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(Research Article)

The use of artificial intelligence in improving the preservation and quality of cashew apple juice drinks for national development

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Abstract

The aim of this paper is to highlight on the use of artificial intelligence in improving the preservation and quality of cashew apple juice with an objective to reduce the astringency as well as microbial count, so that shelf life of the juice will be prolonged. Cashew apples are highly nutritious consisting of vitamins, organic acids, polyphenols, sugars, amino acids and minerals. Although cashew fruits are in abundance, their utilization is limited due to astringency and rapid microbial deterioration. The effects of clarification, sterile filtration and chemical preservation were investigated. The juice from the cashew apple was extracted using mechanical juice extractor with stainless metal. The extractor had an average efficiency of 80%. Three samples of the juice (fresh juice, juice stored under ambient conditions for 24 hrs and refrigerated juice at 5 ^{0}C) were tested for sensory evaluation. The results showed a significant difference ($p<0.05$) between the colour, taste and general acceptability of juice under ambient storage when compared with fresh juice; but there was no significant difference in the mouth feel. There was no significant difference between the colour, taste and mouth feel of the refrigerated juice and fresh juice. The physico-chemical characteristics show that appearance, specific gravity, pH and total soluble solids of the juice are affected significantly ($p<0.05$) by storage under ambient conditions but only the specific gravity changed significantly ($p<0.05$) during refrigeration. The vitamin C content of the refrigerated juice was higher than juice stored under ambient conditions and the juice can be preserved safely under refrigeration up to three months. Mechanical juice extractor should be used in extracting juice as this will reduce wastage and contamination of the products.

Keywords: Artificial Intelligence; Cashew Apple; National Development; Clarification

1. Introduction

Cashew (*Anacardium Occidentale* L.) is an important hard, drought-resistant, tropical economic tree crop which thrives well virtually in all vegetation belts of Nigeria, but grows better in the guinea savanna. Originally, according to [1], Cashew a native of Brazil, was introduced to other parts of the world starting from the 16th century mainly with the intention of afforestation and soil conservation. From its humble beginning as a crop intended to check soil erosion, cashew has come out as a major foreign exchange earner in most of the countries. Cashew apple is a pseudo-fruit rich in reducing sugars (fructose and glucose), vitamins mainly vitamin C (170-350 mg/100 g), minerals, some amino acids, polyphenols, organic acids, carbohydrates and pigments [2, 3], in fact it contains five times more vitamin C than an orange and contains more calcium, iron and vitamin B1 than other fruits such as citrus, avocados and bananas [4], it also possess anti-microbial and anti-mutagenic activities [5, 6]. The juice can be utilized as substrate for the production of dextransucrase, ethanol, biosurfactant, hyaluronic acid, mannitol and many other value added products [7, 8, 9, 10, 11]. The apple is highly perishable but very healthy. It can be eaten fresh or juiced and can be processed industrially into a variety of products such as Syrup, canned fruits, pickles, jams, chutneys, candies, toffees, ice creams, vinegar, marmalade and distilled products such as wine, brandy, gin [12, 13]. About 90% of the cashew apples production is lost

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in the field after removing the nut, this wastage of cashew apples is mainly attributed to short shelf life and rapid microbial action [14]. Unlike other fruit juices, the juice extracted from cashew apple cannot be consumed frequently or "any how" due to its characteristic astringent taste, which causes biting sensation of the tongue and throat limiting the use of cashew apple as a table fruit. In order to decrease astringency and to prevent spoilage, it is essential to investigate a suitable method to process, improve and preserve the juice. Apart from the presence of astringent principles which limits its use in the raw form as well as processed product, cashew apple as a commodity has other limitations as well. It is highly susceptible to physical injury which leads to microbial spoilage within a very short period after harvest. The storability of cashew apple is thus very poor and complete spoilage can occur within hours after harvest. Ripe apples are also subjected to damage by insect and non-insect pests. The system of collection of cashew nuts from fallen fruits after considerable delay also limits the availability of quality cashew apple for processing purposes [15]. Preservation and shelf life evaluation have been carried out in various ways [3, 16, 17, 18, 19]. The use artificial intelligence becomes eminent which is the aim of this study.

Artificial Intelligence is the combination of theories, algorithms, and computing frameworks, facilitating various tasks that require human intelligence such as reasoning, decision-making, speech recognition, language understanding, and visual perception. Artificial Intelligence can help to significantly speed up a process and result in faster and better advised decision-making, Artificial Intelligence augments and complements, it is not a replacement for human intelligence and intuition, where its goal is to help humans become faster and smarter in certain tasks [20]. Artificial intelligence aims to mimic human cognitive functions [21, 22]. The food processing industry is benefitting greatly from the latest advancements in artificial intelligence, which is doing everything from helping to sort foods, maintaining top-notch health and safety compliances, developing new products, and bolstering the supply chain. The technology is essentially helping to streamline work processes, making the work of employees easier and making operations more efficient [23]. The biggest advantage of the application of Artificial Intelligence in the food industry is that it would lessen human errors and the automated process would bring more quality to the product as well as reduce wastage. The ultimate aim would be to attain best quality services and products. Food and beverage industry are turning to implement Artificial Intelligence to achieve better, efficient and best results as food borne diseases are on the increase in industrialized countries and developing countries. The proportion of the population at high risk of illness or death from food borne pathogens is increasing in many countries due to increasing age, the prevalence of chronic diseases and immuno-suppressive conditions, therefore the need for strict food safety standards from the farm to the table. The use of artificial intelligence from farm to table is meant to reduce wide range of sanitary and phyto-sanitary issues that has been highlighted by many authors and this could lead to national development by reducing hunger, poverty and food borne diseases. It will also increase the economic status of the society. Industrializing cashew apples, specifically for the purpose of producing juice, jams, preserves, jelly and whole or diced dehydrated fruits, is a handy alternative to add value to products and generate income to cashew farmers in Nigeria due to the fact that they can be preserved for months without undergoing any undesirable changes, thus maintaining their organoleptic properties, such as aroma, taste, texture and color, besides, what is mostly important, their nutritional values are kept at high levels [24, 25, 26].

Development is a critical factor and a desirable phenomenon in the sustenance and growth of any nation [27], an encompassing process involving the steady and systematic change in the cultural, economic and political spheres of society in a way that increases production, empowers the people and their communities, protects the environment, strengthens institutions, grows quality of life and promotes good governance [28]. National development includes controlling human impacts on the environment, it requires efforts made to eliminate poverty and reduce the number of hungry people. It is believed that the poverty in Nigeria is as a result of corruption and negative attitudes of Nigerians towards the development of the nation. In Nigeria overpopulation and the depletion of natural resources, food security, overexploitation of ecosystems for direct use and non-use utility are among the human-environmental issues which have created social, economic and ecological injustice, different forms of innovations are therefore needed for technological development which is the base for national development. One of such innovation is the use of artificial intelligence in the production of quality cashew juice.

2. Material and methods

The cashew apple juice was obtained through mechanical process. This juice, which contains high levels of tannins, was clarified by adding gelatin to remove tannins and suspended solids. The clarified cashew apple juice was filtered, physico-chemically characterized.

2.1. Collecting and processing of cashew apples

Cashew apples were collected from Federal College of Education, Okene, Kogi State compound. When cashews are brought from the field, they generally have high microbial load, due to their contact with the ground and handling. The ripe fruits were weighed, washed thoroughly with 3% salt solution followed by distilled water, this is aimed at reducing the microbial load on the surface of fruits , the fruits are then soaked in sodium hypochlorite solution 10 minutes in a concentration of 200 ppm (0.02%) of active chlorine and good quality cashew apples were sorted for processing.

2.2. Processing of cashew apple juice

Continuous hydraulic press made of stainless steel equipped with a screw that spins and crushes the apples, was used to extract the juice as it is more efficient and productive as well as avoid excessive release of tannins due to the abrasive force caused when apples come in contact with the sides of the screw. An efficient method of clarification by [26, 29] was used. Watery solution of Gelatine with 10% concentration (1g of gelatine/100ml of water) this was heated to the temperature of 50^0C this allows the gelatine to dissolve in the water. The gelatine solution is added to juice little by little, pouring a thread of the solution into the juice, this was constantly stirred until the colour changed to milky and precipitates were formed. The juice was then filtered carefully using a series of filters, Whattman and Millipore membrane filters of pore size 0.44 µm and 0.22 µm under sterile environment until clear, clarified, colourless, transparent and glossy juice was obtained. Citric acid and benzoic acid at a concentration of 0.1 g/L each were added to juice and transferred to sterilized glass bottles. Replicate samples were refrigerated and analyzed for juice quality at an interval of 30 days. Fresh cashew apple juice was used as the control sample.

2.3. Shelf life study

The shelf life of the juice is studied in terms of sensory, physico-chemical and microbiological quality.

2.4. Sensory evaluation.

Sensory evaluation is unique source of product information concerned with measuring the response of people to products in terms of appearance, aroma, taste, texture and after taste without benefit of label, pricing or other imagery [30]. Three samples of the juice (fresh juice, juice stored under ambient conditions and refrigerated juice) was judged for mouth feel, colour, flavour, taste, sedimentation and overall acceptability. Ambient storage duration was for 24 hrs and refrigerated storage was at 5^0C [12, 31]. The juices were served to 20 students from the Department of Biology in Federal College of Education, Okene. With fresh juice as control, the sensory attributes of juice under ambient storage was compared with juice under refrigerated storage. The hedonic scale rating was used to assess the likability and acceptability of both the fresh juice and preserved juice. The scale ranges from one through nine with one being “dislike extremely,” five being “neither like nor dislike,” and nine being “like extremely.” The means of the scores by the judges were tested by analysis of variance for significant differences ($p \leq 0.05$) between their respective juice samples.

2.5. Physico-chemical analysis

The pH of the cashew juice was measured using a standard pH meter (PHYWE, range 0-14). The pH of 7 after which the bulb was dipped in another buffer solution and the reading on the scale was adjusted. The bulb was dipped into the juice samples and the pH reading of the juice was repeated 3 times and the average were recorded.

The colour and clarity of the juice were analysed using spectrophotometer and absorbance values of the juice determined at 450nm and 600nm wave length. The measurement was made by inserting the coveter (glass tube) containing the samples into the light path of the spectrophotometer which measured the intensity of light at various wave lengths transmitted by the solution. The intensity of light was determined by the electric detector, which converted radiant energy to electric energy. The diluted juice samples which had the absorbance value at 450nm was used as a standard and the other filled with the juice were inserted into the instrument and knob was switched off before taking the reading of the absorbance on the electronic scale.

Viscosity in centipoises was determined using Ostwald’s viscometer. Vitamin C content as mg/100 ml, total and reducing sugars as % were determined using a refractometer. The sample was poured on the sample holder and covered. The readings was taken directly from the scale when viewed from the eye-piece after adjusting the knob until there was a clear demarcation between yellow and light by a red light which the red line was at the centre of the cross. The analysis was carried out for the respective samples and recorded.

The specific gravity of the juice samples were measured by the use of hydrometer. The hydrometer was dropped into the juice sample when it was cooled at 20°C after extraction in a measuring cylinder and was allowed to float. The readings were taken directly from the hydrometer scale by reading the upper meniscus. This was measured by using 0.1N NaOH solution and phenolphthalein indicator. The juice sample (25ml) was diluted to about 25ml with distilled water. One hundred milliliter solution of the sample was titrated with 0.1N NaOH per 100ml of original solution. This values were then converted to percentage titratable acidity using a standard formular.

2.6. Microbiological analysis

The numbers of micro-organisms (bacteria, yeasts and molds) present in the fruit juice were determined using the pour plate count method a recommended in the International Commission on Microbiological Specification for Foods [32]. The pipettes and plates were sterilized by autoclaving at 121°C before use and hygienically stored. The agar (potato dextrose) was prepared. Appropriate serial dilutions of the samples were carried out and then the agar was allowed to cool to 15°C. 0.1ml of the selected dilution was spread on triplicate plates using sterile glass spreader. The plates were covered immediately and gently shaken, then placed at 37°C for 24-48hrs. The microbial growth on each of various sample plates were counted and recorded. This was repeated at one week interval for (4) weeks.

Total count = Initial dilution x subsequent x Amount of plated = Dilution Factor.

3. Results and discussion

The cashew apples from the field yielded 840 ml/kg (80%) juice. Fresh juice was viscous but after clarification (with gelatine) and filtration it was observed that the juice became clear without any turbidity, this shows the decrease in viscosity (1.398 to 1.258 cps) indicating better physical stability of the juice which was found to be stable for the 30 days under study. Clarification was necessary as it clears the juice by reducing the suspended solids and lowers the tannin concentration.

3.1. Sensory evaluation

Fresh cashew apple juice was light yellow in colour. The colour of Sample A (the untreated fresh juice) became darker on daily bases during storage. Within the first two weeks of storage, the samples became very dark due to the action of non-enzymic browning reaction in the juice during storage, whereas the treated juice (clarified + preservatives) after filtration was colourless throughout the storage period this could be due to the gelatine action and preservatives (Citric acid and benzoic acid) added to the juice . The colour of sample B (clarified and preserved with Citric acid), C (clarified and preserved with benzoic acid) and D (clarified and preserved with both Citric acid + benzoic acid) did not change as they maintained colourless and clear juice for 30 days, without cloudiness, haze or precipitation. This maintenance of colour could be attributed to the clarification and the preservative effects on the juice samples which inactivated enzyme browning in the juice.

Table 1 The colour of cashew juice samples under 30 days of storage

Sample	**Fresh Juice**	**Stored Juice**	
	(28 °C)	Refrigerated Juice (5 °C)	Juice under ambient storage (28 °C)
Untreated juice (Sample A)	0.17	0.17	0.17
Clarified and preserved with Citric acid (Sample B)	0.17	0.16	0.50
Clarified and preserved with benzoic acid (Sample C)	0.17	0.16	0.40
Clarified and preserved with Citric acid + benzoic acid (Sample D)	0.17	0.17	0.51

When spectrophometric test for absorbance was carried out as shown in Table 1, the result gave 0.17 for the first day. When stored for 30 days, samples B, C and D recorded absorbance value of 0.16, 0.16 and 0.17 respectively when stored under low temperature and increased in the absorbance values when stored in room temperature compared to low temperature storage and recorded 0.50, 0.40 and 0.51 respectively.

Table 2 Sensory evaluation of cashew juices under ambient and refrigerated storage in 24 hours

Sensory attributes	Juice under ambient storage	Refrigerated Juice
Mouth feel	1.56	2.41
Colour	3.21*	3.08*
Flavour	1.50	2.35
Taste	2.89*	2.46*
Sedimentation	2.35	3.20
Overall acceptance	2.59*	1.56*

* – means there are significance different ($p<0.05$)

The results in Table 2 indicated a significant difference ($p<0.05$) between the colour, taste and acceptability of juice under ambient storage and the refrigerated juice, while there was no significance difference between mouth feel, flavour and sedimentation.

Table 3 Mean scores of sensory acceptance of fresh and preserved cashew apple juice

Attribute	Fresh juice	Clarified and preserved sample with Citric acid + benzoic acid				
Storage time (in days)		Day 1	Week 1	Week 2	Week 3	Week 4
Colour	4.0	9.0*	8.5	8.5	8.5	8.5
Flavour	7.5	7.5	7.0	7.0	6.5	6.5
Taste	4.5	8.0*	8.0	7.5	7.0	7.5
Sedimentation	7.5	7.5	7.5	7.0	7.5	7.0
Overall acceptance	8.5	9.0	8.5	8.0	7.5	7.0

The hedonic scale rating of both the fresh juice as well as preserved juice was 9.0 for likability or the acceptability of both the samples. The mean sensory scores of the juice presented significant difference in taste and colour up to 30 days (Table 3). This could be due to decrease in tannins causing astringency and the removal of coloured pigments from the fresh juice as a result of clarification. There was no significant difference in sedimentation, flavour and overall acceptability throughout the storage period, indicating the effectiveness of the preservation method in retaining sensory attributes.

3.2. Physico-chemical analyses

Clarity of the juice indicates good appearance and acceptability.

Table 4 Significant changes in important physico-chemical characteristics of preserved cashew apple juice

Storage time (in days)	pH	Total sugars (%)	Vitamin C (mg/100 ml)	TSS (%)	Tannin content (%)
0 (fresh juice)	3.40*	9.60	190.00	15.5	0.58*
7	3.33*	9.62	190.00	15.7	0.42*
14	3.20*	9.61	190.00	15.9	0.38*
21	3.15*	9.59	190.20	16.2	0.23*
30	3.10*	9.60	190.20	16.0	0.20*

* – means there are significance difference ($p<0.05$)

The results of physico-chemical evaluations are as shown in Table 4. The pH which influences palatability of the preserved juice decreased from 3.40 to 3.10 up to 30 days. This decrease in pH could be as a result of the action of citric acid and benzoic acid. Most of the bacteria will not grow at low pH and hence good keeping quality of the juice is maintained [32]. A significant difference ($p<0.05$) exists in the specific gravity, pH and vitamin C content of the juice stored under ambient storage.

Total and reducing sugars in the preserved juice were stable up to a period of 30 days. Total soluble solids content (TSS) of fruit juices detect the level maturity of fruits used for making juice. Total soluble solids of the juice were stable in the range of 15.5 – 16.0 % Brix for the 30 days showing that the fruits were collected at mature stage. This might be the reason for good palatability and acceptability of the juice, as can be deduced from the fact that reducing sugars are the main constituents of soluble solids. This agrees with [15, 26, 29] who reported on the production various ways of producing cashew juice

Vitamin C content of the juice was found to be 190±1.0 mg/100 ml and was stable throughout the 30 days, a slight decrease noted in vitamin C could be due to oxidation, which occurs in fruit juices during storage and is highly dependent on the presence of oxygen in the head space or dissolved in the juice.

3.3. Microbial analysis

Table 5 Microbial quality of the preserved cashew apple juice

No. of days	**Fresh juice**			**Clarified and preserved sample with Citric acid + benzoic acid**		
	Bacteria (in CFU/ml)	Yeasts (in CFU/ml)	Molds (in CFU/ml)	Bacteria (in CFU/ml)	Yeasts (in CFU/ml)	Molds (in CFU/ml)
0	<5	<10	No growth	No growth	No growth	No growth
1	<5	<10	No growth	No growth	No growth	No growth
8	5>	10>	No growth	No growth	No growth	No growth
15	5>	<15	<1	No growth	No growth	No growth
21	<15	<15	<1	No growth	No growth	No growth
28	15>	15>	<5	No growth	No growth	No growth
30	15>	15>	<5	No growth	No growth	No growth

The microbiological count of fresh cashew apple juice was found to be higher (<15). The initial presence of microorganisms in fresh cashew apple juice could be due to the presence of sugars. When the juice was subjected to sterile filtration, complete removal of microorganisms was observed and the juice quality was stable up to 30 days (Table 5).

4. Conclusion

Results obtained from the investigations on extraction and preservations of cashew juice using citric and benzoic acid as preservatives concluded that citric acid and benzoic acid are good preservatives for cashew fruit juice, it also confirmed that the used of stainless manual extractor as well as the combination of clarification, sterile filtration and chemical preservation is suitable for preservation of cashew apple juice up to 30 days under refrigeration. This method was efficient in decreasing astringency, microbial count and in retaining nutrient quality of the juice, since soluble solids, total sugar content and vitamin C were no affected significantly. The juice was also acceptable in terms of sensory attributes. Further, the method described is simple, rapid, inexpensive and convenient for industrial use in the processing and preservation of cashew apple juice. The utilization of the preserved juice should be encouraged as health drink and could be recommended to people with vitamin C deficiency because of its high vitamin C content. Above all, preservation of cashew apple juice is important because of the seasonality of its production which makes it abundantly available during its season and scarce during off season. Stability of shelf-life indicated that the colour, pH, specific gravity, total soluble solid (Brix level) and titratable acidity of the cashew juice was stable during storage when preserved with citric acid and benzoic acid. It is therefore recommended that cashew be processed with other fruits to make blends of juices due to its high ascorbic acid content.

Compliance with ethical standards

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