxic to man to man when taken orally saponins have a number of advantages, the most interesting, is that it can lower plasma cholesterol levels in man and animal. However high saponin levels has been associated with gastroenteritis manifested by diarrhoea and dysentery.	Abel, 2023
Tanin	Cashew apple can contain between 0.01 to 197 mg of tannins per 100 ml, depending on the cultivar, processing, and type. Tannins are polyphenols that give cashew apple a bitter, astringent taste. However, tannins also have antioxidant, anti-inflammatory, and antimicrobial properties.	Emelike, 2016
Flavonoid	Cashew apple contains flavonoids, including quercetin and myricetin, which are known to have health benefits. Liquid chromatography with diode array detection and electrospray ionization mass spectrometry, was used to identify and quantify flavonoids in cashew apple. The flavonoid content of food plant has been reported to offer biological benefits such as reduced risk of cancer and cardiovascular disease.	Cuyckens, 2004
Carotenoids	Cashew apple contains several carotenoids, including β-carotene, β-cryptoxanthin, and 9-*cis*-+13-cis-β-carotene. Apple contains about 2.9-136 mg/100 g carotenoids.	Emelike, 2016

Table 6: Structures of Phytochemicals

Phytochemicals	Structure
Saponin	
Flavonoids	
Tannin	
Carotenoids	

Uses of Cashew Apple

One of the main uses of cashew apple juice is as a beverage for direct consumption by the population. These beverages can be non-alcoholic or mixed with other fruit juices as a tonic be alcoholic (wine, liquor, vinegar) or of local names such as Cajian in Brazil, Muhamet in Nigeria. Cashew apple juice is used as a potential source of substrate for the production of bacterial cells, bioethanol and other value- added products such as dextran, lactic acid, mannitol and oligosaccharides etc. Cashew apple juice is used to obtain bacterial cell nano fibres that produce thermally stable and tensile resistant films and also exhibits antibacterial activity against certain microorganism's such as Gram-positive bacteria. Fermented cashew apple juice can serve as a new source of B-group vitamin probiotic for functional foods and nutraceutical applications in human health. Cashew apple can be processed for human food: spreads (jam, jelly), cakes, sweets and also for animal feed. Indeed, consumption of sun-dried ripe cashew apple feed results in weight gain in ducks. Traditionally, cashew apples are used to cure a number of chronic diseases such as diarrhoea, uterine disorders, cholera, rheumatism etc. It is also taken as a remedy for stomach disorders and is used to treat throat infections in Cuba and Brazil. In Bolivia, it is taken as a brain stimulant to improve human memory. Many therapeutic properties are attributed to cashew apple juice: anti-oxidant, anti-fungal, anti-bacterial, Anti-tumour, anti-inflammatory, anti-mutagenic (Lau, 2023). Table 7 shows the various uses of Cashew Apples.

Health benefits of cashew apple

The nutritious nature and high polyphenolic content have various implications for the use of the cashew apple in maintaining and promoting health. The significant amount of essential minerals found in cashew apples make them a good choice for maintaining strong immunity, promoting proper fluid balance, nerve transmission and muscle contraction, and also for the management of micronutrient deficiencies. High mineral content can aid bones cardiovascular health, and assisting metabolism, and bioactive pathway. The fruit has various traditional and medicinal uses, 34 due to its rich phytochemical profile. Thus, the cashew fruit has the potential to be used as a nutraceutical and pharmaceutic ingredient. Traditionally, cashew juice issued for the treatment of sore throats, colds, and coughs, and gastric disorders, including diarrhoea, dysentery, and ulcer. The significant amounts of polyphenolic compounds in the apple make it an excel lent source of natural antioxidants, such as anthocyanins, flavonoids, flavones, carotenoids, gallic acid, protocatechuic acid, conjugate cinnamic acid, and free cinnamic acid (Aslam, 2024). Table 8 shows the bioactive substances present in cashew apple by products and their health benefits.

Phytochemicals like flavonoids, tannins, and other acids have been found to contribute significantly to the anti-inflammatory, anti-microbial, and wound-

Table 7: Uses of Cashew apple

Cashew apple used as various industry	**Uses**	**References**
1. Food Application	Cashew apples have many food applications, including juice, wine, jam, pulp, squash and as an ingredient in other foods. Cashew apple juice can be used to make wine, probiotic beverages, and bioethanol. It can also be used as a medium for microbial cultivation to produce compounds like lactic acid dextran, cashew apple jam is a good source of nutrients and energy. Cashew apple juice can be fermented to make wine, ethanol, vinegar, citric acid and probiotic or an alcoholic drink.	Adegunva, 2019
(A) Baking industry	Utilizing Cashew apple Fiber in various food products including cookies from wheat cashew Fiber composite flour, cakes from wheat-cashew pomace flour. And biscuit from wheat-cashew pomace composite flour. The composition of cashew apple Fiber and its Fiber constituents indicate the possibility of developing new additives from it. Considering the economic and nutritional potential of cashew nuts, the use of cashew kernel flour could be considered as an ingredient in bakery products. However, it is very little consumed by Ivorians and great distribution. The objective of this study is to evaluate the effect of the partial substitution of wheat flour by delipidated cashew kernel flour on the physiochemical, functional and sensory properties of composite breads. The cashew kernel is an important delicacy which is mainly used in confectionary and as dessert nut such as cakes, pastries, candies and chocolates by enriching their taste and appearance. Cashew kernel meal could therefore be exploited to upgrade carbohydrate rich bread, since there is dearth of knowledge on the effect of cashew kernel meal on the nutritional of bread. The development of new products and the use of wastes have been more intensively explored in different areas of the world: **1. Cookies:** Salve and Swami (2023) reported the physico-chemical and sensory evaluation of cookies supplemented with osmo-convective dried cashew apple powder. They concluded that cookies prepared with 10% osmo-convective dried cashew apple powder best acceptability with maximum diameter (46.75 mm), lowest thickness (8.43 mm), breaking strength (31.25 N) and maximum sensory score of colour and appearance (8.60), test (8.43), crispiness (8.60), texture (8.40). Ebere (2015) studied on physico-chemical sensory properties of cookies prepared from refined wheat flour and cashew apple residue as a source of fibre. They concluded that the addition of cashew fibre improved the crude fibre contents of cookies irrespective of the method used in sample preparation. Both the physical and sensory properties were acceptable in terms of overall acceptability. **2. Breads:** Swami and salve (2024) studied on bread prepared from Osmo convective dried cashew apple powder and its quality evaluation revealed that the treatment B i.e.90:10% wheat flour and cashew apple powder is appropriate to prepared bread having good moisture content, fat, protein and ash content with maximum sensory score of colour and appearance, flavour, texture, taste and overall acceptability.	Adegunwa, 2020 Sylvain, *et al.* 2018 Salve and Swami, (2023) Swami and Salve, (2024)

	3. Cake: (Adegunwa 2020) Reported on the potential utilization of cashew apple fiber, which is often discarded as a waste or byproduct of cashew juice processing, in food development through characterization and value addition. Where, Cakes produced from wheat substituted with 5–30% cashew apple fiber were acceptable based on consumers' ratings. However, 5 and 10% cashew apple fiber substituted wheat cakes were comparable to 100% wheat cake in all sensory attributes. **4. Biscuits:** Ogunjobi and ogunwolu (2010) studied on Quality of Cassava flour biscuits could be improved with supplementation of cashew apple powder in term of protein, fiber, fat, ash and vitamin C. The whole cassava flour biscuits were no significantly different from the cashew apple powder supplemented up to 20% in all sensory attributes tested except aroma, which may be due to the pleasant flavour of cashew apple powder.	Adegunwa, 2020 Ogunjobi and Ogunwolu, (2010)
(B) Confectionery	The confectionery industry is prominent sector globally, known for its production of various confections, including chocolate candies, gum products, and other sweets. The manufacturing process of these products involves the use of significant quantities of sugar and sugar substitutes, cocoa, fats, emulsifiers, and flavours. The confectionery products are characterized by their sweet teste and texture, which are achieved through the careful selection and combination of ingredients. The confectionery Industry Incorporates a variety of nuts in the production of chocolate, candies, and chocolate spreads. Flavour profiles are known to be enhanced by nuts of the sugary confections and cashews make a popular choice for confectionery manufactures seeking to create products with a distinctive flavour profile. As result, cashews have become a staple ingredient in the confectionery industry, and the use of cashews and they're by products is expected to increase in the future.	Morales 2018 Kannan 2021
(C) Meat products	Bio preservation is a method in which natural ingredients having antimicrobial properties are added to food products to extend their shelf-life while maintaining their original characteristics. The technic used for food preservation are super chilling, high-pressure processing, and cold plasma, but nowadays consumers are much more conscious about their health, and demand natural methods to control spoilage by avoiding the extensive use of chemicals. Foods preserved without adding chemicals are more attractive in the market threat to gut health, bio preservatives extracted from plant-based sources are the best alternatives The consumption of synthetic prese" vats in large quantities can pose a threat to gut health, bio preservatives extracted from plant-based sources are the best alternatives in this situation.	Kareem, 2020 Kumar, 2020
2. Medicinal Application	Cashew apple is red or orange in colour. This are rich in vitamin C, so can be used for diseases that can be developed due to the deficiency of vitamin C, like for skin. These are preserved in glass jars. Cashew apple is pseudo-organic product that is the delicious natural and nutritious. These contain sugars, tannins, phenols, amino acid, ascorbic acid, minerals and Fiber. The cashew apple has sweet flavour having delicate skin. Cashew apple gives an anti-scorbutic property. Hence the juice of this apple can be used as diuretic, for the treatment of renal diseases, and for the cholera. The amount of ascorbic acid, solvent solids, decreasing sugars and all out acids were found to change among outskirts and focus of the cashew apple.	Muhammad, 2021

3. Utilization of Cashew apple waste	Waste of cashew apple is largely produced in processing industries. This waste can be used as feed source in dairy and piggery units. After the extraction of juice, the cellulose rich processing unit waste (pomace) can be used has high nutrient rich poultry and cattle feed in wet or dry format. Bio-surfactants are the compounds super-active which can decrease superficial solids and interfacial tension between solids, liquids, and gases. Bio surfactants are be used as food, pharmaceutical, environmental application as emulsifier, foaming detergent solubilizing agent. The cashew cake bagasse's containing cellulose 19-24%, hemicellulose 12%, lignin 22-38%. Xylose is abundant in the monomer unit of cashew hemicellulose. However, the strain native to it Saccharomyces cerevisiae cannot utilize xylose. Cashew waste has the potential to withstand with various products in market due to its high nutritive and chemical compound its can be versality used in the different fields.	Patade 2020

Table 8: The bioactive substance presents in cashew apple byproducts with their health benefits

Cashew waste	Bioactive compound	Range	Health benefit	Reference
Cashew apple	Ascorbic acid	190mg/100 ml.	Strength immune system. Help in collagen synthesis.	Dheeraj 2023
Cashew apple juice	Tannin	191 mg/100ml	Anti-inflammatory drug and antiseptics. Good for maintaining strong, immunity, scavenging free radicals, neuropathic functioning.	Reina 2022
Cashew gum	Anacardia acids	80% if extracted through solvent extraction	Antidiarrheal Gastroprotective Anti-inflammatory Anti-microbial activities Antitumoral	da Silva 2022
Cashew nut Testa/ husk	Polyphenol such as catechin, catechin Gallet	Free from (62.5%), bound form (21.8%), esterified fractions	Antioxidant and antimicrobial properties. Fat oxidation, and resistance of LDL.	Sruthi 2023
Cashew apple bagasse	Ascorbic Acid	6.61 mg/g	Ascorbic acid served as functional. Antioxidant activity	Patra 2022

healing properties of human cells upon consumption of cashew apples (Yaw 2023).

CASHEW APPLE IN VARIOUS FOOD APPLICATIONS

Cashew apple Feni

The cashew apple Feni is prepared through fermentation and distillation process. Matured and ripened cashew apples are collected, juice extracted, fermented and subjected to the distillation process. By distillation method, the concentration of alcohol can be adjusted to the required level. Cashew Feni has been awarded the Geographical Indication registration in 2009 as a special alcoholic beverage from Goa. The hydrocarbons, volatile and mineral constituents of cashew Feni are ethanol (42.85%), acetic acid (12.28%), ethyl acetate (55.97%), acetaldehyde (18.28%), furfural (3.22%) and copper (1.04%) (Preethi 2019).

Cashew apple wine

One of the approaches of wine making from the cashew apple, the initial sugar concentration was

increased to above 20% (w/v) by adding sucrose. The inoculum size of yeast also played an important role in fermentation process inoculum volume in the range about 0.1% to 12% was preferable. In general, lower ambient temperature result in a longer fermentation time, but a good aroma due to preservation of ester compounds. Under optimal ambient temperature, the final ethanol concentration in the wine was in the range of 5% to 12%. Owing to the perishability of fresh cashew apples, the use of dried cashew apples was also practiced for wine production. Cashew apples can be sundried, mashed and made to powder form for long-term use. To prepare "MUST" (MUST is the freshly crushed grape juice which contains the skins, seeds and stems of the fruit for wine preparation) the powder is usually mixed with water, to achieve an initial solid content of 20%. This method resulted in an alcohol content in wine of about 7% (v/v), which was found to be lower than wine made from fresh cashew apple juice (9.2 % v/v). However, wine made from cashew apple powder had a characteristic brown colour, with appreciable sensory attributes, which were comparable to wine made from cashew apple juice (Kannan, 2021).

Cashew apple vinegar

Cashew apple vinegar preparation consists of two stages (a) alcoholic fermentation, (b) acidic fermentation. Yeast 2.0 g in 20 ml coconut water is added and kept for 12 hours to make starter solution. To clarify the cashew apple juice, cooked and cooled sago gruel 5g is added along with starter solution into 1 lit of extracted unclarified cashew apple juice. This solution is kept for twelve days for alcoholic fermentation in narrow-mouthed plastic bottles, with cotton plugging. After twelve days, the fermented supernatant juice is separated through filtration (to obtain alcoholic ferment) into a wide mouth glass container or clay pot and added with thrice the quantity of mother vinegar for acidic fermentation. This container is kept tied with a muslin cloth, allowing air passage, for 15 days. The clear juice portion is filtered to a clean stainless -steel vessel and pasteurized by keeping in boiling water for 10 minutes, cooled and bottled on the 16th day to get vinegar with 5 to 6% acidity. For continuous vinegar production, the filtrate can be used as mother vinegar (Sobhana, 2011).

CASHEW APPLE JUICE AND PULP

Juice

Extraction and preservation: The ripe apples are washed well preferably in 3% salt solution. Juice is extracted with the help of hydraulic press and filtered. De-tanning is to be done to remove the astringent principles from the juice. An efficient method of de-tanning and clarification (Mini and Mathew, 2008) of cashew apple juice for beverage preparation involves addition of 5g powdered sago (as paste) per litre of the juice and keeping for 12 hours. The upper layer of the clear juice is decanted carefully without mixing with sediments. This juice is preserved by addition of 2.5g Potassium meta-Bisulphite (KMS) and citric acid per litre of juice.

Pulp

Prepared from ripe cashew apples. The cleaned apples are dipped in 5% salt solution for three days for de-tanning by changing water every day. Fourth day, the fruit are taken out washed thoroughly and stored in KMS 1% salt solution. The apples are taken out from KMS solution, washed well in water, pressure cooked and pulped with the help of pulper. It is better to store the apples as such and prepare pulp as when required (Saroj, 2015).

Cashew apple squash

The procedure for preparation of juice and squash is similar. But the consistency of squash can be achieved by adding more sugar and citric acid. Freshly harvested cashew apples are washed in running water and ensured to be free from soil debris or microbial spoilage. The juice extraction can be achieved through basket press, screw press or hydraulic press. Poly Vinyl Pyrrolidone is added at the rate of 10 g per 8 to 10 lit of cashew juice and passed through muslin cloth for clarification. After 20

to 40 min the clear supernatant is added with sugar at the rate of 3 kg per litre of juice and preservatives viz., 6 g of sodium benzoate and 100 g of citric acid. The squash can be diluted with three times of water and serve (Preethi, 2019).

Cashew apple cider

Apple cider analysed for its functional nutrient value and shelf-life aspects in both stored conditions like refrigeration and room temperature as well. Based on biochemical behaviour of the products at both the storage conditions, it was observed that the product stored at refrigeration temperature was able to retain maximum of its nutrients till completion of 24 months (vitamin C - 109 mg/100 ml, total phenols - 137 mg/100 ml, CUPRAC Assay – 84 mg/100 ml and FRAP Assay - 246 mg/100 ml) compared to the fresh one (vitamin C - 220 mg/100 ml, total phenols - 205 mg/100 ml, CUPRAC Assay - 98 mg/100 ml and FRAP Assay - 452 mg/100 ml). But the samples stored at room temperature were found stable with maximum nutrient retention only up to 12 months of storage without any damaging change in sensory quality of the product (Preethi, 2019).

Pre-Treatment of cashew apple before fermentation process

Before juice extraction, cashew apples are decontaminated by washing in 100 ppm chlorine water for the removal of contaminating microbes. The juice once extracted from the cashew apple is subjected to other pre-treatment procedures to make it free from unwanted components such as tannins and pectin's that may affect the quality of juice. Tannins belong to a group of phenolic compounds which can form active complexes with proteins and other macromolecules that can significantly affect the quality and aroma of Feni. Studies indicate the presence of 0.6 mg tannins / 100 g of cashew apple juice (Kannan, 2021). Table 9 shows the Potential products from fermentation of cashew apple.

Tannins, owing to their ability to form complex with salivary protein and glycoprotein, impart a slight acidic taste to the fruit. Tannins can be removed by the addition of proteins (e.g., gelatine) or starch (e.g., sago, cassava starch) to the juice followed by filtration or siphoning. Studies reported that the addition of enzymes such as pectinase could improve the yield of extraction and clarification of cashew apple juice. Pectinase is a group of enzymes that are composed of pectin lyase, pectin esterase, and polygalacturonase. During the fermentation process, pectin esterase is the one that degrades the pectin and releases methanol into the products. The commercially available pectinase, such as Rapides ADEX-D (100 g/ton), which is produced from *Aspergillus* spp., is especially developed for juice extraction (Kannan 2021).

Cashew apple can be also utilized through biotechnology, which depending on the substrates and microorganisms can yield a variety of products. The potential of cashew apples to be fermented

Table 9: Potential products from fermentation of cashew apple

Sl. No.	Products from fermentation of cashew apple	Temperature	Microorganism	Yield / Productivity	References
1	Lactic Acid	37°C	*Lactobacillus casei*	2.3 g/l/h	(Silveira, 2012)
2	Cashew apple wine	32°C	*Saccharomyces cerevisiae*	2.5 mg/ 100 ml per bottle	(Amerine, 1980)
3	Tannase	40°C	*Aspergillus oryzae*	3.42 $U/_{gd}$	(Rodrigues, 2007)
4	Pectinase	40°C	*Aspergillus sp.*	0.29 U/mg	(Silva, 2005)
5	Biosurfactant	30°C	*Acinetobacter calcoaceticus*	—	(Rocha, 2006)

into different products, including: Wine, various enzymes, biosurfactant, probiotic beverages, lactic acid and oligosaccharides (Rabelo, 2009).

Lactic Acid

A diluted cashew apple juice was employed for the production of lactic acid from lactobacilli casei NRRL-B 442 It was observed that higher the concentrations of reducing sugar higher was the productivity of the lactic acid, until the concentrations of reducing sugar reached 60 g/L. A supplementation of 6 g/L of Ammonium sulphate (12 % w/w of nitrogen & carbon ratio) at optimal conditions of PH 6.5 and temperature 37°C improved lactic acid yield by about 95 % with a productivity of 2.3 g/L/h (Silveira, 2012).

Wine

One kilogram of cashew apples was cleaned by washing in tap water and by immersing for 3 days in 5% salt solution to reduce tannin content (Ogunmoyela, 1983), after which they were steamed for 15 min at a pressure of 15 lb. The apples were then crushed in a mixer cum grinder and the juice was extracted by using a juice squeezer (Ogunmoyela, 1983) The juice must was filtered through cheese cotton cloth had 12 °Brix and was treated with sodium metabisulfite (SMS) (100 mg/mL) to inhibit the growth of undesirable types of microorganisms such as acetic acid bacteria, wild yeasts and Molds. Then, cane sugar and tartaric acid were added into the juice (amelioration) to attain 17 °Brix and pH 3.6, respectively fermentation was carried out at room temperature of 32 ± 2C for 6 days. Racking of wine was carried out when total soluble sugars (TSS) reached 2–3 °Brix. Two or three more racking were done at 15-day intervals to remove any sediment deposited in the wine. After racking, the wine was clarified with the addition of 0.04% bentonite and analysed. SMS (100 mg/mL) was added as preservative before bottling (Amerine 1980).

Tannase

Tannase production from cashew apple bagasse can be achieved by solid-state fermentation of Aspergillus oryzae. The optimal moisture content for producing tannase was about 40%. Higher or lower moisture content decreased the enzyme production rate. Microbial production of tannase required an inducer-tannin. Due to the presence of tannin in cashew apple (0.64 mg/100 g cashew apple pulp), tannase activity was detectable after inoculation of the fungi (Campos 2002).

However, addition of tannic acid at 2.5% w/w increased tannase activity more than fourfold. Supplementation with higher concentrations of tannic acid caused growth inhibition, resulting in less enzyme synthesis. Organic nitrogen sources such as peptone and yeast extract had no effect on enzyme synthesis due to complex formation between tannin and protein. In contrast, an inorganic counterpart, e.g. ammonium sulphate, increased enzyme production. Supplementation with ammonium sulphate at 2.5% was suit able for better productivity of tannase. Tannase activity and productivity reached its maximum (3.42 U/gds and 0.128 U/gds•h, respectively) at fermentation times between 24 to 48 h, before decreasing thereafter (Rodrigues, 2007).

Tannin, or tannin acyl hydrolase is an enzyme that catalyses the hydrolysis reaction of hydrolysable tannin and gallic acid esters. The products of the reaction are gallic acid and glucose, which can be utilized by microorganisms for energy metabolism (Rodrigues *et al.* 2008). Tannase is widely produced by the fungi in the genus of *Aspergillus* and *Penicillium*. Some yeast and bacteria also have tanase producing capability. Tannase has been used for production of garllic acid. Tannase has also been used for clarification of wine and fruit juices to prevent has formation and sedimentation (Belur *et al.* 2011).

Pectinase

Pectin esterase can be prepared by solid-state fermentation of fruit waste containing pectin, e.g. cashew apple, banana, pineapple and grape, by *Aspergillus* sp. The cashew apple bagasse was dried to a moisture content of 8 to 10% (w/w) and inoculated with *A. foetidus* at 2×107 spore/g for 6 days.

A combination of urea and ammonium sulphate (1.5% and 5% of waste mass, respectively) was a suitable nitrogen source for growth of the fungi in cashew apple. The highest activity of pectin esterase in cashew apple waste (0.29 U/mg) was obtained by a fermentation temperature of 40°C for 8 days. However, the enzyme activity was lower than that prepared from grape waste (0.35 U/mg), but higher than a mixture of orange bagasse and wheat bran (0.071 U/mg) Silva and Venkatesh (2005).

Pectin or pectic substances are complex polysaccharides containing galacturonic acid as a basic monomer. Pectinase are a group of enxymes that catalyse the reaction for degrading pectic substances (Jayai *et al.* 2005).

Pectinn esters can be prepared by solid- state fermentation of fruit waste containing pectin, e.g., cashew apple, banana, pineapple, and grape, by *Aspergillus* sp.

Biosurfactant

Biosurfactant production by *Acinetobacter calcoaceticus* was carried out in batch assays and process parameters were monitored microbial growth, biosurfactant production and emulsifying activity (E24) of the fermentation broth using a defined medium and *Acinetobacter calcoaceticus*. The highest biomass yield was obtained after 24 h of incubation, which remained in stationary phase up to 96 h. At this phase, the surface tension of the broth was reduced by 11% just after biomass addition to the culture medium, which continued unchanged until 96 h. Some authors (Lobato 2002). report the same behaviour and explain that even in the presence of a small concentration of bio surfactant, the critical micellar concentration may be achieved, above which no further variation in the sur face tension can be observed (Rocha, 2006).

Cashew pulp waste

While the majority of products from cashew apple pulp are obtained via a fermentation process, there are a few value-added end products such as organic fertilizer, food products like jams, jellies, Fruit Bars & Leather, Fruit candy, Tutty Fruity, Chutney, pickles, energy drinks, and cookies which directly utilize fruit juice or pulp for manufacturing (Kannan, 2021).

Value added products from Cashew apple pulp in food processing

Jam

The most important pulp product, jam is prepared by boiling the fruit pulp with a sufficient quantity of sugar to a reasonably thick consistency, firm enough to hold fruit tissues in position. Generally, cane sugar (sucrose) of good quality is used for jam preparation. The proportion in which it is added depends not only on the fruit, but also on its acidity and degree of ripeness. The quantity added should be adequate to give the maximum strength to the pectin- sugar- acid gel. Jam should contain a minimum of 68.5 per cent total soluble solids (Kannan, 2021).

Cashew apple is washed thoroughly to remove any adhering dust and dirt and immersed in 3% salt solution for three days to reduce the tannin content, after which the fruits are steamed at 0.7 1.05 kg cm^{-2} for 15–20 min. Then the apples are made into pulp using mixing grinder and cooked after mixing with 750 g sugar per kg of apple. A pinch of citric acid is added towards the end of the cooking process to improve the taste. The finished hot jam is stored in well sterilized glass bottles covering with a disc of waxed, tissue paper or molten paraffin wax on the surface of the jam after cooling (Preethi, 2019).

Fruit Candy

Dried cashew apple fruit impregnated with cane sugar after draining excess syrup is called a candied fruit. In this process, cashew apple is thoroughly cleaned by washed with water. Later, immerse the apple in 3% salt solution to reduce the tannin content. Drain out the salt water next day and steep the fruits in fresh salt solution and repeat the process for three days. Remove the salt water and add Potassium meta bisulphite (625 mg kg^{-1}) and keep apples in this solution for another 2-3 days. After washing the fruits

thoroughly with water, blanched in boiling water for 5 minutes followed by steaming at pressure of 0.35 kg cm-2 for 5 minutes to make it soft texture (Runjala, 2017).

Pour the syrup having 30° Brix over the apples until they are completely submerged. Keep the fruits immersed in the syrup completely for 24 hours. Next day the fruits are taken out and sugar is added to the same syrup for raising the concentration up to 35° Brix. Syrup is again boiled for about 10 min. and pour back over the apples. The strength of the syrup is progressively increased by 5° Brix at a time for the next three days and then by 10° Brix at a time for the 6th and 7th day, until the final strength of the syrup reaches 70° Brix. Keep the apple for eight to ten days in the syrup for complete absorption of sugar. The fruits are removed from the syrup, drained for half an hour and subjected to slow drying in shade. Pushpalatha and Shobhana (2015).

Fruit Bars

Fruit bars can be prepared by adding pectin, sugar, glucose and potassium meta bisulphate (KMS) to the cashew fruit pulp adjusting the brix of the pulp to 24-30°. The pulp is layered on aluminium trays after heating to 90°C for two minutes and dried in cabinet drier to 15% db. moisture. After drying, the fruit sheets are cut into slabs of fruit bar having 80° brix (Runjala, 2017).

Tutty Fruity

Cashew apple can be utilized for the preparation of tutty fruity. The procedure is followed as in the preparation of candy, and before final drying; the apples are removed from the syrup and allowed to drain off the syrup completely. The apples are cut into small cubes and again immersed in 70° Brix syrup for 2-3 days. After three days the syrup is drained off and the bits are dried in shade. About 715 g of tutty fruity can be prepared using 1 kg of cashew apple (Saroj, 2019).

Chutney

Fully ripe cashew apples are treated with salt solution as mentioned for the preparation of jam. Cut the cashew apple of desired size and add equal quantity of sugar syrup and allowed to boil in a vessel. During the process, chopped onion and grated ginger 30 g each are added. Powdered cumin seed, pepper, cardamom, cinnamon and coriander one teaspoon each are transferred to clean muslin cloth and tied to form a spice bag. This bag is carefully placed inside the cut cashew apples just before the final stage of boiling in order to transfer only the flavour during cooking. Later, salt to taste and 20 ml vinegar per kg of fruits have to be mixed. Tie all the powdered spices in a clean thin piece of cloth. Boil the mixture until it is sufficiently thickened and store in sterilized jars (Saroj, 2019).

Cashew apple juice

The ripened cashew apples are collected, and juice is extracted through the screw press method. Some Feni makers follow the stomping method for the extraction of cashew apple juice. In the micro level units, cashew apples are generally crushed manually in a shallow tank to obtain the juice. While in large-scale, cashew apples are crushed through manual as well as motorized bench-press machines to obtain the juice (Kannan, 2021).

The juice extraction efficiency can be enhanced by adopting different pressing methods such as Hydraulic press followed by screw press or perforated press cage method instead of labor-intensive manual stomping. Extraction efficiency can be further enhanced by recycling a part of fresh cashew juice into the new batch of the cashew pulp that is fed into the extractor (Wilczynski 2019). Fig. 2 shows the various Value-added products from cashew apple: (A) Cashew apple Jam; (B) Cashew apple candy; (C) Cashew apple Fruit Bars; (D) Cashew apple tutty fruity; (E) Cashew apple chutney; (F) Cashew apple juice.

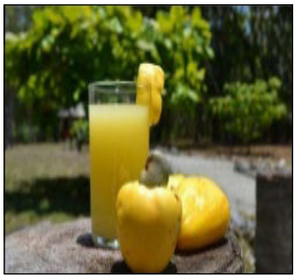
(a) Cashew apple Jam

(b) Cashew apple candy

(c) Cashew apple Fruit Bars

(d) Cashew apple tutty fruity

(e) Cashew apple chutney



(f) Cashew apple juice

Fig. 2: Value-added products from cashew apple: **(A)** Cashew apple Jam; **(B)** Cashew apple candy; **(C)** Cashew apple Fruit Bars; **(D)** Cashew apple tutty fruity; **(E)** Cashew apple chutney; **(F)** Cashew apple juice

Cashew apple bagasse

The cashew apple juice industry produces 15% (w/w) of the bagasse, which results in the generation of huge amounts of waste, However, the composition of cashew apple bagasse (CAB) is a potential raw material that can be used as an alternative and inexpensive lignocellulosic material on the production of fuel and chemicals, such as ethanol and xylitol.

The cashew bagasse is a lignocellulosic waste that is composed mainly of cellulose, hemicellulose and lignin. For these residues are bio converted it is necessary to subject them to physical pretreatments and/or chemicals prior to hydrolysis in order to produce ethanol. Such pre- treatment aimed at removing lignin and hemicellulose, reducing the crystallinity of the cellulose and increasing the porosity of these materials so as to make the pulp more susceptible to hydrolysis (Lima, 2011). Table 10 shows the Nutritional values of cashew apple bagasse.

Cashew apple bagasse hydrolysate

Cashew apple bagasse hydrolysate (CABH) was obtained from the treatment of dried cashew apple

bagasse (CAB), 7.40 ± 0.19% of humidity, with diluted acid sulfuric. The treatment was conducted in autoclave at 121°C for 15 min, using 0.2% m H_2SO_4/m CAB, in 250-ml Erlenmeyer flasks with 100 ml of reaction volume and a solid percentage of 30% w/v Afterwards, the liquid fraction was collected by vacuum filtration (GAST Manufacturing, Inc., Model DOA-P704, Michigan, USA), the pH was adjusted to 4.5 ± 0.2 with Ca $(OH)_2$, and it was filtrated to separate the precipitate. The filtrate, herein named CABH, was used as culture media for ethanol production (Serpa, 2020).

Table 10: Nutritional values of cashew apple bagasse (100 g)

Sl. No.	Nutritional values	Amount (% w/w)
1	Protein (%)	2.75
2	Total carbohydrate (%)	13.94
3	Fat (%)	0.31
4	Moisture (% wet basis)	71.04
5	Ash (%)	0.17
6	Crude Fiber (%)	11.79
7	Soluble dietary Fiber (%)	8.08
8	Insoluble dietary Fiber (%)	91.92
9	Energy (kcal)	78.83

Narek, 2021.

CONCLUSION

Cashew apple contains a high concentration of phytochemicals like flavonoids, anthocyanins, flavones, carotenoids, vitamin C, fiber, sugars, important minerals (calcium, magnesium, iron, potassium, phosphorus, sodium, copper), and organic acids, such as anacardic gallic, protocatechuic, conjugate cinnamic, free cinnamic, and malic acids. These nutrients and phytochemicals in cashew apples are good for maintaining strong immunity and good eyesight, preventing cancer, managing obesity, ulcers as well as cardiovascular diseases. Consumption of cashew apples and their value-added products will thus offer numerous health benefits, and boost the cashew industry. It is recommended that the utilization of cashew apple can be enhanced through its incorporation in food products and blending with other fruit juices to reduce the level of its astringency for better nutrition and food security.

Governments, non-governmental organizations, industry players, businessmen and women, researchers, and engineers are encouraged to contribute their quotas toward promoting the utilization of the cashew apples through the formulation of a good regulatory framework, the establishment of industries for pro cessing, mass education on the health benefits of the apples, hands on training on value-addition, and the provision of stimulus packages for small scale processors.

REFERENCES

Abdul Hussain Kareem, R. and Razavi, S.H. 2020. Planta ricin bacteriocins: As safe alternative antimicrobial peptides in food preservation—A review. *Journal of Food Safety*, **40**(1): e12735**.**

Adegunwa, M.O., Kayode, B.I., Kayode, R.M.O., Akeem, S.A., Adebowale, A.A. and Bakare, H.A. 2020. Characterization of wheat flour enriched with cashew apple (*Anacardium occidentale* L.) fiber for cake production. *Journal of Food Measurement and Characterization*, **14**: 1998-2009.

AMERINE, M.A. and OUGH, C.S. 1980. Wine *and Must Analysis*, John Wiley & Sons, New York.

Balasubramanian, D. and Saroj, P.L. Exploring untapped potential of cashew apple for masses. *Indian Horticulture*, **59**(6).

Belur, P.D. and G. Mugeraya. 2011. Microbial production of tannase: state of the art. *Research Journal of Microbiology*, **6**: 25-40.

Campos, D.C.P., Santos, A.S., Wolkoff, D.B., Matta, V.M., Cabral, L.M.C. and Couri, S. 2002. Cashew apple juice stabilization by microfiltration. *Desalination*, **148**: 61-65.

Costa, J.M.C.D., Felipe, É.M.D.F., Maia, G.A., Hernandez, F.F.F. and Brazil, I.M. 2009. Production and characterization of the cashew apple (*Anacardium occidentale* L.) and guava (*Psidium guajava* L.) fruit powders. *Journal of Food Processing and Preservation*, **33**: 299-312.

de França Serpa, J., de Sousa Silva, J., Reis, C.L.B., Micoli, L., Silva, L.M.A., Canuto, K.M., de Macedo, A.C. and Rocha, M.V.P. 2020. Extraction and characterization of lignin from cashew apple bagasse obtained by different treatments. *Biomass and Bioenergy*, **141**: 105728.

Da Silva, J., De Brito, E.S. and Ferreira, S.R.S. 2023. Biorefinery of cashew by-products. Recovery of value-added compounds. *Food and Bioprocess Technology*, **16**(5): 944-60.

da Silva, G.G., de Oliveira Braga, L.E., de Oliveira, E.C.S., Tinti, S.V., de Carvalho, J.E., L Larini, J.G., Rosalen, P.L., Dionísio, A.P. and Ruiz, A.L.T.G. 2021. Cashew apple by Product: Gastroprotective effects of standardized extract. *Journal of Ethnopharmacology,* **269**: 113744.

de França Serpa, J., de Sousa Silva, J., Reis, C.L.B., Micoli, L., Silva, L.M.A., Canuto, K.M., de Macedo, A.C. and Rocha, M.V.P. 2020. Extraction and characterization of lignin from cashew apple bagasse obtained by different treatments. *Biomass and Bioenergy*, **141**: 105728.

Dewangan, S., Ramteke, V. and Poyam, S. 2021. Cashewnut and Cashew Apple-A Potential Drug and Medicine. *Chronicle of Bioresource Management*, **5**: 156-160.

Dheeraj, Srivastava, A. and Mishra, A. 2023. Mitigation of cashew apple fruits astringency. *Environmental Sustainability,* **6**(3): 319-329.

Lima, E., Lima, F.C.S., Silva, F.L.H., Neto, J.M.S. and Silva, A.S. 2011. "Reviews of Pretreatment for Delignification of the Cashew Apple Pomace for Subsequent Saccharification Process," In: XVIII Sampaio Nacional de Bioprocesses', Universidad de Caxias do Sul, pp. 1-6. (In Portuguese).

Gawankar, M.S., Kulkarni, M.M., Haldankar, P.M. and Salvi, B.R. 2020. Technologies for the Cashew productivity enhancement in Maharashtra. *Emergent Life Sciences Research,* **6**: 5-12.

Garcia Morales, M.A., Juárez, J.C.G., Martínez-Gallegos, S., Roa-Morales, G., Peralta, E., del Campo López, E.M., Barrera-Díaz, C., Miranda, V.M. and Blancas, T.T. 2018. Pretreatment of real wastewater from the chocolate manufacturing industry through an integrated process of electrocoagulation and sand filtration. *International Journal of Photoenergy,* (1): 2146751.

Guilherme, A.A., Silveira, M.S., Fontes, C.P.M.L., Rodrigues, S. and Fernandes, F.A.N. 2012. Modeling and Optimization of Lactic Acid Production using Cashew Apple Juice as Substrate. *Food Bioprocess Technol.*, **5**(8): 3151-3158.

Jayani, R.S., Saxena, S. and Gupta, R. 2005. Microbial pectinolytic enzymes: A review. *Process Biochemistry*, **40**: 2931-2944.

Kannan, V., Rangarajan, V., Manjari, S.D. and Pathak, P.V. 2021. Microbial production of value-added products from cashew apples-an economical boost to cashew farmers. *Journal of Pure and Applied Microbiology*, **15**(4): 1816-1832.

Kumar, P., Verma, A.K., Umaraw, P. and Mehta, N. 2020. Prospects in the meat industry: The new technology could be used for accelerated drying, curing, and other production steps. *Fleischwirtschaft international: Journal for Meat Production and Meat Processing,* (1): 22-27.

Laxman Swami, B. and Urooj, A. 2018. Phytochemical profile and antimicrobial activity of cashew apple (*Anacardium occidentale* L.) extract. *GSC Biological and Pharmaceutical Sciences*, **5**(3): 095-098.

Lima Lobato, A.K.C., Macedo, G.R., Magalha˜es, M.M.A. and Bezerra, M.S. 2002. Estudo cine´tico da produc¸a˜o de biosurfactant. *In* Proceedings of XIV Congresso Brasileira de Engenharia Qiu´mica (In Portuguese).

Lowor, S.T. and Agyente-Badu, C.K. 2009. Mineral and proximate composition of cashew apple (*Anacardium occidentale* L.) juice from northern Savan nah, Forest and coastal Savannah regions in Ghana. *Am. J. Food Technol.,* **4**(4): 154–61.

Mathew, J., Mini, C. and Sobhana, A. 2009. Multiple Uses of Cashew Apple and Station, Madakkathara. Cashew Research and Development in Humid Tropics.

Mohanty S., Ray, P., Swain, M.R. and Ray, R.C. 2006. Fermentation of cashew (*Anacardium occidentale* L.)"apple" into wine. *Journal of Food Processing and Preservation,* **30**(3): 314-322.

M.O., Kayode, B.I., Kayode, R.M.O., Akeem, S.A., Adebowale, A.A. and Bakare, H.A., 2020. Characterization of wheat flour enriched with cashew apple (*Anacardium occidentale* L.) fiber for cake production. *Journal of Food Measurement and Characterization,* **14**: 1998.

Nam, T.N., Minh, N.P. and Dao, D.T.A., 2014. Investigation of processing conditions for Dietary Fiber production from cashew apple (*Anacardium occidental* L.) residue. *Int. J. Sci. Techno. Res.,* **3**: 148-156.

Nurser, P. and Juned, S. 2021. Product development based sensory evaluation and physio-chemical characterization of cashew apple bagasse jam and technology transfer to community. *Trends in Sciences,* **18**(22): 454- 454.

Ogunjobi, M.A.K. and Ogunwolu, S.O. 2010. Physicochemical and sensory properties of cassava flour biscuits supplemented with cashew apple powder. *Journal of Food Technology*, **8**(1): 24-29.

Ogunmoyela, O.A. 1983. Prospects for cashew "apple" processing and utilization in Nigeria. Process Biochem. March/April, 6–7.

Offia-Olua, B. and Onwubiko, B. 2015. Physico-chemical properties and micronutrients of whole wheat flour partially substituted with cashew apple powder. *J. Food Sci. Technol.*, **2**(5): 44-51.

Pacheco, A.M., Gondim, D.R. and Gonçalves, L.R.B. 2010. Ethanol production by used the fermentation using immobilized cells of *Saccharomyces cerevisiae* in cashew apple bagasse. *Applied Biochemistry and Biotechnology*, **161**: 209-217.

Patade, M.A., Gaikwad, S.T., Pathare, M. and Nikhade, Y. 2020. Utilization of cashew nut waste: cashew apple and shell. *International Journal of Chemical Studies,* **8**(1): 2076-2078.

Patra, A., Abdullah, S. and Pradhan, R.C. 2022. Optimization of ultrasound-assisted extraction of ascorbic acid, protein

and total antioxidants from cashew apple bagasse using artificial neural network-genetic algorithm and response surface methodology. *Journal of Food Processing and Preservation*, **46**(3): e16317.

Preethi, P., Manglas're, S., Shradha, K., Pandelela, R., Manikantan, M.R., Reddy, S.V.R., Devi, S.R. and Nayak, M.G. 2021. Cashew apple pomace powder enriched the proximate, mineral, functional and structural properties of cereal based extrudates. *Let.*, **139**: 110539.

Priya, A.D. and Setty, Y.P. 2019. Cashew apple juice as substrate for microbial fuel cell. *Fuel*, **246**: 75-78.

Prommajak, T., Leksawasdi, N. and Rattanapanone, N. 2014. Biotechnological velarization of cashew apple: A review. *Chiang Mai University Journal of Natural Sciences*, **13**(2): 159-182.

Rabelo, M.C., C.P.M.L. Fontes, and S. Rodrigues. 2009. Enzyme synthesis of oligosaccharides using cashew apple juice as substrate. *Bioresource Technology*, **100**: 5574-5580.

Rajala, S. and Kella, L. 2017. Cashew apple (*Anacardium occidentale* L.) therapy etic benefit processing and product development: An over view. *The Pharma Innovation*, **6**(7, Part D, 260).

Reina, L.J.C., Durán-Aranguren, D.D., Forero-Rojas, L.F., Tarapuez-Viveros, L.F., Durán-Sequeda, D., Carazzone, C. and Sierra, R. 2022. Chemical composition and bioactive compounds of cashew (*Anacardium occidentale*) apple juice and bagasse from Colombian varieties. *Heliyon*, **8**(5).

Rocha, M.V.P., R.V.G. Barreto, V.M.M. Melo, and L.R.B. Goncalves. 2009b. Evaluation of cashew apple juice for surfactant production by Bacillus sub tilis LAMI008. *Applied Biochemistry and Biotechnology*, **155**: 366-378.

Rocha, M., Rodrigues, T. G. De Macedo, and Gonçalves, L. 2009a. Enzymatic hydrolysis and fermentation of pretreated cashew apple bagasse with alkali and diluted sulfuric acid for bioethanol production. *Applied Biochemistry and Biotechnology*, **155**: 104-114.

Rocha, M.V.P., Oliveira, A.H.S., Souza, M.C.M. and Gonçalves, L.R.B. 2006. Natural cashew apple juice as fermentation medium for biosurfactant production by *Acinetobacter calcoaceticus. World Journal of Microbiology and Biotechnology*, **22**: 1295-1299.

Rocha, M.V.P., Rodrigues, T.H.S., Melo, V.M., Gonçalves, L.R. and Macedo, G.R.D. 2011. Cashew apple bagasse as a source of sugars for ethanol production by Kluyveromyces marxianus CE025. *Journal of Industrial Microbiology and Biotechnology*, **38**(8): 1099-1107.

Rodrigues, T., Dantas, M., Pinto, G. and Gonçalves, L. 2007. Tannase production by solid state fermentation of cashew apple bagasse. *Applied Biochemistry and Biotechnology*, 137-140: 675-688.

Runjala, S. and Kella, L. 2017. Cashew apple (*Anacardium occidentale* L.) therapeutic values, benefits, processing and product development: An over view. *The Pharma Innovation*, **6**(7, Part D): 260.

Rufino, M.D.S.M., Pérez-Jiménez, J., Tabernero, M., Alves, R.E., De Brito, E.S. and Saura-Calixto, F. 2010. Acerola and cashew apple as sources of antioxidants and dietary fibre. *International Journal of Food Science and Technology*, **45**(11): 2227-2233.

Salve, V.A. and Swami, S.B. 2023. physicochemical and Sensory Evaluation of Cookies supplemented with Osmo Convective Dried Cashew Apple Powder. *Journal of Agriculture Research and Technology*, **48**(2): 319.

Salve, V.A., S.B. Swami, Y.P. Khandetod, and P.U. Shahare. "Evaluation of Bread Supplemented with Osmo Dried Cashew Apple Powder."

Saura-Calixto, F., Garcia-Alonso, A., Goni, I. and Bravo, L. 2000. *In vitro* determination of the indigestible fraction in foods: an alterna tive to dietary fiber analysis. *Journal of Agricultural and Food Chemistry*, **48**: 3342–3347.

Shenoy, D., Pai, A., Vikas, R.K., Neeraja, H.S., Deeksha, J.S., Nayak, C. and Rao, C.V. 2011. Study on bioethanol production from cashew apple pulp and coffee pulp waste. *Biomass and Bioenergy*, **35**(10): 4107-4111.

Silva, D., K. Tokuioshi, E. Da Silva Martins, R. Da Silva, and E. Gomes. 2005. Production of pectinase by solid-state fermentation with *Penicillium viridicatum* RFC3. *Process Biochemistry*, **40**: 2885-2889.

Singh, S.S., Abdullah, S., Pradhan, R.C. and Mishra, S. 2019. Physical, chemical, textural, and thermal properties of cashew apple fruit. *Journal of Food Process Engineering*, **42**(5): e13094.

Skripko, O.V. 2021, February. The technology for producing a high-protein additive from soy and its use in the formulation of dry mix for baking muffins. *In* IOP Conference Series: Earth and Environmental Science (Vol. 640, No. 2, p. 022047). IOP Publishing.

Sobhana, A., Jose Mathew, J.M., Raghavan, C.M. and Pulutan, A.A., 2015. Development of value-added products from cashew apple powder.

Sruthi, P., Roopavathi, C. and Naidu, M.M. 2023. Profiling of phenolics in cashew nut (*Anacardium occidentale* L.) testa and evaluation of their antioxidant and antimicrobial properties. *Food Bioscience*, **51**: 102246.

Sudheer Kumar, Y., R.S. Prakasam, and O.V.S. Reddy. 2009. Optimisation of fermentation conditions for mango (*Mangifera indica* L.) wine production by employing response surface methodology. *International Journal of Food Science & Technology*, **44**: 2320-2327.

Swami, S.B., Thakor, N.J. and Murudkar, P.R. 2015. Effect of yeast concentration and baking temperature on quality of

slice bread. *Journal of Food Research and Technology*, **3**(4): pp.131-141.

Uchoa, A.M.A., Correia da Costa, J.M., Maia, G.A., Meira, T.R., Sousa, P.H.M. and with them Montenegro Brazil, 1., 2009. Formulation and physicochemical and sensorial evaluation of biscuit-type cookies supplemented with fruit powders. *Plant Foods for Human Nutrition*, **64**: 153-159.

Wilczynski, K., Kobus, Z. and Dziki, D. 2019. Effect of press construction on yield and quality of apple juice. *Sustain.*, **11**(13): 3630.