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Physicochemical properties of plant milk beverages produced from african breadfruit, tiger nut, coconut and date fruit

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Abstract:
Plant produce has been used in a variety of ways traditionally and as low-cost alternatives to meat for poor families in some communities in Nigeria. However, there is a need to diversify its use by developing non-traditional food products from them which would enhance wider utilization of the seeds that has been limited because of traditional culinary preparations. African breadfruit seeds, tiger nuts, coconut and date fruits were processed into plant milk beverages. The physicochemical properties of the plant milk beverages were evaluated. The results of the proximate and physical properties of the formulated beverage samples showed average values of 83.05, 1.09, 8.82, 2.01 and 4.64 percent for moisture, ash, protein, fat and carbohydrate contents and 5.00, 5.89, 1.02, and 87.29 percent for pH, total dissolved solid, specific gravity and viscosity. These values were comparable to the values recorded from the control sample which were 81.41, 1.23, 6.00, 3.84 and 7.26 percent and 6.44, 6.04, 1.04 and 88.60 percent for the same quality parameters. The sensory evaluation analysis showed consumer preference to the control sample over the formulated beverage samples probably due to their longtime familiarity with soymilk-based beverages. However, samples 852 and 941 where the preferred samples according to the consumers rating. The study revealed that plant milk formulated from breadfruit milk, tiger nut milk, coconut milk and date fruit juice gave products that are comparable to the conventional soy bean based vita milk in terms of their nutritional composition.
Keywords: *Crude fiber, Crude protein, Specific gravity, milk beverage, Viscosity*

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I. Introduction

Beverages are diverse groups of commodities which serve as drinks. Some beverages such as animal milk are consumed because of their nutritional contents while others are consumed because of their ability to quench thirst or its ability to stimulate or simply because of the pleasure derived in their consumption. Generally, they are grouped into alcoholic and non-alcoholic beverages. The production of Non-alcoholic beverages does not involve fermentation, but they may or may not be impregnated with carbon (IV)[1].

Also, some beverages can be categorized based on their sources either from animals (e.g., cow milk, goat milk and human milk) or from plants. Unlike milk from animal sources, milk can be obtained from plant sources especially legumes and oilseeds such as soybeans. Plants milk are used as alternative to animal milk in communities that have scarcity of milk or where the rate of milk production is lower than consumer's demand for milk[2]. Plant milk are also good alternative for consumers including babies, who do not take animal milk either for religious or medical reasons like in milk allergies (example lactose intolerance). Also, because of nutritional quality and health implications, consumers are moving from over dependance on fats and proteins from animal to those from plant source due to disease incidences associated with fat and protein from animal sources[3].

African breadfruit (*Treculiaafricana*) is a legume which has fruit heads. It is a known and valued food in the diet of many Nigerians. The southern people of Nigeria, especially the Igbos prepare it using different method of traditional preparations and the consumption may vary depending on food habits, ethnic background, culture and traditions. But the processing method in most areas involve cooking in water to make porridge and adding ingredients like salt, pepper, crayfish and dried fish. One can choose to add oil and, in some cases, run off some of the cooking water into a dish to serve as beverage. The small brown seeds have a groundnut flavour when roasted; they are sold in this form in the open market by the Igbos in Nigeria[4].

Tiger-nut (*Cyperus esculentus L)* is among the under-utilized crops in Nigeria which has been reported to be high in mineral and dietary fiber content, which could be effective in the treatment and prevention of many diseases including colon cancer, coronary heart diseases, obesity, diabetes and gastrointestinal diseases[5]. Milk from tiger nut is an authentic natural vegetable drink or dessert and it is prepared with water, sugar and tiger nuts. Tiger nut milk is very rich nutritionally. It is a very nutritive, energy drink for both the young and old[6].

Coconuts are from the tree (*Cocos nucifera*) and they are known for their versatility, which is why they have many uses ranging from food to cosmetics. People in the tropics and subtropics use them as major part of their diets. The oil and milk derived from it are commonly used in cooking, frying, as beverages and also in soaps and cosmetics[7].

Date fruit which refers to the fruits of the date palm tree *(Phoenix dectylifera)* is also among the under-utilized crops in Nigeria. Dates are eaten in both fresh and dried state. Dates have sweet taste, rich flavor and a chewy texture. Aside their taste, they are powerhouses of nutrients which can serve as energy booster and it justifies the reason why Muslims use them to break their fast during Ramadan holy month. Dates are both rich in taste and very healthy for consumption[8].

Plant produce has been used in a variety of ways traditionally and as low-cost alternatives to meat for poor families in some communities in Nigeria. However, there is a need to diversify its use by developing non-traditional food products from them which would enhance wider utilization of the seeds that has been limited because of traditional culinary preparations even though the seeds have potentials for other applications like vegetable oil, flour used for making cakes, cookies, soup thickening, etc. To solve food insecurity problems, there is growing need to develop new products and research on new ways of utilizing high nutritional but under-utilized indigenous staple crops. The increased consumption of beverages displaces other healthier choices such as water, fresh fruit and vegetable juices. Hence producing a food product that will serve the need of a beverage and also make for healthier and more nutritious alternative from plant sources will go a long way in reducing the numerous side effects associated with consuming beverages from other sources. Also, the production of a beverage that contains tiger nut milk and date fruit juice will help promote production and utilization of these under- utilized crops in Nigeria in a way that will make them more accessible and acceptable to the consumers. The aim of this study is to formulate, evaluate and analyze the quality characteristics of non-alcoholic beverages from blends of African breadfruit milk, coconut milk, tiger nuts milk and date fruit.

II. Materials And Methods

Source of raw materials

African breadfruit seeds, tiger nuts, coconut and date fruits were purchased at Oyibo market, old Aba Road Port Harcourt, River state, Nigeria. The chemical additives that were used in this research were purchased from Pokobros Food and Chemical Industries Limited, No.1 Harbour Industrial Layout, Port Harcourt, Rivers state Nigeria and they were of analytical standards.

Preparation of raw materials

The raw materials were prepared and processed in the Food Processing Laboratory of Food Science and Technology Department, Michael Okpara University of Agriculture, Umudike, Abia State Nigeria.

The breadfruit seeds were sorted to remove bad seeds and other solid contaminates. Two (2) kg of the sorted seeds was divided into two parts of 1kg each. One part was thoroughly washed, par-boiled/blanched in hot water for 10-15 min and drained after. The par-boiled seeds were de-hulled manually to get the per-boiled dehulled seeds. The second part of the sorted breadfruit seeds were washed drained and roasted at 72^0C for 30 min, then de-hulled and winnowed to separate the seeds from husks to get the roasted breadfruit seeds. The tiger nuts were sorted to remove bad nuts and contaminants and 2 kg sorted nuts were soaked in worm water for 2 h.The coconut seeds were cracked manually and their endocarp or meat detached from the pericarp using a knife. Two (2) kg of the endocarp were measured, cut into smaller pieces and washed, while the dried date fruits were sorted to remove bad fruits and contaminants, then two (2) kg of the sorted date fruits were chopped into smaller sizes and the enclosed seeds removed and washed.

Processing of raw materials

African bread fruit milk was processed according to the method described by Okafor and Ugwu[9].
Tiger nuts milk was processed according to the method described by Udeozor[6].
Coconut milk was processed according to the method described by Okafor and Ugwu[9].
Date fruit juice was processed as described by JO-Ann[10].

Formulation of plant milk beverages

Two groups of the beverages were formulated using Roasted Breadfruit milk (rBFM), Tiger nut milk (TM), Coconut milk (CM) and Date fruit Juice (DFJ) in three different ratios of (3:5:1:1), (2:6:1:1) and (1:7:1:1) in one group and Cooked Breadfruit milk (cBFM), TM, CM and DFJ using the same ratio in another group. After which 0.3% CMC solution were added to the blends to serve as stabilizer and the formulation were thoroughly mixed, homogenized and pasteurized at 72^0C for 5 min in a water bath and allowed to cool. Exactly 0.2% Potassium sorbate solution and 0.05% Citric acid solution were added to the blends as preservatives. The beverages samples were homogenized, filled into screw capped plastic bottles and stored at room temperature.

Table 1. Proportions of extracts for plant milk formulation

Beverage brand	**Proportion of the milk components in the beverage samples (%)**				
	Samples	Breadfruit	Tiger nut	Coconut	Date fruit
Roasted	621	30	50	10	10
	742	20	60	10	10
	852	10	70	10	10
Cooked	536	30	50	10	10
	482	20	60	10	10
	941	10	70	10	10

Determination of proximate composition

The method described by AOAC[11] was used to determine the moisture content, ash content, fat content, crude fibre, crude protein content and the carbohydrate content of the samples.

Determination of physical properties

The method described by Iwuoha and Kenneth[12] was used to determine the pH, titratable acidity, total dissolved solids (TDS), specific gravity and viscosity.

Sensory evaluation

The sensory evaluation was determined according to the method described by Iwe[13].

Statistical analysis

Analysis of variance was used for the determination of significant differences ($p<0.05$) among treatment means and separation of means was carried out using the SPSS version 20.0. Separation of means was carried out by Duncan Multiple range test and values were reported as means and standard deviation.

III. Results

Proximate composition of the raw materials

The proximate composition of the raw materials used in the production of the plant milk samples were shown in table 2. The highest level of moisture content was recorded from breadfruit seeds with mean value of 8.01% while the least was recorded from coconut with 2.40%. The highest level of protein was recorded from breadfruit seeds with mean value of 12.47%, followed by the protein content of tiger nut (9.71%) and coconut (9.21%), while the lowest level of protein was recorded from date fruit (2.27%). The highest level of fat was recorded from coconut (23.66%), while the lowest fat level was recorded from date fruit (0.70%). Coconut also recorded the highest level of fibre (27.62%), followed by tiger nut (5.63%). The lowest fiber content level was recorded from breadfruit (1.62%).

Tiger nut has the highest level of ash (4.25%), followed by date fruit (3.29%) and the lowest level of ash was recorded from coconut (1.58%). The carbohydrate content was highest in date fruit (76.95%), followed by breadfruit (73.26%), but the least value of carbohydrate was recorded from coconut (35.36%).

Table 2. Proximate composition of the raw materials used in the plant milk production

Samples (%)	**Moisture**	**Protein**	**Fat**	**Fiber**	**Ash**	**Carbohydrate**
Breadfruit	8.01^{a}±0.01	12.47^{a}±0.02	4.23^{c}±0.03	1.62^{d}±0.02	2.26^{c}±0.01	73.26^{b}±0.01
Tiger nut	3.78^{c}±0.01	9.71^{b}±0.01	13.60^{b}±0.01	5.62^{b}±0.02	4.25^{a}±0.01	63.05^{c}±0.01
Coconut	2.40^{d}±0.01	9.21^{b}±0.01	23.66^{a}±0.01	27.62^{a}±0.01	1.58^{d}±0.01	35.36^{d}±0.03
Date fruit	7.20^{b}±0.01	2.27^{c}±0.02	0.70^{d}±0.01	2.13^{c}±0.02	3.29^{b}±0.01	76.95^{a}±0.01

Values are means of triplicate of samples. Values with different superscript in the same column are significantly different at ($P>0.05$). Samples 621,742 and 852 are toasted breadfruit milk-based samples blended

with tiger nut milk, coconut milk and date fruit juice at the ratios of 3:5:1:1, 2:6:1:1 and 1:7:1:1 respectively and samples 536, 482 and 941 are cooked breadfruit milk-based samples blended with breadfruit milk, tiger nut milk, coconut milk and date fruit juice at the ratios of 3:5:1:1, 2:6:1:1 and 1:7:1:1 respectively. Sample 804 is vitamilk which is the reference sample.

Proximate composition of the plant milk samples

The proximate composition of the plant samples are shown in table 3. The moisture content of the formulated plant milk samples were as expected high; 83.87%, 82.30% and 85.07% for the toasted breadfruit-based samples and 82.81%, 80.50% and 83.71% for the cooked breadfruit-based samples. These values were not significantly different (P>0.05) when compared to the value recorded for the reference sample (81.14%). The crude protein content of the toasted breadfruit-based samples ranged from 7.63 to 9.97%, while that of the cooked breadfruit-based samples ranged from 7.58 to 9.00%. The values recorded for the toasted breadfruit-based samples were high in significant difference (P<0.05) when compared to the values recorded from the corresponding cooked breadfruit-based samples which were formulated using the same proportions of the different milk extracts but differing only in the pretreatment of the breadfruit seeds (cooking instead of toasting). The fat content recorded from the plant milk samples were 2.13, 2.21 and 1.88 for the toasted breadfruit-based plant milk samples and 1.98, 2.06 and 1.81 for the cooked breadfruit-based sample. These values were low in significant difference (P<0.05) when compared to the value recorded from the reference sample (3.84%). The ash contents of the plant milksamples were 1.14%, 1.24% and 0.98% for the toasted breadfruit-basedplant milksamples and these values were high in significant difference (P<0.05) when compared to the value recorded from the cooked breadfruit-based samples which have values of 1.09%, 1.19% and 0.91%. The fiber content of the plant milk samples was low; 0.35%, 0.43% and 0.53% for the toasted breadfruit-based sample and 0.31%, 0.39% and 0.44% for the cooked breadfruit-based samples. These values were high in significant difference (P<0.05) when compared to the value recorded for the fiber content of the reference sample (0.26%). The carbohydrate content of the toasted breadfruit-based plant milk samples were 2.66%, 3.90% and 3.93%. These values were low in significant difference (P<0.05) when compared to the value recorded from the cooked breadfruit-based samples (4.90%, 5.56% and 6.87%).

Table 3. Proximate composition of the plant milk samples

Sample (%)	Moisture	Protein	Fat	Ash	Fiber	Carbohydrate
621	82.30^{e}±0.85	9.87^{a}±0.04	2.06^{d}±0.01	0.98^{e}±0.01	0.35^{cd}±0.03	2.66^{d}±0.66
742	83.87^{b}±0.62	9.92^{a}±0.01	1.98^{e}±0.01	1.14^{c}±0.02	0.43^{b}±0.03	3.90^{c}±0.83
852	85.07^{a}±0.05	7.63^{c}±0.01	1.81^{g}±0.02	1.24^{a}±0.01	0.53^{a}±0.01	3.93^{c}±0.08
536	80.50^{f}±0.03	9.00^{b}±0.01	2.21^{b}±0.01	0.91^{f}±0.01	0.31^{de}±0.01	4.90^{bc}±0.01
482	82.81^{cd}±0.01	8.92^{b}±0.02	0.98^{e}±0.01	1.09^{d}±0.01	0.39^{b}±0.01	5.56^{b}±0.01
941	83.71^{bc}±0.01	7.58^{c}±0.01	1.88^{f}±0.01	1.19^{b}±0.01	0.44^{b}±0.03	6.87^{a}±0.02
804	81.41^{ef}±1.53	6.00^{d}±0.28	3.84^{a}±0.68	1.26^{a}±0.12	0.26^{e}±0.30	7.26^{a}±0.05

Values are means of triplicate of samples. Values with different superscript in the same column are significantly different at (P>0.05). Samples 621,742 and 852 are toasted breadfruit milk-based samples blended with tiger nut milk, coconut milk and date fruit juice at the ratios of 3:5:1:1, 2:6:1:1 and 1:7:1:1 respectively and samples 536, 482 and 941 are cooked breadfruit milk-based samples blended with breadfruit milk, tiger nut milk, coconut milk and date fruit juice at the ratios of 3:5:1:1, 2:6:1:1 and 1:7:1:1 respectively. Sample 804 is vitamilk which is the reference sample.

Physicochemical properties of the plant milk samples

The physicochemical properties of the plant samples are shown in table 4. The pH of the toasted breadfruit-based samples ranged from 4.97, 4.95 and 4.96 were slightly low in significant difference (P<0.05) when compared to the pH recorded from the cooked breadfruit-based samples which have values ranging 5.01, 5.06 and 5.04. The total titrable acidity content of the formulated plant milk samples ranged from 25.89 to 25.93 mg/l for the toasted breadfruit samples and from 25.91 to 25.95 mg/l for the cooked breadfruit-based samples. In all, there was no significant different (P>0.05) between the total titrable acidity of the two brands of formulated

plant milk samples. However, the values recorded from the formulated plant milk samples were high in significant level (P<0.05) when compared to the value recorded from the reference sample (25.17 mg/l). The total dissolved solid recorded for the samples were; (5.88, 5.91 and 5.91) mg/l for the toasted breadfruit-based sample and (5.86, 5.87 and 5.91) mg/l for the cooked breadfruit-based samples. These values were low in a significant difference (P<0.05) when compared to the value recorded from the reference sample, which have a total dissolved solid of 6.04 mg/l. The specific gravity recorded for the formulated plant milk samples were 1.02 mg/l for all the toasted breadfruit-based samples and 1.02 mg/l, 1.02 mg/l and 1.02 mg/l for the cooked breadfruit-based samples. The values were slightly low in significant difference (P<0.05) when compared to the value recorded for the reference sample (1.04 mg/l). The viscosity of the formulated beverage samples were; 89.60 cp, 87.95 cp and 88.15 cp for the toasted breadfruit-based samples. These values were low in significant difference (P<0.05) when compared to the values recorded from the cooked breadfruit-based samples which were 86.10 1cp, 85.85 cp and 86.11 cp.

Table 4. Physicochemical properties of the plant milk samples

Sample	pH	TTA	TDS	Specific Gravity	Viscosity
621	4.97^{d}±0.01	25.93^{a}±0.03	5.88^{bc}±0.01	1.02^{b}±0.00	89.60^{a}±0.14
742	4.95^{d}±0.01	25.92^{a}±0.01	5.91^{b}±0.01	1.02^{b}±0.00	87.95^{c}±0.21
852	4.96^{d}±0.01	25.92^{a}±0.01	5.91^{b}±0.01	1.02^{b}±0.00	88.15^{bc}±0.21
536	5.01^{c}±0.01	25.94^{a}±0.01	5.86^{c}±0.01	1.02^{b}±0.00	86.10^{d}±0.14
482	5.06^{b}±0.01	25.94^{a}±0.01	5.87^{bc}±0.01	1.03^{b}±0.00	85.85^{d}±0.21
941	5.04^{bc}±0.01	25.91^{a}±0.01	5.91^{b}±0.01	1.02^{b}±0.00	86.11^{d}±0.00
804	6.44^{a}±0.03	25.17^{b}±0.06	6.04^{a}±0.04	1.04^{a}±0.01	88.60^{b}±0.28

Values are means of triplicate of samples. Values with different superscript in the same column are significantly different at (P>0.05). Samples 621,742 and 852 are toasted breadfruit milk-based samples blended with tiger nut milk, coconut milk and date fruit juice at the ratios of 3:5:1:1, 2:6:1:1 and 1:7:1:1 respectively and samples 536, 482 and 941 are cooked breadfruit milk-based samples blended with breadfruit milk, tiger nut milk, coconut milk and date fruit juice at the ratios of 3:5:1:1, 2:6:1:1 and 1:7:1:1 respectively. Sample 804 is vita milk which is the reference sample. TTA = Titratable acidity, TDS = Total Dissolved Solid

Sensory evaluation of the plant milk samples

The sensory evaluation scores of the plant milk samples are presented in Table 5. The results for the formulated plant milk samples show that the toasted breadfruit-based samples were rated high compared to the cooked breadfruit-based samples for all the sensory attribute tasted, except for colour attribute, where the rating of the cooked breadfruit-based samples were slightly high in significant different (P<0.05) when compared to the toasted breadfruit-based samples.

Table 5. Sensory evaluation scores of the plant milk samples

Samples	Colour	Taste	Aroma	Mouth feel	General acceptability
621	6.70^{a}±1.45	5.20^{a}±1.79	6.10^{a}±1.74	6.05^{a}±1.68	6.70^{a}±1.70
742	6.91^{a}±0.83	6.60^{ab}±1.53	6.95^{a}±1.73	7.75^{a}±1.54	7.25^{a}±1.37
852	7.35^{b}±1.14	7.80^{bc}±2.17	7.30^{ab}±1.42	7.90^{a}±1.71	8.10^{ab}±1.57
804	7.45^{b}±1.79	8.75^{d}±2.36	8.40^{b}±1.64	8.65^{b}±1.46	8.95^{b}±1.39
536	7.20^{b}±1.32	6.60^{ab}±2.07	6.00^{a}±1.74	6.00^{a}±1.72	6.55^{a}±1.95
482	7.55^{b}±1.36	6.80^{ab}±1.79	6.10^{a}±1.73	6.15^{a}±1.59	7.15^{a}±1.96
941	7.65^{b}±1.84	7.50^{bc}±1.15	6.30^{a}±1.42	6.85^{a}±1.66	7.95^{ab}±1.40

Values are means of triplicate samples. Values with different superscript in the same column are significantly different at ($P < 0.05$). Samples 621,742 and 852 are toasted breadfruit milk-based samples blended with breadfruit milk, tiger nut milk, coconut milk and date fruit juice at the ratios of 3:5:1:1, 2:6:1:1 and 1:7:1:1 respectively and samples 536, 489 and 941 are cooked breadfruit milk-based samples blended with breadfruit milk, tiger nut milk, coconut milk and date fruit juice at the ratios of 3:5:1:1, 2:6:1:1 and 1:7:1:1 respectively. Sample 804 is vitamilk which is the reference sample.

IV. Discussion

In all the results of the proximate composition of these raw materials were in line with reports of previous researchers[14,15].

The high level of moisture in the milk samples were expected as beverages are liquid food products which has water as the major constituent and it makes them susceptible to microbial contamination as many microorganisms can thrive in such high moisture environment. However, the slight differences in. moisture content among the samples may be attributed to the different blending ratio used in the formulation of each sample as each component of the blend have different amount of dissolved solids and the amount of a particular component in a sample will determine to an extent the moisture content of the samples[16,17]. Also, pretreatment method (boiling and toasting) of the breadfruit seed may have an effect on the final moisture content of the product.

The difference in protein content may be attributed to the variation in pretreatment given to the breadfruit seeds before the extraction of their milk, as previous research has shown that toasted breadfruit seeds have higher protein content as compared to cooked breadfruit seeds[18]. However, the protein content of all the formulated plant milk samples were all high in a significant difference ($P<0.05$) when compared to the value recorded from vitamilk (6.00%) which was used as the reference sample and also higher than the values recorded by researchers for milk from other leguminous plants; 3.38% and 2.71% for breadfruit milk and soymilk as reported by Onweluzo and Nwakalor[19], 3.67% for melon seed milk as reported by Akubor[20] and 2.71% for soybean milk as reported by Nnam[21]. Also, the protein content of the plant milk samples were higher than that of dairy milk (3.5%) as reported by Passmore and Eastwood [22]. The high values of protein in the formulated plant milk samples may be due to the high protein content of breadfruit seeds and tiger nut which according to the report of Udeozor[6] are higher than the protein content of most leguminous plant, soybean inclusive. The high protein content of the formulated plant milk samples was in line with one of the primary aim of this research which is producing a protein rich beverage from plant source that will be an upgrade to most of the conventional beverages which are poor protein sources and help in solving the protein deficiency problem that has been source of concern in developing countries, Nigeria inclusive.

The values for the fat contents were unexpectedly lower than the minimum 3% fat level required by the Codex Alimentarius Standard as reported by Passmore and Eastwood[22], putting into consideration the high levels of fat in tiger nut and coconut seeds that were components of the formulated beverages. The low-fat level in the samples may be attributed to the processing treatment that involves extraction using water which is a polar solvent and as such may not be very effective in extracting the fat (non-polar solvent) contained in the production materials and also due to loss of fat during pretreatment of the breadfruit seeds[23,20].

The finding for the ash content maybe attributed to the leaching of nutrient in boiling water during the cooking of the breadfruit seeds. In all, the ash content values recorded from the formulated beverage samples were higher compared to the ash content of melon seed milk (0.72%), soymilk (0.81%) and breadfruit milk (0.79%) as reported by Akubor[20], Nnam[21] and Onweluzo and Owo[24].

The low fiber content recorded from the plant milk samples is expected basically because they are liquid products which are generally low in fiber, while the higher fiber content recorded by the formulated plant milk samples compared to the reference sample may be attributed a large extent to the high fiber content of tiger nut, coconut and date fruit according to previous researchers[25,6,8], which were transmitted to the beverage after formulation.

The different in the carbohydrate contents may be attributed to the variation in the processing of the breadfruit seeds, as boiling of breadfruit seeds has been reported to make carbohydrate more available than roasting[26]. However, the carbohydrate content of the reference sample (7.66%) was higher in a significant difference ($P<0.05$) to the values recorded from the formulated beverage samples and these may be attributed to difference in raw material used in the production of the respective products and also the effectiveness of extraction mechanism employed. Nevertheless, both the formulated plant milk samples and the reference sample have carbohydrate content level comparable to that of human milk (6.8%) and dairy milk (5.0%) as reported by Beuchat and Nail[27].

The pH values recorded from the plant milk samples were slightly acidic because of the citric acid used as preservative in the formulated beverage samples. This acidic condition is also good as it will discourage the growth of many bacteria in the plant milk samples and also will help in activating the optimum fungal inhibiting

ability of potassium sorbate used in the formulated plant milk samples as preservatives, since it requires slightly acidic condition to be effective as fungi inhibitors[11].

The high total titrable acidity recorded from the formulated plant milk samples could be attributed to the presence of citric acid used in the plant milk samples as preservatives and also tiger nut milk component of the samples which has been reported by previous researchers to be slightly acidic[28,29,6].

The variation between the total dissolved solid of the formulated plant milk samples and the reference sample could be attributed among other factors to the level of stabilizers used during production and the method of extraction of milk from the plant source used as raw material in the production process[30]. However, the values of total dissolved solid recorded in the plant milk samples were close to the reports of previous researchers; 5.86 mg/l for breadfruit milk as reported by Ifediba and Ozoh[31], 6.00 mg/l for soymilk as reported by Onweluzo and Nwakalor (2009) and 6.01mg/l for breadfruit- corn milk blends according to the report of Elsamani *et al.*[32]

The difference in the specific gravity could be attributed to the processing method used during extraction of the milk components from the plant sources and the nature of the plant source raw materials (Ifediba and Ozoh 2018). The values recorded for specific gravity from the formulated plant milk samples were within the range of specific gravity recorded from milk products from other sources; soymilk (1.018 mg/l), coconut milk (1.01 mg/l), goat milk (1.03 mg/l) and cow milk (1.016 mg/l)[33].

The observed variation between the viscosities of two brands of formulated plant milk could be due to the higher consistency of milk from the cooked breadfruit seeds to the milk extracted from the toasted breadfruit seeds.

The results for the sensory evaluation may be attributed to the roasting pretreatment given to the breadfruit seeds used in producing this brand which gave a brownish yellow colour to the breadfruit seeds resulting in the brownish colour of the plant milk.

The results recorded for the taste attribute of the plant milk sample shows that samples that contained lower proportion of breadfruit milk for both toasted and cooked breadfruit-based samples were rated higher than the samples with higher proportion of breadfruit milk. However, the rating were not significantly different at $P>0.05$. This observation may be attributed to the characteristic taste of breadfruit milk which the consumers may not be conversant with. The same trend was also observed for the rating for aroma attributes of the beverage samples. And this observation may be because of the characteristic aroma of breadfruit milk which the panelist may not be used to and as such affected there rating of samples with high breadfruit milk proportion. However, the difference in rating for aroma between samples with highest proportions of breadfruit milk (621 and 536), and the other samples containing lower proportion of breadfruit milk were not significantly different at $P>0.05$. This observation may be due to the characteristic aroma of breadfruit milk which the panelist may not be used to and as such affected there rating of samples with high breadfruit milk proportion.

V. Conclusion

The study revealed that plant milk formulated from breadfruit milk, tiger nut milk, coconut milk and date fruit juice gave products that are comparable to the conventional soy bean based vita milk in terms of their nutritional composition. However, the plant milk samples were rated lower to the vita milk in consumers' preference. The roasted breadfruit-based samples were also rated high for the sensory attributes studied except for colour where the cooked breadfruit-based samples have more sensory appeal.

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