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Effect of Packaging Materials, Storage Time and Temperature on the Colour and Sensory Characteristics of Cashew (*Anacardium occidentale L.*) Apple Juice

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Abstract Cashew (*Anacardium occidentale L.*) apple juice was produced and pasteurized at 80°C for 15 min in a water bath. The juice was packaged in different packaging materials – green (G), brown (B), white (W) bottles and polyethylene sachet (S) in 200ml batches and stored for four months at room (28°C) and refrigeration (4°C) temperatures to study the effect of packaging materials on the colour and sensory qualities of cashew-apple juice (CAJ). There were significant differences ($p<0.05$) in the values for colour (5.6 – 8.3 EBC) of the juice stored at 28°C as compared with those stored at 4°C. Samples B and G retained more colour (7.0 and 7.2 EBC) at refrigeration temperature when compared with samples W and S. Sensory qualities (colour and general acceptability) of CAJ stored with various packaging materials was significantly affected while taste and flavour of CAJ packaged with G and B samples were not significantly affected at the room temperature up to the fourth month. At 4°C, there was no significant difference ($p>0.05$) in all the sensory qualities of CAJ between the first two months in all the packaging materials studied. At third and fourth months, samples W and S was significantly affected while there was no significant effect between G and B samples at these months. Therefore, CAJ can conveniently be produced and stored in green and brown bottles for up to four months in the refrigeration temperature to retain its colour and sensory qualities. CAJ could also be stored in polyethylene sachet but not more than two months while the fruits are in season to serve as a cheap source of fresh drink and to reduce the 90% wastage of cashew-apples in the orchard.

Keywords: *packaging materials, storage temperature, colour, sensory characteristics, cashew-apples, juice*

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1. Introduction

Cashew tree (*Anacardium occidentale L.*) is one of the major plantation cash crops grown in Nigeria. The fruit consists of mainly the nuts containing an embryo (cashew kernel) and a false fruit commonly called cashew-apple [1]. According to FAO [2], Nigeria produced 660,000 Mt of raw nuts in 2007 and given the weight ratio of apple to nut 8:1 [3]. The annual production of cashew-apples in Nigeria is about 5.2 million Mt, which is left to rot in the orchard. One of the main causes for this is the short post-harvest life of the fruit, coupled with the non-existent industrialization capacity and the short harvest period which is from February to April. The study carried out at Cocoa Research Institute of Nigeria (CRIN) revealed that the present consumption of cashew-apples either in raw or processed form is about 10% of production [4] while 90% is wasted annually in Nigeria. There is need to preserve it for further utilization in the development of some products, which would be acceptable to consumers.

As a result of the need to find a wider use for cashew-apples, researchers from different countries have reported on the products from cashew-apples. These included preparation of jam and preserves [5]; sun-dried cashew-apples [6]; conversion of apple juice into alcohol and non-alcoholic beverages, candied fruit, fresh juice, jelly, syrup and pectin [7]; fermentation of the juice into wine [8] and preparation of cookies from wheat flour and cashew-apple residue as a source of fibre [9].

According to Food and Agriculture Organisation [10], the major component of fruits is water derived from the extra and intracellular fluids necessary for metabolic processes and maintenance of cell sugar. Water composition ranges from 97% in some wild barriers to 70% in over ripe grapes and less than 50% in fruits drying naturally on the plant. As a result of this, fruits and their juice are becoming an important part of the modern diet in many communities. They are nutritious and can play a significant role in a healthy diet because they offer good taste and a variety of nutrients found naturally. Fruit juices are fat-free, nutrient-dense beverages, rich in vitamins, minerals and naturally occurring phytonutrients that contribute to

good health [11] and promote detoxification in the human body [12].

The ban on importation of fruits and drinks in Nigeria has made it imperative and more profitable to engage in the extraction of juice from raw fruits such as cashew-apples and other fruits and by extension, the preservation and packaging of the fruits with the objective of preserving the product for a longer time. Preserved fruit juice commands a higher value and can be consumed more conveniently than whole fruits [13,14]. This has become the business activity of great significance. Countries with abundant fruit resources having short harvest season are focusing more for established storage to maintain quality of fruits, increase its shelf life and preserve fruit juices for off-season use [11].

To preserve, store and package fruit juices to increase its shelf life has led many researchers to carry out work on different fruits. Francis and Elizabeth [15] studied ascorbic acid retention in canned lime juice preserved with sulphur dioxide and benzoic acid. The role of sodium benzoate as a chemical preservative in extending the shelf life of orange juice was done by Muhammad *et al.*, [16] while the effects of packaging materials, storage temperature and time on roselle-mango juice blends was carried out by Mgaya-Kilima *et al.*, [17]. All these were a means of preserving fruits during its off-season.

Colour is an important quality of fruit. Colour development in fruits is due to the formation of anthocyanin pigment in the skin of fruits. According to Curry [18], anthocyanin production and colour is influenced by a range of environmental and management factors in the orchard. Environmental control of temperature, humidity and pest as well as inventory control is needed to minimize these changes in fruit juice during storage. In treated juices, there is still the potential for deterioration. This can take the form of intrinsic spoilage due to juice constituents or extrinsic induced by the environment [10]. According to Hurst *et al.*, [19], "residual enzyme activities changes colour, flavour and consistency of the fruit juice product".

Packaging is a significant aspect in the food processing industry as it serves the important functions of containing the food, protecting against chemical and physical damage while providing information on product features, nutritional status and ingredient information [20]. Various packaging materials such as high-density polyethylene (HDPE), polypropylene (PP), metal cans and glasses are commonly used for packaging of fruit juices [21]. In order to facilitate preservation, it is a technological practice to package juices in these materials.

Processing of cashew-apples to produce fruit juice in order to prevent wastage and to preserve it for use during off-season is the objective of the present research. The focus of this work is to know how best and long the cashew-apple juice (CAJ) could be stored, evaluate the effect of varying coloured packaging materials, time and storage temperature on the colour and sensory characteristics of the cashew-apple juice.

2. Materials and Methods

2.1. Materials

Mature, ripe cashew (*Anacardium occidentale L.*) apples, red and yellow varieties were harvested in an orchard at Uturu, Abia State, Nigeria. A total of hundred kilograms of fruits was utilized.

Bottles of different colours such as white, green, brown and high-density polyethylene sachets were purchased from Next-time Supermarket, Port Harcourt, Rivers State, Nigeria.

2.2. Methods

The fruits (cashew-apple) were sorted to remove the rotten ones, deseeded, weighed and washed in running water. Average weight of the apples was 35±3.5g and average weight of the nuts was 4.5±0.9g. The apples were allowed to drain off water after washing. They were sliced and blended using Sumeet Food Processor (Model A). The blended apples were then pressed to express the juice through muslin cloth folded into 2, 4 and 8 layers, respectively. The obtained juice (200ml batches) was filled into ten bottles for each colour (white "W", green "G", brown "B") and high-density polyethylene sachets (S) and pasteurized at 80°C for 15 min in a water bath. The bottles were corked by means of capping machine, the sachets sealed using a heat sealer and cooled rapidly to room temperature by immersing them in cold water bath [22] then stored at 28°C and 4°C for a period of four months.

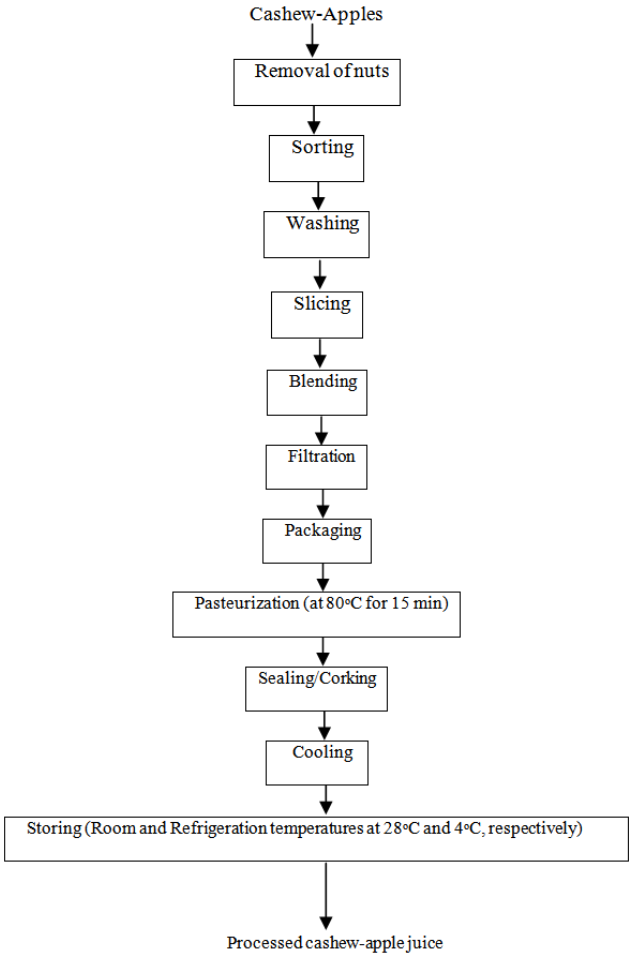

Figure 1. Simplified flow diagram of cashew-apple juice extraction. (**Source:** Authors' Computation)

2.3. Colour Determination

The colour of the freshly pasteurized cashew-apple juice and samples stored at room and refrigeration

temperatures were measured after 7 days for four months using Lovibond Tintometer in accordance to EBC (European Brewery Convention) colour scale. A special kit Lovibond AF 330 on the Lovibond Comparator 2000^{+} for visual colour grading was used which ranges from 2 to 27. This was done by matching 25mm optical glass cell with the precalibrated coloured glass filters. In each case, samples were determined in triplicate and the mean values recorded to represent a particular month.

2.4. Sensory Evaluation

The stored samples at different temperatures were evaluated on colour, flavour, taste and general acceptability. 20 untrained panellists "Students and Staff of Food Science and Technology Department, Rivers State University of Science and Technology, Port Harcourt, Rivers state, Nigeria" were used for the evaluation. A descriptive five point hedonic scale as described by Iwe [23], with 1 and 5 representing the least and the highest scores, respectively were used to score the juice for the characteristics mentioned above. The samples were coded and served randomly in white disposable cups one at a time. They were given enough water for month rinsing between each sample. The evaluation was done weekly, four weeks were taken to represent one month and was done continuously for a period of four months.

2.5. Statistical Analysis

The data obtained were subjected to Analysis of Variance (ANOVA) using Statistical Package for Social Science (SPSS) version 20.0 software 2011. Significant means were differentiated using Turkey's text to establish least significant differences among treatments

3. Result and Discussions

3.1. Effect of Packaging Materials, Storage Time and Temperature on the Colour of CAJ.

The unit for colour measurement was EBC (European Brewery Convention). The range was 2 (yellow) – 27 (red) visual. The colour of the juice stored in polyethylene (S) was significantly ($p<0.05$) higher than those stored in bottles as shown in Table 1. There were gradual increases in the values for colour as time of storage progressed for samples W, G and B, though show no significant ($p>0.05$) effect on the colour of the juice at room temperature. This observation is not in agreement with the report of Mgaya-Kilima *et al.*, [17] who observed a decrease in colour with increase storage time of roselle-mango juice blends. Falade *et al.*, [24] reported 47.4% and 36.8% decrease in colour in sweetened Julie and Ogbomoso mango juice stored at 25°C. Marti *et al.*, [25] also reported a significant decrease in colour during storage of pomegranate juice for 150 days at 25°C. The different reports made by these researchers may be attributed to different fruits used; different storage temperatures, the nature of the packaging materials in these studies and breaks down of flavonoids molecules in the juice. Fellow and Hampton [26] stated that properties of packaging materials has effect on colour of juice stored in them. The juice still retained a deep yellow colour due to the fact that carotenoids are almost insoluble and is not affected much by the presence of acids and alkalies [27].

Table 1. Effect of Packaging Materials, Storage Time on the Colour of Cashew-Apple Juice Stored at Ambient Temperature.

Samples	Month Zero	Month One	Month Two	Month Three	Month Four
W	5.1±0.34^{a}	5.8±0.00^{a}	6.4±0.07^{b}	7.0±0.24^{b}	7.8±0.41^{b}
G	5.1±0.34^{a}	5.7±0.41^{a}	6.1±0.02^{b}	6.8±0.41^{b}	7.4±0.45^{b}
B	5.1±0.34^{a}	5.6±0.24^{a}	6.2±0.00^{b}	6.9±0.36^{b}	7.5±0.01^{b}
S	5.1±0.34^{a}	6.4±0.00^{a}	7.0±0.41^{a}	7.8±0.00^{a}	8.3±0.01^{a}
LSD		0.7	0.6	0.9	0.9

Values on the same column with the same letter superscript are not significantly different ($p>0.05$).
Key: W = white bottle, G = green bottle, B = brown bottle, S = polyethylene (sachet).

There were no significant ($p>0.05$) changes in the colour of the variously packaged juice after the first and second months at refrigeration temperature. There were significant variations in the colour of the variously packaged materials at the end of the third and fourth months but these values were lower than the values obtained for the third month at room temperature. Pasteurization of the juice inactivated the enzymes due to protein denaturation and as such helped to stabilize the colour of the juices. Cashew-apple juice should be pasteurized adequately before storage if the attractive colour of the juice is to be maintained.

Table 2. Effect of Packaging Materials, Storage Time on the Colour of Cashew-Apple Juice Stored at Refrigeration Temperature.

Samples	Month Zero	Month One	Month Two	Month Three	Month Four
W	5.1±0.34^{a}	5.5±0.12^{b}	5.8±0.05^{bc}	6.9±0.10^{a}	7.0±0.02^{a}
G	5.1±0.34^{a}	5.5±0.05^{b}	5.6±0.07^{b}	6.8±0.07^{a}	7.0±0.04^{a}
B	5.1±0.34^{a}	5.5±0.14^{b}	5.6±0.04^{b}	6.8±0.11^{a}	7.2±0.08^{a}
S	5.1±0.34^{a}	6.0±0.40^{a}	6.3±0.06^{a}	7.3±0.09^{a}	7.6±0.06^{a}
LSD		0.70	0.60	0.35	0.7

Values on the same column with the same letter superscript are not significantly different ($p>0.05$).
Key: W = white bottle, G = green bottle, B = brown bottle, S = polyethylene (sachet).

3.2. Sensory Evaluation of CAJ Stored in Different Packaging Materials at Different Temperatures.

The result of sensory evaluation with respect to flavour, colour, taste and general acceptability is presented in Table 3 and Table 4 (room and refrigeration temperatures), respectively. At room temperature, sample B was the most acceptable followed by sample G, W and S. Sample B and G were the most acceptable after the second, third and fourth months but the values decreased with time. This may be due to break down of some volatile aroma and flavour components with time [28,29]. Sample S scored the lowest in all the sensory attributes followed by W. As stated earlier, the penetration of light into these packaging materials might have caused break down of some chemical components of the juice. Their acceptability was lowest at the fourth month of storage. At room temperature, ageing occurred slowly causing fruit juices held on retail store shelves for three or more years to change its colour and flavour [26].

Table 3. Sensory Evaluation of CAJ Stored in Different Packaging Materials at Room Temperature.

Months	Samples	Colour	Flavour	Taste	General Acceptability
0	W	4.56^{a}	4.10^{a}	3.00^{a}	3.50^{a}
	G	4.56^{a}	4.10^{a}	3.00^{a}	3.50^{a}
	B	4.56^{a}	4.10^{a}	3.00^{a}	3.50^{a}
	S	4.56^{a}	4.10^{a}	3.00^{a}	3.50^{a}
1	W	4.33^{a}	3.07^{a}	3.33^{a}	3.40^{a}
	G	4.46^{a}	3.47^{a}	3.47^{a}	3.40^{a}
	B	4.53^{a}	3.53^{a}	3.53^{a}	3.53^{a}
	S	4.33^{a}	3.27^{a}	3.47^{a}	3.33^{a}
2	W	2.67^{b}	3.07^{b}	4.40^{a}	3.00^{b}
	G	3.47^{a}	3.93^{a}	4.50^{a}	3.47^{bc}
	B	3.60^{a}	4.00^{a}	4.67^{a}	4.13^{ac}
	S	2.67^{b}	3.00^{b}	4.33^{a}	2.93^{b}
3	W	3.40^{b}	3.27^{b}	3.46^{a}	3.27^{c}
	G	4.40^{a}	3.67^{b}	3.60^{a}	4.00^{bc}
	B	4.53^{a}	4.33^{a}	3.53^{a}	4.67^{ab}
	S	3.40^{b}	3.20^{b}	3.46^{a}	3.33^{c}
4	W	2.67^{c}	3.27^{b}	2.67^{b}	2.80^{c}
	G	3.87^{b}	4.07^{a}	4.53^{a}	3.40^{bc}
	B	4.53^{a}	4.00^{a}	4.67^{a}	3.40^{bc}
	S	2.73^{c}	3.20^{b}	2.73^{b}	2.67^{c}

Values in the same column not having the same superscript are significantly ($p<0.05$) different.
Key: W = white bottle, G = green bottle, B = brown bottle, S = polyethylene (sachet).

Table 4. Sensory Evaluation of CAJ Stored in Different Packaging Materials at Refrigeration Temperature.

Months	Samples	Colour	Flavour	Taste	General Acceptability
0	W	4.56^{a}	4.10^{a}	3.00^{a}	3.50^{a}
	G	4.56^{a}	4.10^{a}	3.00^{a}	3.50^{a}
	B	4.56^{a}	4.10^{a}	3.00^{a}	3.50^{a}
	S	4.56^{a}	4.10^{a}	3.00^{a}	3.50^{a}
1	W	4.40^{a}	4.40^{a}	4.13^{a}	4.53^{a}
	G	4.53^{a}	4.60^{a}	4.20^{a}	4.80^{a}
	B	4.47^{a}	4.67^{a}	4.13^{a}	4.87^{a}
	S	4.33^{a}	4.47^{a}	4.20^{a}	4.60^{a}
2	W	4.60^{a}	3.87^{a}	4.60^{a}	4.00^{a}
	G	4.87^{a}	4.20^{a}	4.67^{a}	4.00^{a}
	B	4.80^{a}	4.20^{a}	4.47^{a}	4.20^{a}
	S	4.53^{a}	3.93^{a}	4.53^{a}	3.73^{a}
3	W	3.93^{bc}	3.53^{a}	3.87^{a}	3.60^{b}
	G	4.67^{a}	3.67^{a}	4.13^{a}	4.47^{a}
	B	4.60^{a}	3.47^{a}	4.27^{a}	4.60^{a}
	S	3.66^{c}	3.33^{a}	4.00^{a}	4.47^{b}
4	W	3.53^{b}	4.27^{a}	3.53^{a}	3.47^{b}
	G	3.87^{a}	4.27^{a}	4.00^{a}	3.93^{b}
	B	4.60^{a}	4.33^{a}	3.87^{a}	4.27^{a}
	S	3.53^{b}	4.13^{a}	3.33^{a}	3.53^{b}

Values in the same column not having the same superscript are significantly ($p<0.05$) different.
Key: W = white bottle, G = green bottle, B = brown bottle, S = polyethylene (sachet).

There were no significant differences ($p>0.05$) in the sensory characteristics of the various samples stored at refrigeration temperature in the first and second months as shown in Table 4. There were no significant differences ($p>0.05$) in flavour and taste among all the samples even after the fourth month of storage. This is similar with the report of Freitas *et al.*, [30], who observed that sensory attributes (flavour and taste) did not vary significantly between the beginning and the end of the storage period. At the end of the third month, sample S and W were rated less attractive and less acceptable compared with G and B. At the end of the fourth month, scores for general acceptability for sample B was the highest (4.27). Sample B preserved the sensory attributes of the juice best followed by G then W and lastly S. Braddock and Marcy [29] in their study on orange juice concentrate stated that both storage temperature and time affected the sensory quality of fruit juice in terms of decrease in taste, flavour and general acceptability.

4. Conclusion

The bottling process used in this research is a simulation of canning though not as effective because canning temperature is higher than that applied while bottling. There were gradual increases in the values of colour as time of storage progressed in all the packaging materials studied. The juice packaged with sachet material affected the colour most compared to other packaging materials both at 28°C and at 4°C. The storage period of about four months was effective in preserving the sensory attributes of flavour and taste of the juice in all the packaging materials studied while the colour and general acceptability was only preserved with green and brown bottles at the fourth month at 4°C. Room temperature was not effective in preserving CAJ in all the packaging materials studied but green and brown bottles was found to strive over time

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