Journal of Research in Forestry, Wildlife & Environment Vol. 16(4) December, 2024
E-mail: jrfwe2019@gmail.com; jfewr@yahoo.com
http://www.ajol.info/index.php/jrfwe
87-100

ISBN: 2141 – 1778
Odeyemi et al., 2024

A REVIEW OF VALUE-ADDED PRODUCTS FROM CASHEW FRUITS IN NIGERIA IN THE LAST TWO DECADES

Odeyemi, E. F.,[1] Olorundare B. O.,[2] Ajewole, A. O.,[3] Atanda J. F.,[4] Ogunsowo, A. O.,[5] Raji, M. O.,[6] Akinola, C. O.,[7] Adesokan, M. A.,[8] Mustapha, K.,[9] Arowolo, S. T.,[10] Atolagbe, T. E.,[11] Yusuf, T. I.[12] and Jayeola, C. O.[13]

[1,2,3,4,5,6,7,8,9,10,11,12,13]Department of Value Addition Research, Cocoa Research Institute of Nigeria, PMB 5244, Idi-Ayunre, Ibadan, Oyo State, Nigeria.

*Corresponding Author: lizkunle3js@gmail.com; +2348030677956

ABSTRACT

The cashew (Anacardium occidentale) tree produces cashew fruit which has two distinct parts; the real fruit called the nut that houses the kernel and the fleshy apple referred to as the pseudo-fruit. Cashew fruit has been found to contain a good quantity of essential nutrients such as fatty acids, proteins, carbohydrates and adequate amounts of micronutrients. In many countries of the world, cashew apples and nuts have applications in the food and manufacturing industries, Nigeria inclusive. This review reports different approaches employed by Nigerian researchers in the last twenty years in transforming cashew apples and nuts into value-added products for consumption.

Keywords: Cashew fruit, Value-added products, Food, Nigeria

Correct Citation of this Publication

Odeyemi, E. F., Olorundare B. O., Ajewole, A. O., Atanda J. F., Ogunsowo, A. O., Raji, M. O., Akinola, C. O., Adesokan, M. A., Mustapha, K., Arowolo, S. T., Atolagbe, T. E., Yusuf, T.I. and Jayeola, C. O. (2024) A Review of Value-Added Products from Cashew Fruits in Nigeria in the Last Two Decades. *Journal of Research in Forestry, Wildlife & Environment Vol.16 (4):*

INTRODUCTION

Anacardium occidenatale L., commonly called cashew is an important dicotyledonous tropical evergreen tree belonging to the family Anacardiaceae, order Sapindal, and genus Anacardium. The genus comprises about eight species, among which Cashew (*A.occidentale*) is of economic importance due to its edible fleshy apple and kernel (Adelere *et al.*, 2020; Cherian and Lekshmi, 2021). It originated in Brazil and adapted to the different parts of the world where it is cultivated as a major cash crop, most especially in West African countries such as Ghana, Republic of Benin, Cote d-Ivoire, Nigeria and Guinea-Bissau (Akinnibosun and Oyetayo, 2018). In the past, the cashew tree was mostly grown to control soil erosion, mitigate desertification, as an ornamental plant and for the production of wood used in furniture making. Whereas, in recent times, great attention has been drawn to the cashew fruit due to its enormous economic importance and value-added products obtained from its various parts (Alabi *et al.*, 2023, Akyereko *et al.*, 2022, Adeigbe *et al.*, 2015). In Nigeria, cashew tree cultivation has become very popular across many parts of the country, where it serves as a major household business and a source of livelihood (Ogunjobi and Ogunwolu, 2010; Asogwa *et al.*, 2008). It is noteworthy to state that,

different research on cashew production and its numerous utilization commenced at the Cocoa Research Institute of Nigeria, Ibadan in 1971. Many reports have been documented on this from then until now. This review looks at the various by-products from cashew fruit (the apple and the nut) developed in Nigeria in the last two decades.

The Cashew Fruit

The cashew tree produces cashew fruit. This fruit has two distinct parts; the real fruit usually called the nut that houses the kernel and the fleshy apple referred to as the pseudo-fruit. Plate 1 shows the pictorial representation of cashew apple and its sectional view. The kidney-shaped real fruit (nut) is a greenish to pale brown structure having three layers; the pericarp which is the hard skin layer, the epidermis layer (testa) and the cashew seed layer (kernel). The cashew apple is a pseudo fruit formed by the enlarged receptacle of the flower into a bell-shaped hypocarpium that turns red, yellow or orange when fully ripe (Arifan *et al*., 2024; Ketaki *et al.,* 2020). Cashew fruit has been found to contain a good quantity of essential nutrients such as fatty acids, proteins, carbohydrates and adequate amounts of micronutrients. It was reported that the fatty acid content of cashews helps in controlling cholesterol and thyroid metabolism and is active in cancer prevention (Arifan *et al*., 2024).

Image of cashew fruit

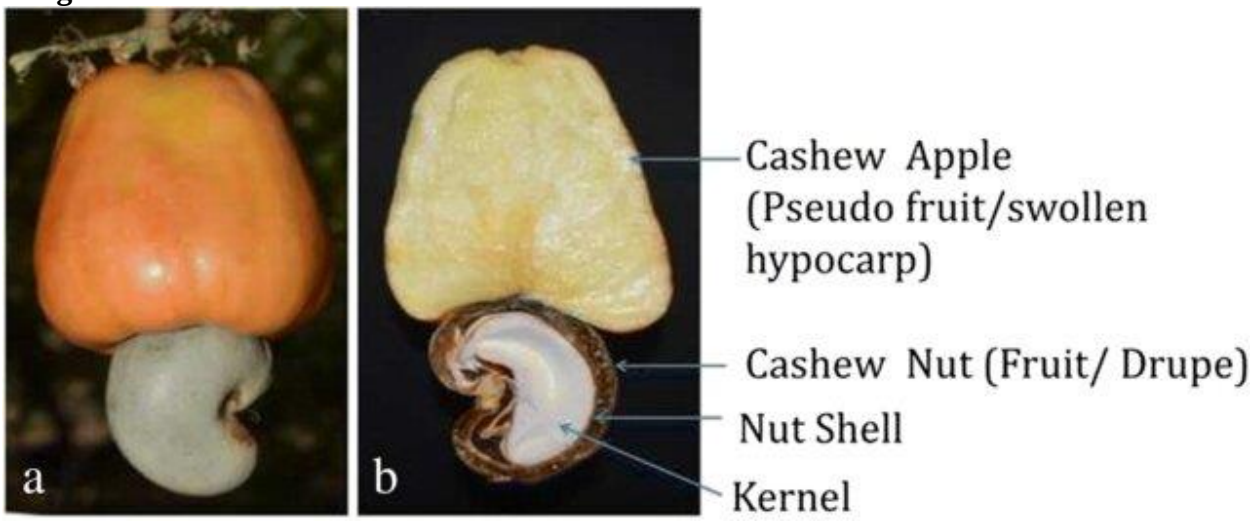

Plate 1: Pictorial Representation of Cashew Fruits and its Sectional View (Source: Savadi *et al*., 2020). Accessed: 8/19/2024.

The Cashew Apple (The Pseudo-fruit)

Cashew apple is the fleshy and juicy part of the cashew fruit. It is much larger than the nut as it's about 90% of the whole fruit. Cashew apple has a special flavour and taste and is a very nutritious fruit. It is a good source of antioxidants, amino acids, minerals, vitamins, carotenoids, carbohydrates, organic acids, and phenolics (Ketaki *et al*., 2020; Akinwale *et al.*, 2001). Table 1 below shows the chemical composition of cashew apple as reported by Sobhana *et al.* (2019)**.**

Table 1: Chemical Composition of Cashew Apple

Parameter	Composition
Moisture	86.3%
Protein	0.2%
Fat	0.1%
Carbohydrate	12.3%
Crude Fibre	0.9%
Calcium	10.0 mg/100g
Phosphorus	10.0 mg/100g
Iron	0.2 mg/100g
Vitamin C	180 mg/100g
Minerals	200.0 mg/100g
Thiamin	0.02 mg/100g
Riboflavin	0.05 mg/100g
Nicotinic acid	0.4 mg/100g
Carotene	23 μg/100 g

All these constituents of this cashew fruit are responsible for its utilization in treating sore throat, cardiovascular diseases, chronic dysentery, and management of certain cancers (Akyereko *et al.,* 2022; Akinwale, 2000). A cashew apple contains glucose and fructose which acts as a ready energy source and insulin regulator, while their calcium content facilitates joint and bone wellness. Cashew apple is also known as a mouth cleanser as it maintains oral freshness and strengthens the gum. The fresh and fermented products of cashew apples prevent muscular degeneration, muscle cramps and insomnia (Patade *et al.*, 2020).

Cashew apple juice is the major product from the cashew pseudo-fruit, commonly called cashew apple. It has been found to contain five times the ascorbic acid content of orange juice and ten times that of pineapple juice (Akinwale, 2010). The production of juice from cashew apples has been well reported, particularly in Nigeria. The freshly harvested mature and fully ripe cashews will be sorted to remove the bad or rotten ones, followed by the careful removal of the nuts, then washed thoroughly under running water and blanched

However, the high moisture and sugar content of the cashew apple makes it susceptible to decaying and deterioration as soon as it ripens due to microbial activities. Therefore, it is highly essential to utilize this nutritious fruit during its season to prevent the associated economic losses. In Nigeria, the cashew apple has found application in the food industry in production of juice, drinks, jam, syrup, pastries, ethanol, wine, vinegar and some other value-added products.

Value- added Products from Cashew Apples

Cashew Apple Juice

for about ten minutes to improve the nutritional level and reduce its astringency (Ukonze *et al*., 2018). This is allowed to cool down and then the juice will be extracted with an extractor either manually or otherwise. The extracted cashew juice will be sieved using a fine-sized mesh muslin cloth, preservative such as sodium benzoate is added to the juice, stirred properly to homogenize before bottling and pasteurizing at 80^{o}C for 10 minutes. The pasteurized juice can be stored for up to twelve months on the

shelf (at room temperature). The cashew apple juice can be blended with other fruit juice such as lemon, grape, lime, orange or pineapple at a ratio of 3 to 1 and best served chilled (Emelike *et al*., 2019; Nwosu *et al.,*2015; Akinnibosun *et al.,* 2019; Akinwale *et al*., 2010).

However, the cashew apple juice produced has an astringent taste due to its high tannin content, hence the need to reduce its astringency is germane to improve its palatable and acceptability as other fruit juices. This drawback in cashew apple juice led to another product development which is clarified cashew apple juice (Blanchard *et al*., 2023).

Clarified cashew apple juice is obtained by the addition of clarifying agents such as starch from cassava and rice (gruel) gelatine, bentonite, silica sol, and polyvinyl pyrrolidone to the extracted juice (Blanchard *et al*., 2023; Ukonze *et al*., 2018). According to Ukonze *et al*. (2018), industrial fruit juice clarification is mostly done with the aid of gelatin, but the use of rice gruel is more economical and safer. The process involves a gradual addition of 125 ml of rice gruel (starchy liquid obtained from parboiled rice) to 1 L of raw cashew apple juice and then thoroughly mixed for about 5 minutes for homogenization. This mixture will be allowed to stand until all the tannins (colloids present in the juice) coagulate at the base of the container and the clear solution is decanted off or siphoned using a rubber tube into a clean container. The clear solution obtained is the clarified cashew apple juice.

Cashew Apple Wine

Wine is an alcoholic beverage made from fermented fruit juice with selected yeast such as *Saccharomyces cerevisiae* (Baker's yeast). Some studies have been done in Nigeria on the production of wine from cashew apples (Awe *et al*., 2010; Joseph, 2010; Akinwale, 2010). It involves the careful selection of matured and fully ripe cashew apple fruits. These will be washed, rinsed with clean water and surface sterilized in 1% sodium hypochlorite solution to remove the microbial contaminants. This will then be crushed with a sterilized grinder/blender and filtered to obtain the juice. The extracted juice will be diluted with warm water (45^{o}C) in a ratio of 1:4 (juice to water) to obtain the 'must' (young wine) needed for the production of the wine. One tablet of sodium/potassium metabisulphate (Campden tablet) will be crushed and added to one gallon (4.5litres) of the must to remove microbial contaminants, followed by the incorporation of 1% citric acid, 30% sucrose and 0.67 g/L of ammonium sulphate as the sources of nutrients for the yeast that will be subsequently added. Fermentation, which can be either aerobically or anaerobically, sets the foundation for the taste, aroma and overall quality of wine produced. Following the aerobic process described by Awe and Olayinka (2011) with slight modifications, 1 g/L of the yeast *Saccharomyces cerevisiae* will be sprinkled on the surface of the must in the fermenting jar. The inoculated must will be covered with muslin cloth and incubated at room temperature (28 ± 2°C). The fermenting must will be aerated daily by stirring twice to encourage yeast multiplication. Aerobic fermentation will be terminated after two weeks to obtain the new wine. The fresh wine will be left for at least three months to age and racked (decanted) at two-week intervals within this period. Cashew wine is usually a light-yellow alcoholic beverage having different degrees of alcoholic content due to the fermenting yeast and period of fermentation

Cashew Apple Yoghurt

Aroyeun, (2004) produced yoghurt in which cashew apple juice was used as a nutritious additive following standard procedures and methods. The cashew apple juice incorporated yoghurt obtained was reported to be compared favourably with the reference

sample (Fan milk yoghurt) in all the attributes evaluated with no significant difference.

Cashew apple syrup

High-quality cashew apple syrup with a sweet taste and aroma is obtained by boiling cashew apples. This juice is cooked continuous stirring with or without any additive till it turns syrupy. It was reported that 1.5 L of cashew apple syrup can be obtained from 2 kg of cashew apples (Akinnibosun and Oyetayo, 2018; Nwosu *et al*, 2015).

Cashew apple jam

Production of jam solely from cashew apple fruits and a mixture of fruits is well documented (Kolo *et al*., 2022; Emelike and Akusu, 2019). Following the method described by Kolo *et al*. (2022), cashew fruits will be separated into nuts and apples. The cashew apple will be thoroughly rinsed, chopped into small pieces and drained. This will be boiled in sparingly salty water to remove the astringency and drained for about 5 minutes. The boiled and drained cashew apples will be placed inside a non-stick pot, sugar, lime (citric acid), and water will be added and the mixture will be covered. This will be allowed to boil at 80^{o}C for about 30 minutes until set to obtain the jam. The jam formed will be hot-filled into a jar that has been sterilized, sealed and stored at room temperature.

Cashew apple alcohol

Information on the production of alcohol from cashew apples is very scanty. Nwosu *et al*. (2015) reported that 1.5% alcohol was recovered from cashew apple juice. It was also documented that to optimize the production of alcohol from the cashew apple, immobilized *Saccharomyces cerevisiae* yeast is employed.

Cashew apple pomace

This is the residue obtained after the extraction of juice from the cashew apple. It is also referred to as cashew apple fibre or bagasse. Cashew pomace is considered a waste in most countries as it is underutilized. However, cashew apple pomace contains 8.0% moisture, 2.6% ash, 6.0% crude protein, 1.2% fat, 4.0% crude fibre and 78.2% carbohydrate, calcium, phosphorous, and iron with some important vitamins and phytochemicals having antioxidant activity (Adegunwa *et al*., 2020; Akubor *et al*., 2014). Feeding on fibre-rich diets has been found to reduce the risk of some types of cancers and aid in food digestion.

The use of cashew apple pomace is well documented by Nigerian researchers. Generally, the process involves washing, cutting into pieces of matured cashew apple and blanching in 1% sodium metabisulphite solution at 100^{o}C or just in hot water for about 10 minutes, filtered and then drained. While some authors extracted the juice with the use of juice extractor prior oven drying at about 50-60^{o}C for 48 hours or sundry for about a week (Adegunwa *et al*., 2020; Ahaotu *et al*., 2018), others went straight to the drying process (Akubor, 2016b; Ebere *et al*., 2015; Ogunjobi and Ogunwolu, 2010) to obtain the cashew apple pomace powder. This powdered cashew apple pomace is used as an additive in the development of various food systems such as bread, cake, snacks, animal feed and others.

Value-added products from cashew pomace

Cashew biscuit

Ogunjobi and Ogunwolu, (2010) made cassava flour biscuits augmented with cashew apple pomace powder at different compositions and found that this combination is good for biscuits production. Meanwhile, Akubor, (2016a) appraised the quality of biscuits substituted with cashew apple pomace flour The ingredients used in the study were 49.5% flour (which was a mixture of wheat and cashew apple pomace at 5, 10, 15, 20, 30 and 50% wheat flour in a food blender operated at full speed (1200 rpm) for five min.), 20% margarine, 10%

homogenized whole egg, 20% sugar and 0.5% baking power. The procedure involves thorough mixing of all the ingredients followed by kneading. The dough is then cut into portions, placed in greased pans, baked in the ovum at 160^{o}C for 20 min and cooled to ambient temperature (30±2^{o}C). The 100% wheat flour biscuits were used as control.

Cashew apple pomace animal feed

Recently, the production and formulation of animal feed from its different raw materials has gone very high, hence the need to explore cheaper alternatives. The cashew apple pomace can be used as dietary fibre in animal feed formulation. Ahaotu *et al.* (2018) substituted cashew apple pomace for groundnut cake at four different levels of 0, 10, 20 and 30 % in the formulation of rabbit feeds. This author reported that using dried cashew apples promoted the early maturity of the rabbits and brought about good economic returns.

Cashew apple pomace cookies

Ebere *et al*. (2015) produced cookies from a blend of cashew apple pomace/fibre and wheat flour by substituting the required wheat flour with 5, 10, 15 and 20 grams of cashew-apple fibre consecutively about wheat flour. This author reported that the cookies produced compared very well with the control (100%), most especially at the lower concentrations of the cashew apple pomace. This product was achieved by blending 40 g of margarine, 35 g of sugar, a medium size whole egg and powdered milk, blended at a medium speed until a light and fluffy cream was obtained. Sieved wheat flour, appropriate cashew-apple fibre, 1 g baking powder and 0.5 g salt were slowly added to the cream mixture. With a rolling pin, the dough was flattened on a lightly floured table surface, cut, placed on greased baking pans and baked in an oven at 130^{o}C for 20 min.

Cashew apple pomace cake

Adegunwa *et al*. (2020) and Akubor, (2016a) produced a cake that compared favourably with purely wheat flour cake by substituting wheat flour with finely milled cashew apple fibre at different concentrations of 5, 10, 15, 20, 25 and 30% while 100% wheat flour serves as the control. Specifically, it was reported that cakes obtained from wheat flour substituted with up to 20% cashew apple fiber compared favorably with wheat flour cake.

The ingredients used in the production of cakes include 30 g of flour (a blend of wheat flour and cashew apple pomace at different concentrations), 18.6 g margarine, 0.12 g salt, 12.0 g milk, 0.6 g egg, 12.0 g sugar, 0.75 g of baking powder and 25.98 ml of water. All the ingredients except water will be weighed and mixed together thoroughly. Margarine will be added and rubbed in until thoroughly kneaded. The dough will be cut out and baked in greased pans in an oven at 160 °C for 20 min (Adegunwa *et al*., 2020 and Akubor, 2016a).

Cashew Nuts

The cashew nut is a kidney shaped nut that, when fresh is dark in colour and grayish brown when completely dried. Embedded within this very hard cashew nut is the kernel which is being surrounded by a thin layer of testa. Reports on the utilization of cashew nut and its kernel both in the food industry and in the production of other valuables are well documented (Yusuf *et al*., 2023; Uche *et al*., 2022; Olaleye *et al*., 2021; Olalekan-Adeniran *et al*., 2018; Jayeola *et al*., 2017; Okafor *et al*., 2014; Ojinnaka and Agubolum, 2013; Ogunwolu *et al*., 2009). To access its usability, different approaches are employed to separate the kernel and testa from the nut. Firstly, the dry raw cashew nuts will be sorted to remove stones, dirt and unhealthy cashew nuts. According to Olalekan-Adeniran *et al.* (2018), the sorted raw cashew nuts will be steam-boiled at a pressure of 4.5kg/cm for about 20 min. This will be cooled for 24h and

then shelled with the aid of a hand operated shelling machine. The kernel will then be removed carefully from the shell and pre-dry in an oven at 50 – 70^{o}C for four h to achieve an easy removal of the testas (peels) from the kernel. The peeled kernels will be kept at room temperature ready for further use.

Uche *et al*., (2022) milled roasted cashew kernel into cashew kernel flour which can serve as a functional ingredient in the formulation of snack products as an alternative to legumes/wheat flour.

Value-added Products from Cashew Nuts Kernels and Shells

Cashew Kernel Milk and Yoghurt

Jayeola *et al*. (2017) produced nutritious cashew milk and yoghurt that compared very well with the ones in the market. This was done by weighing 250 g of cashew kernels and soaking them in 5% NaCl solution overnight to reduce the phytic acid in the kernels and to make their nutrients more readily available. The soaked kernel will be drained, cleaned and grinded to a smooth paste. This will be followed by diluting the cashew kernel paste obtained with water in a ratio of 1:3, sieved and the supernatant, which is the cashew kernel milk will be sweetened with 16 g of sugar, 0.6 g of vanilla flavour, bottled, pasteurized at 78°C for 30 min and finally refrigerated.

After the production of the cashew kernel milk, cashew kernel yoghurt is obtained by the inoculation of the produced milk with S*treptococcus thermophilus* and incubated at 45°C for 7 h to coagulate. The resulting yoghurt will then be stored over the night in a bath of cold water and refrigerated. Similarly, Emelike *et al*. (2019) produced cashew kernel milk that has high nutrient contents, suitable for ulcer patients and can substitute dairy milk. Also, Olatidoye *et al*. (2017) prepared acceptable yoghurt-like products from cashew kernel milk and cow milk at various concentrations.

Cashew Kernel Biscuit

Cashew kernel biscuit was produced by Aroyeun (2009) using cashew kernel meal and wheat flour. Cashew kernel meal was first obtained by roasting the kernels at about 80^{o}C in the oven for one h 30 min, cooled and ground using a blender. The blended flour will then be mixed in a ratio of 4 to 1 of water to flour. This mixture will then be boiled and the oil/water mixture will be boiled again until the water eventually dries out via evaporation. The residue will be dried at 100°C for 1 h to obtain the meal.

To prepare the biscuit, the proportion of ingredients needed are; 30% sugar, 38% margarine, 0.5% baking powder, 1% dried vanilla flavour, 1% salt and 25% water. The process involved replacing the wheat flour with 10, 15, 25 and 50% cashew kernel meal. The flour blend (cashew kernel meal and wheat flour), sugar, margarine and salt were mixed for about 5 min to get a creamy dough, followed by adding baking powder and the flavouring agent. Water will be added gradually with continuous mixing until a properly mixed, slightly firm dough is obtained. The dough will be kneaded on a fat-cleaned surface, manually rolled into sheets and cut into shapes. The cut dough pieces will be transferred into fat-greased pans and baked at 180°C for 15 - 20 min in a baking oven. The biscuit produced with 10% cashew kernel meal was documented to compare very well with one obtained from the market.

Cashew Kernel Ice Cream

Yahaya *et al*. (2022) made highly nourishing ice cream from cashew kernel milk. This was done by replacing skimmed milk with cashew kernel milk at 10:90, 20:80, 30:70, 40:60 and 50:50 of cashew kernel and skimmed milk. The ice cream was produced following standard procedures. When subjected to various analyses and evaluations, it was stated that the ice cream can be made from up to 20 % cashew kernel milk and used in ice cream production as a source of pleasant taste, texture and flavour.

Cashew Kernel Spread

Spreads are added to bread, crackers, and other bakery products to enhance their texture and flavour. Traditionally, they are produced from butter and cheese, but in recent times, spreads have been made from fruits, peanuts, cashew nut kernels with wide acceptance as a healthier alternative.

Olaleye *et al.* (2021) and Nwosu *et al.* (2014) produced a spread from a blend of cashew kernel/chia seed and cashew kernel/groundnut respectively. It was reported that the spread obtained had almost the same qualities when compared with the ones on the market shelf. Production of spread involves blending the ingredients which are; 2 g of gelatin, 0.32 g of ascorbic acid, 4.9 g of sugar, 0.2 g of salt and 30 mL oil with the mixture of cashew kernel slurry and the other fruit/nut slurry. This is followed by pasteurization at 60°C for 3 minutes. The spread will be allowed to cool before being packed into an airtight container.

Cashew Kernel Snacks/Cookies

The incorporation of cashew kernel flour into different snack formulations is well documented (Emelike and Akusu, 2018; Olaleye *et al.*, 2017; Okafor *et al.*,2014; Ojinnaka and Agubolum, 2013). Specifically, Ojinnaka and Agubolum (2013) make a snack called kuli kuli in the Yoruba language from a combination of groundnut and ashew kernel paste at ratio 100:0, 50:50, 30:70, 70:30 and 0:100 per cent. The study revealed that the sensory evaluation of the resulting products showed that samples produced from 100% groundnut and groundnut/cashew kernel blends were more acceptable than those produced from 100% cashew kernels.

Cashew Kernel Oil and Cashew Nut Shell Oil

Generally, oils are fatty liquid substances at room temperature and constitute an essential part of man's diet. Cashew kernel oil is an edible oil that can be used as a food-grade oil for humans and in animal feed because of its high protein content while cashew nut shell oil is a non-edible oil, mostly used industrially as a raw material in the production of paints, electrical insulating varnishes, friction linings, pesticides and epoxy resins (Yusuf *et al*., 2023; Aremu *et al.*, 2015; Akinhanmi *et al*., 2008).

Several studies have been conducted on the extraction of oil from cashew kernel (Yusuf *et al*., 2023; Adepoju *et al*., 2019; Idah *et al*., 2014; Akinhanmi *et al*., 2008). To obtain the oil, the Soxhlet extraction technique was mostly employed. A known quantity of the kernels/nut shells is fed into the Soxhlet extractor containing a particular volume of normal hexane at about 80ºC for 8 hours for complete oil extraction. The extracted oil will then be placed into a beaker and covered with perforated aluminium foil to allow the escape of highly volatile n-hexane. The oil-free from n-hexane will be recovered after 24 hours for further uses and applications.

On the other hand, cashew kernel oil is obtained traditionally by roasting the kernels to a golden brown and milled into a slurry (paste). Water is added to the slurry and the mixture is stirred and kneaded using hand until the oil separates to the top and sides of the utensils being used for the kneading. The light yellow cashew kernel oil will then be decanted. According to Aremu *et al*. (2015), the oil obtained from the traditional process is of high quality though with some drawbacks. These include non-suitability for large scale production, laborious, slow and very tedious when compared with other methods. Interestingly, it was widely reported that the chemical properties of cashew kernel oil produced are within specification for vegetable oils, hence they can be used as vegetable oil when refined.

Cashew Kernel Cereals

Cereals are food products made from processed grains that are often eaten as the first meal of the day and usually supplemented with other food classes.

Emelike *et al.* (2020) formulated breakfast cereals from blends of acha, wheat, cashew kernel flours and prawn powder following standard procedures. The result showed that cashew kernel and prawn can enrich cereals formulated from the flours of the raw materials used.

CONCLUSION AND RECOMMENDATION

Lots of opportunities abound in the use of the different parts of cashew fruits both domestically and industrially to achieve food security. Presently, the major drawback to this is the lack of storage facilities especially for the apples and the level of knowledge of the processing technologies available. It is therefore important to conduct studies on suitable method of storage for the cashew apples and create awareness among cashew farmers and consumers about the nutritional values and health benefits of cashew fruits to ensure their proper exploitation. Furthermore, researchers working on value-added products from cashew fruits should make adequate documentation of the various technologies developed in the processing of both cashew apples and kernels and ensure they are made available in the public domain. It should be noted that more research is required on the effective utilisation of cashew nut shells. The food and other manufacturing industries should equally scale up the cashew processing industry so that these products will be readily available to consumers. It is also essential to have innovative product development research and vigilant market analysis to make the sustainability of the cashew industry a success.

REFERENCES

Adegunwa, M., Kayode, I., Kayode, R., Akeem, S., Adebowale, A., and Bakare, H. (2020). Characterization of wheat flour enriched with cashew apple (Anacardium occidentale L.) fiber for cake production. *Journal of Food Measurement and Characterization.* 14. 10.1007/s11694-020-00446-9.

Adeigbe, O.O., Olasupo, F.O., Adewale, B.D. and Muyiwa, A.A. (2015). A review of cashew research and production in Nigeria in the last four decades. *Scientific Research and Essays*, 10(5), pp. 196-209.

Adelere, I., Aboyeji, D., Akindurodoye, F., Adabara, N. and Babayi, H. (2020). Cashew plant- mediated biosynthesis of silver nanoparticles and evaluation of their applications as antimicrobial additive for consumer care products. *Tanz. J. Sci.* 46: 768 -778. https://doi.org/10.4314/tjs.v46i3.17

Adepoju, A., Coker, O. and Adetula, O. (2019). Effects of processing methods on the proximate and physicochemical properties of flour and oil of cashew nut. *Nigerian Journal of Nutritional Sciences*, 40(1).

Ahaotu, E.O., Ihekoronye, B., Onyekwere, M.U. and Lawal, M. (2018). Effects of Dried Edible Cashew (Anacardium Occidentale) Apple on the Performance and Economics of Production of Grower Dutch Rabbits. *International Journal of Research in Agriculture and Forestry*, 5(12): 21-29

Akinhanmi, T. F., Atasie, V. N., and Akintokun, P. O. (2008). Chemical composition and physicochemical properties of cashew nut (Anacardium occidentale) oil and cashew nut shell liquid. *Journal of Agricultural, Food and Environmental Sciences*, 2(1): 1 – 10

Akinnibosun, F.I. and Oyetayo, A.M. (2018). Turning agricultural wastes to wealth in Nigeria: a review of Cashew (*Anacardium occidentale L.*) peduncle (apple) potentials. *Nigerian Research Journal of Engineering and Environmental Sciences*, 3(1): 57-64

Akinwale, T. O., Olubamiwa, O., Ajav, E. A. (2001) Cottage processing of cashew apple juice in Nigeria: physico-chemical and sensory evaluation of product. *Journal of Food Technology in Africa*, 6(2): 56-58

Akinwale, T. O. (2000) Cashew Apple Juice: It's Use in Fortifying the Nutritional Quality of Some Tropical Fruits. *European Food Research and Technology*, 211, 205-207. https://doi.org/10.1007/s002170050024

Akubor, P. (2016a). Chemical composition, physical and sensory properties of biscuits supplemented with cashew pomace flour. NSUK *Journal of Science and Technology*, Vol. 6: No. 2. 2016. pp. 125 -128

Akubor, P.I., Egbekun, M.K. and Obiegbuna, J.E. (2014). Quality assessment of cakes supplemented with cashew pomace and soybean flour. *Discovery*, 9(20): 8-13

Akubor, P. (2016b). Chemical composition, functional and pasting properties of cashew pomace and wheat flours. *International Journal of Agricultural and Veterinary Sciences.* 2. 28- 37. 10.18819/ijavs.2016.1549.

Akyereko, Y. G., Wireko-Manu, F. Alemawor, F. and Adzanyo, M. (2022). Cashew Apples in

Ghana: Stakeholders' Knowledge, Perception, and Utilization. *International Journal of Food Science*. 2022. 1-10. 10.1155/2022/2749234.

Alabi, O. Y., Odeyemi, E. F., Buari, R. A., Ogunsowo, A. O. and Olorundare, B. O. (2023). Efficacy of Botanicals in the Control and Management of Insect Pests of Cashew (Anacardium occidentale): A Review. *Journal of Research in Forestry, Wildlife and Environment*, 15(2): 220 – 229.

Aremu, M. O., Ibrahim, H. and Bamidele T. O. (2015). Physicochemical Characteristics of the Oils Extracted from Some Nigerian Plant Foods – A Review. *Chemical and Process Engineering Research*, 32: 36-52

Arifan, F., Hidayah, M., Susanti, S., Ratnani, R., Utami, P. and Prasetyo, A. (2024). Optimization of Oven Temperature on the Chemical Quality of Cookies Made from Cashew Nut Waste Flour. E3S Web of Conferences. 503. 10.1051/e3sconf/202450305004.

Aroyeun S.O (2009). Utilization of cashew kernel meals in the nutritional enrichment of biscuit. *African Journal of Food Science*, 3(10), 316 – 319

Aroyeun, S. O. (2004). Optimization of the utilization of cashew apple in yogurt production. *Nutrition and Food Science, 34(1), 17–19.* doi:10.1108/00346650410516171

Asogwa E., Hammed L., and Ndubuaku T. (2008). Integrated production and protection practices of cashew *(Anacardium occidentale* L.) in Nigeria. *African Journal of Biotechnology, 7 (25), 4868-4873.*

Awe, S. and Olayinka, T.E. (2011). Effect of cashew wine on histology and enzyme activities of rat liver. *Journal of Toxicology and Environmental Health Sciences.*

Bianca, D. and Stefano, C. (2014). Cashew, from seed to market: a review. *Agronomy for Sustainable Development*, 34 (4): 753-772.

Blanchard, G., Doudjo, S., Yaya A., Ouattara, Ew, K. and Ernest, K. (2023). A literature review of cashew apple processing. *African Journal of Food, Agriculture, Nutrition and Development.* 23(2). 22452-22469. 10.18697/ajfand. 117. 20705.

Cherian, S. and Lekshmi, P. (2021). Ready to serve Aloe vera Gel blended functional Cashew apple beverage for improved nutritional and sensory qualities. J. Krishi Vigyan 9: 194 – 199. https://doi.org/10.5958/2349-4433.2021.00036.2

Ebere, C., Emelike, N. and Kiin-Kabari, D. (2015). Physico-Chemical and Sensory Properties of Cookies PrepYBared from Wheat Flour and Cashew-Apple Residue as a Source of Fibre. *Asian Journal of Agriculture and Food Sciences*, 3(2).

Emelike, N. and Akusu O.M. (2018). Proximate Composition and Sensory Properties of "Kuli-Kuli"Produced from the Blends of Groundnut and Cashew Kernel. *International Journal of Food Science and Nutrition Engineering*, 8. 1-4. 10.5923/j.food.20180801.01.

Emelike, N. J. T. and Akusu, O. M. (2019). Quality Attributes of Jams and Marmalades Produced from Some Selected Tropical Fruits. *Journal of Food Processing and Technology,*

10(5). doi: 10.4172/2157-7110.1000790

Emelike, N. Tamuno, J., Akusu O.M., and Ohwesiri, A. (2019). Physicochemical, Mineral and Sensory Characteristics of Cashew Nut Milk. *International Journal of Food Science and Biotechnology*. 4. 1-6. 10.11648/j.ijfsb.20190401.11.

Emelike, N., Achinewhu, S., and Ebere, C. (2020). Nutritional Composition, Functional and Organoleptic Properties of Breakfast Cereals Formulated from Acha, Wheat, Cashew Kernel and Prawn. *European Journal of Agriculture and Food Sciences*. 2. 10.24018/ejfood. 2020.2.5.112.

Idah, P., Imologie, S. and Mohammed, M.A. (2014). Extraction and Characterization of Cashew Nut *(Anacardium Occidentale) Oil and Cashew Shell Liquid Oil. Academic Research International, 5: 50-54.*

Jayeola, O., Yahaya, E., Ogunwolu, O., Igbinadolor, R., and Mokwunye, C. (2018). Physicochemical, microbiological and sensory characteristics of cashew milk formulated yoghurt. *African Journal of Food Science*, *12*(8), 204–209. doi:10.5897/AJFS2017.1607

Joseph, Au. (2010). Comparative Studies of Wine Produced by Spontaneous and Controlled Fermentation of Preserved Cashew (*Anacardium occidentale*) Juice. *Research Journal of Biological Sciences*. 5. 460-464. 10.3923/rjbsci. 2010. 460.464.

Ketaki, B., Vaishali, A. and Amit, A. (2020). Anacardium Occidentale by-Product: A Review on Sustainable Application and Added-Value. *Journal of food nutrition and metabolism, 3(1):3-6. http:// dx. Doi.org/10.31487/j. JFNM. 2020. 01.04*

Kolo, S. *et al.* (2022). Production and Evaluation of the Nutritional Properties of Cashew Apple Jam for Consumer Acceptance. *Lapai Journal of Applied and Natural Sciences*, 7(1); 70 - 73.

Nwosu, J.N., Iwouno, J.O., Uzoukwu, A.E., Anyanwu, C.O. and Osuchukwu OA (2014). Evaluation of the Proximate and Sensory Properties of Spread Produced from Cashew Nut and Groundnut Blend. *Austin Journal of Nutrition and Food Science*, 2(6): 1031.

Nwosu, C., Adejumo, O. A. and Udoha, W. N. (2015). Cashew apple utilization in Nigeria: Challenges and prospects. *Journal of Stored Products and Postharvest Research*, 7(2): 29-31. https://doi.org/10.5897/JSPPR2015.0190

Ogunjobi, M. A. K. and Ogunwolu S. O. (2010). Physicochemical and sensory properties of cassava flour biscuits supplemented with cashew apple powder. *Jourrnal of Food Technology*, **8:**24–29. https://doi.org /10.3923/jftech.2010.24.29

Ogunwolu, S.O., Henshaw, F. O., Mock, H. P., Santros, A., and Awonorin, S.O. (2009). Functional properties of protein Concentrates and isolates produced from cashew nut". *Food Chemistry:* 852-858.

Ojinnaka, M. C and Agubolum, F. U. (2013). Nutritional and sensory properties of cashew nut-Wheat based cookies". *American Journal of Food and Nutrition*, 3(3): 127-134

Okafor, G.I., and Ugwu, F.C. (2014). Production and evaluation of cold extruded and baked ready-to eat snacks from blends of breadfruit

(*Treculia africana*), cashew nut (*Anacardium occidentale*) and coconut (Cocos nucifera)". *Food Science and Quality Management* 23: 1-13.

Olalekan-Adeniran M., and Ogunwolu S. O. (2018). Comparative Quality Evaluation of Oven- Roasted and Honey-Coated Cashew (*Anarcadium occidentale*, L.) Nut produced using Locally Fabricated Cashew Nut Processing Machine in Nigeria." *International Journal of Environment, Agriculture and Biotechnology*, 3(5).

Olaleye, H., Oresanya, T. and Lawal, K. (2017). Quality Assessment of Enriched Snacks from Blends of Plantain Flour and Cashew Nut Protein Concentrate". *Innovative Techniques in Agriculture* 2.2 (2017): 345-351.

Olaleye, H., Oresanya, T. and Bello, Z. (2021). Physicochemical, Textural, Rheological and Sensory Properties of Chia Seed-Cashew Nut Spread. *Journal of Culinary Science & Technology*. 21. 1-11. 10.1080/15428052.2021.1929635.

Olatidoye, O., Sobowale, S., Ogundipe, O., and Akinwande, A. (2017). Production And Quality Evaluation Of Imitation Yoghurt From Blends Of Cow Milk And Cashewnut Milk (Anacadium Ocidentale). *International Journal of Advanced Research and Publications,* 1(5).

Patade, M., Gaikwad, S., Pathare, M. and Nikhade, Y. (2020). Utilization of cashew nut waste: Cashew apple and shell. *International Journal of Chemical Studies.* 8. 2076-2078. 10.22271/chemi.2020.v8.i1ae.8570.

Savadi, S., Bm, Muralidhara., and Preethi, P. (2020). Advances in Genomics of Cashew Tree: Molecular Tools and Strategies for Accelerated Breeding" *ResearchGate Tree Genetics & Genomes 16(5)* DOI: 10.1007/s11295 - 020-01453-z

Sobhana, A. (2019). Cashew apple Utilization-generating wealth from waste. *Advances in Nutrition and Food Science,* 4:1–5.

Uche, O. N., Ekete, E. B. and Ide P. E. (2022). Effects of Processing Methods on the Functional Properties and Mineral Composition of Cashew Kernel Flour. *Journal on Processing and Energy in Agriculture 26: 3-4*

Ukonze, J., Ogu, E., Onu, F., Dimelu, I., Ifeanyieze, F. and Ejiofor, T. (2018). Impact of clarification process on the nutritional, mineral and vitamin composition of cashew (Anacardium occidentale) apple juice. *African Journal of Biotechnology*. 17. 337 - 342. 10.5897/ AJB2017. 16337.

Yahaya, L., Aroyeun S. O., Adeyemi E. A., Oloyede A. A., Mokwunye F. C., Aroyeun H. E., Raji M. O., Ajewole A. O. and Olalekan-Adeniran M.A. (2022). Proximate, antioxidants, microbiological and sensory profiles of Cashew kernel/Skimmed milk (CKM/ SKM) ice cream blends during storage. *African Journal of Food Science and Technology*. 13. 1-08. 10.14303/ajfst.2022.022.

Yusuf, S., Baba, A. S., Abubakar, A. and Sayaya, S. (2023). Extraction and determination of physicochemical properties of cashew nut oil. *International Journal of Novel Research in Engineering and*

Pharmaceutical Sciences. 10. 77-87. 10.5281/zenodo.8027365.