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Development of plant based milk beverage from coconut and cashew nut milk

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Abstract
Beverages formulated from extracts of coconut meat and cashew nut were compared for their proximate composition as well as sensory parameters. Formulation of beverage was done in accordance with preliminary studies and 1:3 (w/v) of coconut: water and 1:4 (w/v) of cashew nut: water were blended together along with inclusion of xanthum gum, sugar and flavor in different proportions (50:50, 60:40, 70:30 and 80:20). The sensory attribute mean scores for the milk beverage mixes varied substantially ($p<$ 0.05). Typically, the blend prepared from a 60:40 mixture of butterscotch-flavored cashew milk and coconut milk, with a mean score of 8.16±0.62 during sensory evaluation was the most accepted of the sample combinations. The proximate composition parameters varied among the blends with 60:40 blend showing values as follows: moisture 84.67±0.41%, protein 2.40±0.07%, fat 0.96±0.11%, ash 0.40±0.05% and 11.56±0.40% for total carbohydrates. Color, viscosity, pH, total solids and free fatty acid were also analyzed for the all the four blends.

Keywords: Plant based milk, coconut milk, cashew nut milk, proximate analysis

1. Introduction
Beverages are recognized as the most active functional food category. Several characteristics of milk promote the bioavailability and absorption of the nutrients it provides. It has been demonstrated that lactose increases the bioavailability of calcium and other minerals, but sucrose, starch, glucose, and maltose do not. (Chalupa-Krebzdak *et al*., 2018) [2]. In recent years, consumers have been more concerned in products that provide health benefits. Similarly, cow's milk alternatives are a product category that is gaining popularity in the market (Jeske *et al*., 2018b) [7]. The necessity for cow's milk replacements has been highlighted mostly due to pathological causes and food choices like veganism and vegetarianism.

Plant-based milk alternatives (PBMA) have persisted for centuries. PBMA are becoming more popular due to a variety of variables and customer demands, including health issues like milk allergies and lactose intolerance. Plant milk alternative is aqueous extracts of cereals, oil seed, legumes as well as pseudo cereals which resemble animal milk (Mäkinen *et al*., 2015) [11]. These products are supposed to replicate animal milk, a nutrient-rich emulsion produced by breastfeeding mammals that contains lipids, proteins, amino acids, minerals and vitamins (Tangyu *et al*., 2019) [19]. Furthermore, they frequently lack complete nutritious benefits of animal milk and are tainted with unpleasant off-flavors (Outi *et al*., n.d.; Sethi *et al*., 2016) [18]. Horchata, or "tigernut milk" in Spain; Boza, a fermented beverage made from rye, wheat, maize and millet in Bulgaria, Turkey and Albania; Sikhye, a beverage consisting of malt extract, cooked rice as well as sugar in Korea; and soy milk from China are just a few examples of traditional plant-based beverages. Soy milk is the most popular plant milk alternative (Gambo & Da'u, 2014; Kim *et al*., 2012) [5, 9].

Plant based milk (PBM) are water-based plant extracts that resemble cow's milk in appearance. The plant material is extracted with water after the raw materials are ground into a slurry, and then it is strained to eliminate suspended solid particles, and then separating the liquid for beverage production. Based on the product, inclusion of components such as oil, flavorings, stabilizers as well as sugar can be done before or after processing, followed by heat treatments or homogenization to produce the final product (Jeske *et al*., 2016; Outi *et al*., n.d.). Despite certain changes, the main structure of a present industrial-scale process for varied plant materials is essentially the same. The aqueous extract is produced using two methods: soaking and wet milling of plant sources (wet process), and dry milling of raw ingredients and water extraction of the flour (dry process).

Raw material pretreatment may be required to enable as well as enhance extraction, improve nutritional profile, improve sensory features, and remove off-odors. Raw material pretreatments comprise of deshelling, soaking, and blanching. Blends of two or more PBMAs have also been proposed as a means of improving nutritional or sensory properties (Reyes-Jurado *et al*., 2021).

Although plant based milk alternatives have a low protein level, they still include proteins that may cause allergies, such as tree nuts and soy, which are two of the top eight food allergens. Nearly 14% of individuals with a cow's milk allergy also have a soy protein intolerance (Patel & Volcheck, 2015). Since lactose and cholesterol are exclusively found in animal products, PBMA's products are devoid of both of these ingredients (Tsai *et al*., 2018). Despite having a similar consistency and appearance as animal milk, PBMAs differ significantly in terms of nutritional content as well as bioavailability. Fortification or combining different plant based milk is required to improve the nutritional content (N Yadav, 2017).

Almond, coconut, and peanut have high levels of vitamins C, E, and antioxidant characteristics (Sethi *et al*., 2016) [18]. In comparison to cow milk (3.28 g/100 mL), soymilk has a higher protein content (up to 8.71 g/100 mL), but it is deficient in all important amino acids. Furthermore, oat milk substitutes and soymilk may have a greater caloric density (64 kcal/100 mL) than cow milk, although soybean, coconut, rice, flax, cashew, pea, almond and quinoa milk substitutes are often lower in calories (Reyes-Jurado *et al*., 2021). Vanga *et al*., (2018) [21] showed that coconut milk, soy milk, rice milk and almond milk include all the key nutrients: lipids, carbohydrate, proteins, minerals and vitamins. Legume-based foods have a beany and earthy aroma that is regarded as unattractive and restricts their popularity.

Coconut (*Cocos nucifera* L.) is commercially significant and widely utilized in many traditional Pacific and Asian cuisines. It is a well-known source of coconut milk, cream, and oil products, also dried coconut flesh and coconut water (Chambal *et al*., 2012) [3]. Coconut milk is indeed an o/w emulsion prepared from aqueous extract of the coconut endosperm. It includes medium-chain triglycerides (MCTs), the bulk of which is lauric acid, which is readily digested, absorbed, and transformed by the liver into ketone molecules that improve brain function. (Fernando *et al*., 2015; Patil & Benjakul, 2018). To make coconut milk, the most typical method is to shell the nut and extract the flesh, which is then cleaned and shredded. Milk is derived from coconut flesh, either with or without adding water. Coconut milk is susceptible to enzymatic rancidity induced by microorganism, producing phase separation and off-flavor. To address this, emulsifiers, stabilisers, and various preservatives can be used (Abdullah *et al*., 2015; Katz, n.d.; Paul *et al*., 2020) [1]. As coconut milk is not rich in protein it can be blended with other plant based milk alternatives.

The cashew nut (*Anacardium occidentale*) is high in proteins (21.2%), lipids (46%), carbs (22.3%), vitamins, fibers, and mineral. It is advised for cholesterol regulation since it decreases LDL cholesterol while boosting HDL cholesterol. The majority of lipids included are mono- and polyunsaturated fatty acids, with a preponderance of oleic as well as linoleic fatty acids (Amorim *et al*., 2018). Because cashew nut milk lacks beany taste, combining it with coconut milk may significantly decrease the inherent nutty flavor of coconut while increasing the protein content.

To the best of our knowledge, no research have been reported in the literature on creation of plant-based milk beverages using coconut milk and cashew nut milk blends. As a result, the nutritional content and consumer acceptance of plant-based milk beverages made from varying concentrations of coconut milk and cashew milk were studied in this research.

2. Materials and Methods

2.1 Materials

Coconuts, cashew nut and other raw ingredients were bought from local market Thanjavur, Tamil Nadu. The procured coconut had a maturity of about 11 months. Further materials and equipment utilized were of analytical grade and the chemicals used were of food grade from HiMedia (Chennai, India).

2.2 Methods

2.2.1 Preparation of PBM beverage samples

For preparation of coconut milk (CM), mature coconut was dehusked, deshelled and brown testa was removed and the coconut meat was then washed properly with water and blanched for 5 min at 80 ºC to reduce initial microbial count. In accordance with the preliminary studies conducted 1:3 (1 part of coconut: 3 part of water) proportion was used for preparation of coconut milk. The coconut and water were combined in a standard blender at moderate speed for about 3-5 minutes, and the subsequent product was strained through muslin cloth for extracting fine coconut milk. The coconut milk was stored under refrigeration condition at 4 ºC.

Cashew nuts were washed and soaked in water overnight for moisture absorption to increase the extraction yield and that water was disposed to decrease the anti-nutritional factor. The rehydrated nuts were blanched at 80 ºC for 3-4 min. For cashew nut milk (CNM) extraction water was added in the proportion of 1:4 (1 part of cashew nut: 4 part of water) and was processed in blender at moderate speed for 3-5 min. The obtained material was filtered through muslin to obtain cashew milk.

Coconut milk and cashew nut milk was blended in following proportions (i) 50% CM and 50% CNM (ii) 60% CM and 40% CNM (iii) 70% CM and 30% CNM (iv) 80% CM and 20% CNM. The milk was defatted to standardize fat content. To the blended milk, other ingredients like xanthum gum (0.1g/ 100ml) for stabilization, sugar for sweetness and flavor were added. The prepared milk was then homogenized at 15000 rpm for 2 min in a homogenizer. It was then pasteurized at 63 ºC for 30 min by double boiling method. All the prepared samples were stored under refrigerated condition (4 ºC) for analysis.

2.3 Chemical analysis

All the analysis was conducted in triplicates. For the determination of moisture content, known amount of sample was taken and oven dried at 130ºC for 2 hours until constant mass. In a muffle furnace, ash was evaluated by incineration: sample was pre heated for about 1 hour at 100 °C in crucibles and ashed for 5 hours at 524 °C. According to AOAC 2005, the protein was estimated using the Kjeldhal method. The Rose Gottlieb method was used to assess fat content.

2.4 Viscosity, pH and Total soluble solids (TSS)

Viscosity of each sample was determined by Brookfield

viscometer, using 5-10ml of sample and is expressed in cp. pH was determined using digital pH meter, using 10ml of sample. For TSS measurement 2 drops of sample was placed in hand held digital refractrometer which directly shows the value and is expressed in ºBrix. Free fatty acid was analyzed by weighing 5g of sample and adding 25ml of 95% ethanol. Using phenolphthalein as an indicator, the solution was titrated with 0.1N NaOH (Mahesar *et al*., 2014) [10].

2.5 Color determination
The color was determined using Hunter Lab colorimeter, where L* signifies lightness and darkness, a* shows the redness and greenness and b* measures the yellow and blue intensity.

2.6 Sensory analysis
Sensory assessment of the developed plant based milk beverage was conducted Sensory Lab, NIFTEM (T). The samples were coded and served to 30 panelist consisting of male and female students. The assessors were between 21-30 year old. Each assessors were given coded sample to evaluate for color, texture, taste, mouthfeel, after taste and overall acceptability. The sensory evaluation was conducted using a nine-point hedonic scale: with 1 being severely disliked and 9 being very liked.

For the final sensory evaluation the following samples were provided, (i) vanilla flavored 50% CN- 50% CNM (ii) vanilla flavored 60% CN- 40% CNM (iii) vanilla flavored 70% CN- 30% CNM (iv) vanilla flavored 80% CN- 20% CNM (v) butterscotch flavored 50% CN- 50% CNM (vi) butterscotch flavored 60% CN- 40% CNM (vii) butterscotch flavored 70% CN- 30% CNM (viii) butterscotch flavored 80% CN- 20% CNM (ix) Control sample. Each assessor was given approximately 20 ml from each sample in glass cups with code numbers at a refrigerated temperature.

2.7 Statistical analysis
All analyses were carried out in triplicate. With Minitab version 18, means were compared using Tukey's analysis. The level of significance was determined at ($p< 0.05$).

3. Result and Discussion
3.1 Optimization of plant based milk
For optimization of formulation of coconut milk and cashew milk two different ratios of bean: water were evaluated. 1:3 and 1:1 for coconut milk and 1:4 and 1:6 for cashew milk (Nkechi Juliet Tamuno, 2019; Rincon *et al*., 2020) [13]. The combinations obtained were then subjected to proximate, physical and sensory evaluation and the obtained results are showed in Table 1. Fat, protein and ash content were significantly different ($p< 0.05$) among each ratios in both the milk depending upon the dilution.

Both coconut milk and cashew milk showed comparatively higher protein, fat and ash content for less dilution. The sensory evaluation revealed 1:3 blend of coconut milk as more acceptable and cashew milk does not showed much significant difference between the two ratios.

The proximate and physical analysis values for the both the milk type was in alignment with previously conducted studies (Faisal Manzoor, 2017; Nkechi Juliet Tamuno, 2019; Rincon *et al*., 2020) [13].

The moisture content ranged from 83.95 – 90.73% for coconut milk and 85.88 – 96.16% for cashew nut milk with respect to dilution. Also since there was no substantial difference among the viscosity of 1:3 and 1:4 (w/v) of coconut milk and cashew nut milk, these two ratios were further blended and analysis was carried out.

3.2 Chemical analysis
Coconut milk includes lauric acid, a saturated fat that has been linked to fostering brain growth. Rarely are allergic responses linked to coconut milk intake (Chambal *et al*., 2012; Sethi *et al*., 2016) [3, 18]. The reason to blend coconut milk with cashew milk was to increase the protein content and absence of beany flavor in cashew nut milk is an added advantage for blending.

The proximate analysis of the blended samples in different ratios of coconut milk: cashew nut milk, that is, A (50:50), B (60:40), C (70:30) and D (80:20) are presented in table 2. Control sample is the commercially available vanilla flavored soy milk. Protein value ranged from 2.45% (A- 50% coconut milk: 50% cashew nut milk) to 1.89% (80% coconut milk: 20% cashew nut milk) among the samples. There was a significant variation in protein value ($p< 0.05$) with increase in coconut milk in the blended milk, whereas control samples showed 3% protein value. This was because coconut milk had comparatively lower protein content which is known (Jeske *et al*., 2018). Plant proteins show lower values compared to animal milk. In addition to having lower protein content, plant-based proteins often have far less quality when compared to proteins from cow's milk (Jeske *et al*., 2018a) [6]. Cow's milk has a greater protein level (3.39 g/100 g) than soymilk (2.92 g/100 g), yet both are allergenic (Kattan *et al*., 2011) [8].

Also, there was a noticeable difference in the fat content. A larger amount of coconut milk in the beverage resulted in more fat, whereas a higher proportion of cashew nut milk resulted in more protein. However, the defatted samples (A, B, C and D) showed significant difference when compared to the plain coconut and cashew nut milk. Fat content ranged from 0.83% in blend A to 1.16% in blend D. The main components of coconut milk are typically moisture and fat content. (Tansakul & Chaisawang, 2006) [20] showed in their experiment that plain coconut milk contained about 55% moisture, 35% fat and 10% solid non-fat. According to (DebMandal & Mandal, 2011) [4], the percentage of lipids in mature coconut is around 60%.

Moisture content for both the proportion ranged from 83.46% to 89.11%. The discrepancy in moisture content in the developed milk beverage might be attributed to the amount of water utilized in the extraction procedure. Furthermore, the high moisture level indicates that the milk beverage must be preserved by cold storage. The ash value of a food commodity is used to determine its mineral content. Ash content of the produced blend ranged from 0.20% to 0.46% (Nkechi Juliet Tamuno, 2019) [13].

3.3 Viscosity, pH and Total soluble solids (TSS)
The rheological properties of a certain food emulsion is determined by the kind and concentration of the ingredients included within it (McClements, 2015) [12]. The addition of xanthum gum had a significant ($p< 0.05$) effect on the viscosity of the prepared beverage. The viscosity of the coconut milk and cashew milk was found to be 1.28 and 1.32 Cp respectively, but the blended beverage ranged from 13.4 Cp for blend A and 9.93 for blend D. Hence, hydrocolloids are found to enhance the viscosity and influence flow behavior (Mäkinen *et al*. 2015 Saha & Bhattacharya 2010) [11, 17].

All samples had pH values greater than 6.30. The pH of a solution is an essential parameter that represents its chemical

conditions. The pH can influence biological functioning, nutritional availability and microbial activity (Ranadheera *et al*., 2019). According to Raghavendra *et al*., (2010) [16] at pH of 6 coconut milk showed high stability and with decrease in pH coconut milk protein easily coagulated and precipitated. The total soluble solids of plain milk differed significantly ($p< 0.05$) from the blended milk due to the addition of sugar, xanthum gum and flavor. There was no noticeable difference among the different proportion of blended milk, the TSS value ranged from 14.98 to 15.26 ºBrix.

3.4 Color

The color of food is among the first characteristics that customers notice, impacting their decision and preference (Jeske *et al*., 2016). Hunter Lab color measurements of the produced plant based milk are reported in table 3. There reported a significant difference ($p< 0.05$) in lightness value of the sample among the plain plant milk and the blended milk. The lightness value of coconut and cashew nut milk were reported to be 88.62 and 85.24 respectively. But in the prepared blended sample the lightness value decreased to 72.85 in blend A and 61.81 in blend D, thus indicating that with increase in concentration of coconut milk, there reported a decline in lightness value. This decrease in lightness value is due to removal of fat from the sample which induced a translucent appearance to the sample. Blend A was reported to show higher a* and b* values than the other blends because of the higher concentration of the cashew nut milk in the blend A. Blend B, C and D does not vary significantly ($p>0.05$) in terms of greenness and yellowness.

Table 1: Proximate composition and physical properties of coconut milk and cashew milk in different ratios.

Milk type	Ratio / Composition	1:1 (w/v)	1:3 (w/v)
Coconut milk	Moisture (%)	83.95^{b}±0.73	90^{a}.73±0.55
	Ash (%)	0.76^{a}±0.05	0.66^{a}±0.15
	Fat (%)	7.62^{a}±0.34	5.7^{b}±0.17
	Protein (%)	3.41^{a}±0.15	2.16^{b}±0.05
	pH	6.41^{a}±0.01	6.43^{a}±0.09
	TSS	1.53^{a}±0.11	1.36^{a}±0.20
	Viscosity	2.22^{a}±0.01	1.28^{b}±0.01
	Ratio / Composition	1:4 (w/v)	1:6 (w/v)
Cashew milk	Moisture (%)	85.88^{b}±1.87	96.16^{a}±0.90
	Ash (%)	0.76^{a}±0.15	0.66^{a}±0.05
	Fat (%)	4.24^{a}±0.22	2.46^{b}±0.25
	Protein (%)	5.65^{a}±0.08	2.83^{b}±0.13
	pH	6.44^{a}±0.10	6.45^{a}±0.14
	TSS	1.79^{a}±0.1	1.56^{a}±0.15
	Viscosity	1.32^{a}±0.02	1.02^{b}±0.43

Note* Means following by same letters in column does not vary with Tukey's test ($p< 0.05$).
All analyses were carried out in triplicate.

Table 2: Proximate composition of plant based milk blend made from coconut and cashew milk produced in different proportion.

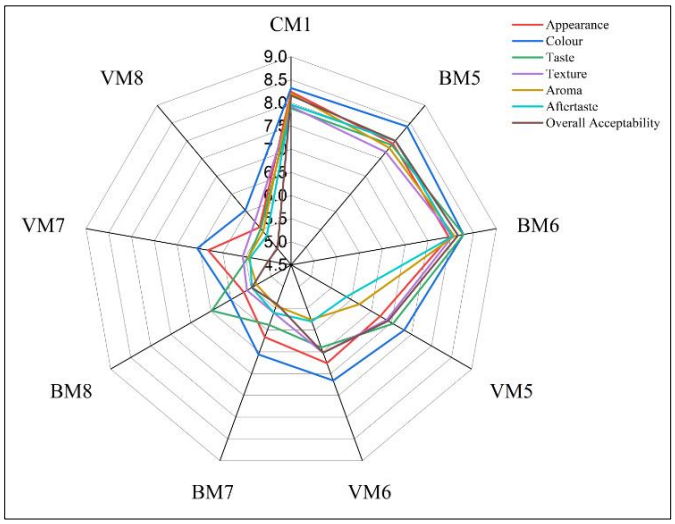
Sample	Moisture %	Fat %	Protein %	Ash %	Carbohydrate %
Coconut (1:3)	90.73^{a}±0.55	5.7^{a}±0.17	2.16^{d}±0.05	0.66^{b}±0.15	0.74^{f}±0.31
Cashew (1:4)	85.88^{cd}±1.87	4.24^{b}±0.22	5.65^{a}±0.08	0.76^{a}±0.15	3.44^{e}±1.67
Control	82.71^{d}±0.55	1.6^{c}±0.11	3.0^{b}±0.10	0.30^{f}±0.05	12.6^{a}±0.01
A	83.46^{d}±0.80	0.83^{e}±0.05	2.45^{c}±0.05	0.46^{c}±0.05	12.80^{a}±0.98
B	84.67^{cd}±0.41	0.96^{e}±0.11	2.40^{c}±0.07	0.40^{d}±0.05	11.56^{b}±0.40
C	87.07^{bc}±0.99	1.02^{de}±0.11	2.18^{d}±0.16	0.34^{e}±0.05	9.37^{c}±1.26
D	89.11^{ab}±0.40	1.16^{d}±2.71	1.89^{e}±0.09	0.32^{f}±0.05	7.53^{d}±0.52

Note* A - 50% coconut milk and 50% cashew milk, B- 60% coconut milk and 40% cashew milk, C-70% Coconut milk and 30% cashew milk, D- 80% coconut milk and 20% cashew milk.
Means following by same letters in column does not vary with Tukey's test ($p< 0.05$).
All analyses were conducted in triplicate.

Table 3: Color measures, viscosity, pH, total solids and free fatty acid of the formulated plant based milk from coconut and cashew nut in different proportions.

Sample	L*	a*	b*	Viscosity (Cp)	pH	TSS (ºBrix)
Coconut (1:3)	88.62±0.65^{a}	-0.60±0.04^{a}	2.04±0.13^{c}	1.28±0.01^{e}	6.53±0.09^{ab}	1.36±0.20^{e}
Cashew (1:4)	85.24±0.66^{a}	-0.65±0.08^{a}	8.26±0.29^{b}	1.32±0.02^{e}	6.54±0.10^{a}	2^{c}±0.1^{d}
Control	79.47±3.57^{b}	-0.63±0.05^{a}	18.23±0.24^{a}	8.92±0.11^{d}	6.56±0.01^{ab}	15.8±0.05^{a}
A 50:50	72.85±0.25^{c}	-1.42±0.01^{d}	0.46±0.01^{e}	13.4±0.2^{a}	6.58±0.01^{ab}	14.98±0.15^{b}
B 60:40	65.62±0.19^{d}	-0.95±0.01^{c}	0.80±0.02^{d}	11.3±0.10^{b}	6.54±0.01^{ab}	15.2±0.10^{b}
C 70:30	63.65±0.24^{d}	-0.89±0.01^{bc}	0.89±0.08^{d}	10.43±0.20^{c}	6.54±0.01^{ab}	15.24±0.09^{b}
D 80:20	61.81±0.15^{d}	-0.85±0.01^{b}	0.99±1.35^{c}	9.93±0.15^{d}	6.56±0.01^{b}	15.26±0.20^{b}

Note* A - 50% coconut milk and 50% cashew milk, B- 60% coconut milk and 40% cashew milk, C-70% Coconut milk and 30% cashew milk, D- 80% coconut milk and 20% cashew milk.
Means following by same letters in column does not vary with Tukey's test ($p< 0.05$).
All analyses were conducted in triplicate.



VM5-vanilla flavored 50% CN- 50% CNM; VM6- vanilla flavored 60% CN- 40% CNM; VM7-vanilla flavored 70% CN- 30% CNM; VM8-vanilla flavored 80% CN- 20% CNM; BM5-butterscotch flavored 50% CN- 50% CNM; BM6- butterscotch flavored 60% CN- 40% CNM; BM7- butterscotch flavored 70% CN- 30% CNM; BM8- butterscotch flavored 80% CN- 20% CNM; CM1- Control sample.

Fig 1: Sensory analysis of developed plant based milk beverage

3.5 Sensory analysis

Sensory analysis of 9 samples are given in the table. A nine-point hedonic scale was used to assess the sensory attributes of freshly made milk blends. Control sample (CM1) was commercial vanilla flavored soy milk. Two flavors were used vanilla and butterscotch in 4 blends that is 50:50, 60:40, 70:30 and 80:20. From the preliminary studies coconut: water ratio of 1:3 and cashew nut: water ratio of 1:4 had more significant nutritional content and better acceptability. Concerning the results from sensory analysis, the best hedonic scale rate was for butterscotch flavored milk 60% coconut milk and 40% cashew milk (BM6) followed by butterscotch flavored milk 50% coconut milk and 50% cashew milk (BM5). Butterscotch flavor had more overall acceptability than vanilla. There was no significant difference between BM6 and BM5 in terms of appearance, color, taste, aroma and aftertaste. Addition of sugar and flavor improved the sensory characteristic of the produced plant based beverage. A study by (Obinna-Echem *et al*., 2018) [14] reported on the physico-chemical as well as sensory attributes of blends of milk drink blend made from tigernut and coconut. The result indicated an increase in likeness of the blend with increase in coconut milk substitution. (Nkechi Juliet Tamuno, 2019) [13] investigated the physicochemical as well as sensory assessment of cashew nut milk and reported that incorporation of sweeteners in cashew milk enhanced the acceptability among the consumers. The sample with vanilla flavor reported least point on hedonic scale in terms of aroma and aftertaste.

4. Conclusion

Plant based milk beverage based on coconut milk and cashew milk was developed in this study. Combining two plant raw materials was an effective strategy for developing a sustainable plant based milk replacement with high protein and favorable sensory properties. From this study formulation of 60% coconut and 40% cashew nut milk with butterscotch flavor, added sugar gained higher acceptance considering the nutritional quality aspects and sensory analysis than rest.

Plant-based milk alternatives represent a massive growth opportunity for health wellness food market and should be extensively researched through the integration of technological interventions, innovative processing, as well as fortification methodologies in order to develop a nutritionally complete beverage with high overall acceptability. Furthermore, plant based milk substitutes will remain a prominent area of research in food science and technology's development of newer product category in order to meet consumer acceptability through technological intervention.

5. Conflict of interest

The authors have no competing interests to declare that are relevant to the content of this manuscript.

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