

## CASE STUDY

### Assessing coconut milk as an alternative to cow milk in Ghanaian cuisines

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#### Abstract

Coconut is widely consumed raw in Ghana as refreshing coconut water and raw coconut white. The matured coconut is used to make toffees, oil, and as an accompaniment to an enjoyed cassava/yuca croquette (a local snack called Bankye Kaklo in Twi or Agbeli Kaklo in Ewe). Coconut milk, however, is not widely used in Ghana. Three different coconut milk variants were prepared, and their nutritional values (vitamins, fat, and proteins) compared with four cow milk-based variants and one imported commercial coconut milk. The vitamins in the coconut milk were 14.1 mg/100 ml, 22.9 mg/100 ml, and 24.7 mg/100 ml compared to cow milk variants (0.46 mg/100ml, 0.42 mg/ml, 0.42 mg/100ml, 0.003 mg/100ml) and 0 mg/100 ml for commercial coconut milk. The proteins of the coconut milk were 1.8 %, 1.6 %, and 1.4 %, which were lower than the commercial cow milk with 8.2 %, 6.7 %, 5.7 %, and 7.6 %, and the commercial coconut milk with 0.2 %. In terms of the fat content, the three coconut milk variants had 8.7 %, 7.7 %, and 11.2 % respectively compared closely to the commercial cow milk with 9 %, 8 %, 8.2 %, and 9 % respectively, and commercial coconut milk with 2 %. The study also sought to find out coconut milk's preference to cow milk. A total of 30 people ages 16 to 45 years were randomly interviewed about their appreciation of coconut milk in their everyday meals, and 22 responded negatively. The 8 who were positive preferred to consume it as a refreshing drink other than adding it to porridge or beverage.

**Keywords:** Coconut Milk, Cow Milk, Evaporated Milk, Condensed Milk, Sugar, Honey

#### Introduction

Coconut is a tree that is cultivated for its enormous functions, mainly for its medicinal and nutritional values added to human life (Agyemang-Yeboah, 2011). Numerous products are obtained from the coconut plant, which includes tender coconut water, copra, coconut oil (Wallace, 2019; Boateng *et al.*, 2016), coconut milk (mainly from the tender kernel and the coconut water), raw kernel, coconut cake (coconut flour, desiccated coconut), coconut toddy, coconut shell (used for artifacts, charcoal), coconut leaves (as roofing materials in rural areas or burnt to ash and used as lime), coir pith (an excellent soil conditioner as well as used as a good ground for growing orchid), etc. Coconut provides varied uses from all its parts and it is most closely related to palm as a very useful plant ("Tree of Life") (Foale *et al.*, 2005) as it remains a unique source of numerous natural products for the development of medicines against various diseases as well as the development of industrial products. The numerous parts of the tree have numerous medicinal properties such as antibacterial, antifungal, antiviral, antiparasitic, antidermatophytic, antioxidant, hypoglycaemic, hepatoprotective, immunostimulant (Lima *et al.*, 2015; Wallace, 2019; Hewlings, 2020).

Coconut has been a constant contributor to the Gross Domestic Product (GDP) of Ghana and this plays a critical role in improving the food security of the country as a whole. Pricing of coconuts tripled within a period of three years, i.e., GH¢ 0.20 in 2007 to GH¢ 0.60 in 2010 (Quartey, 2011), and the price continued to surge from GH¢ 0.60 to GH¢ 2.00, a percentage increase of 233.33 % from 2011 to 2016 (a period of five years). Coconut production in Ghana suffered a setback in 2009 when a disease named Cape Saint Paul Wilt attacked numerous coconut plants and resulted in an outbreak that gravely affected the coconut production business in Ghana (Nkansah-Poku *et al.*, 2009; Danyo, 2011). The government of Ghana since then has put in efforts by supporting the Ministry of Food and Agriculture with funds to devise measures to help

resuscitate the coconut sub-sector. Currently, a fruit of coconut in prime cities like Accra and Kumasi, Ghana ranges between GH¢ 3.50 and 5.00 depending on the area where it is purchased.

Coconut is economically important and used in many traditional foods especially in Asia as a source of dietary fat (DebMandal and Mandal, 2011; Karunasiri *et al.*, 2020). Coconuts are distinct from other fruits for their large quantity of 'water' and when immature, they are known as tender nuts and may be harvested for their portable coconut water. Coconut is also highly nutritious and rich in fibre, vitamins, and minerals. It is classified as a 'functional food' because it provides many health benefits beyond its nutritional content.

There are generally two varieties of coconut that thrive very well on Ghanaian soil. They are the tall and dwarf varieties. The tall type, which has a 30-meter-long growth potential and produces enormous nuts, does not develop fruit until it is 5 to 7 years old. The dwarf variety is more uncommon, has a thinner trunk, a quicker succession of inflorescences, and bears its fruits early (after two years) (FruiTrop, 2011). Coconut oil, mature coconut meat, and coconut cream all have great energy content measured in calories. Coconut milk, which is as creamy as whole milk has relatively lesser protein than whole milk, but it presents no difficulties to lactose-intolerant individuals who may have complications like cramps, gas accumulation, diarrhoea, and bloating when consuming cow milk because coconut milk has very little to no lactose (DI Costanzo and Canani, 2019). The coconut water contains a refreshing nutrient-rich liquid. The husk fibres can be used as compost or stuffing or can be woven to make ropes and mats (McMahon, 2022). The shell, when dried, can be carved into buttons and other decorative items. Coconut shells can also be used to produce activated carbon (Hung, 2012).

Coconut milk is an aqueous extract from the coconut kernel (Karunasiri *et al.*, 2020). It can be used together with cow milk to prepare affordable (Sanful, 2009), delicious and nutritious yoghurt, which does not differ from the popular type produced from cow milk in all sensory quality attributes (Imele and Atemnkeng, 2001). Yoghurt is popular in Ghana and is usually taken as a snack or dessert to aid in digestion (Sanful, 2009). Coconut milk adds flavour and taste to products such as ice cream and biscuits (Patil and Banerjee, 2017). Coconut

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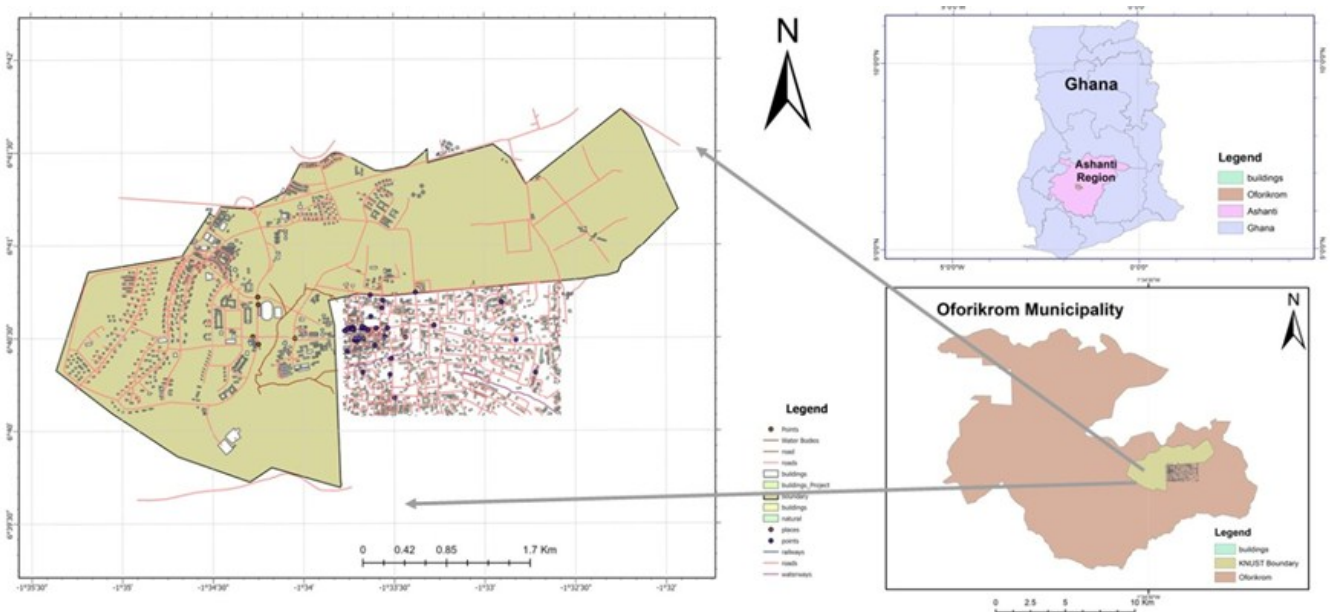
milk has relatively high antioxidant properties due to the presence of phenolic compounds as compared to cow milk. These compounds protect macromolecules such as proteins, lipids and DNA against oxidative damage (Nadeeshani *et al.*, 2015).

Coconut milk is a natural oil-in-water emulsion, stabilized by some proteins existing in the aqueous phase (Arumughan, Balachandran and Sundaresan, 1993; Patil and Benjakul, 2018), the fat content being 31 – 35 % as compared to 3 – 4 % in cow milk. Coconut milk has a lot of calories since it contains a lot of saturated fat. Although the nutritional value varies depending on the product, coconut milk generally contains vitamins and minerals. For instance, the nutritional profile of coconut milk drinks differs from that of canned coconut milk (Eske, 2022). Even though coconut milk is widely used in Asian cuisines, it has very limited use in the Ghanaian environment. Coconut is mostly eaten raw until recent times when the coconut milk began to penetrate the Ghanaian market. This study was therefore carried out to compare the nutritional values (vitamins, fat, and proteins) of coconut milk (evaporated, sugar-sweetened condensed, and honey-sweetened condensed) and, also, to ascertain the readiness of people to incorporate coconut milk and its products as alternative to cow milk in their daily meals.

## Materials and Methods

### Description of the study area

This study was undertaken at the KNUST-Ayeduae enclave. The university community and environs is made up of people of different ages, and classes, ranging from the students to workers as well as the community people, leaving around the university campus. KNUST and Ayeduae are very close vicinities, and both are in the Oforikrom Municipality in the Ashanti Region of Ghana. The study area is represented in Figure 1 with the KNUST campus in the green with the Ayeduae community close by it.



**Figure 1** A map of the study area

## Method

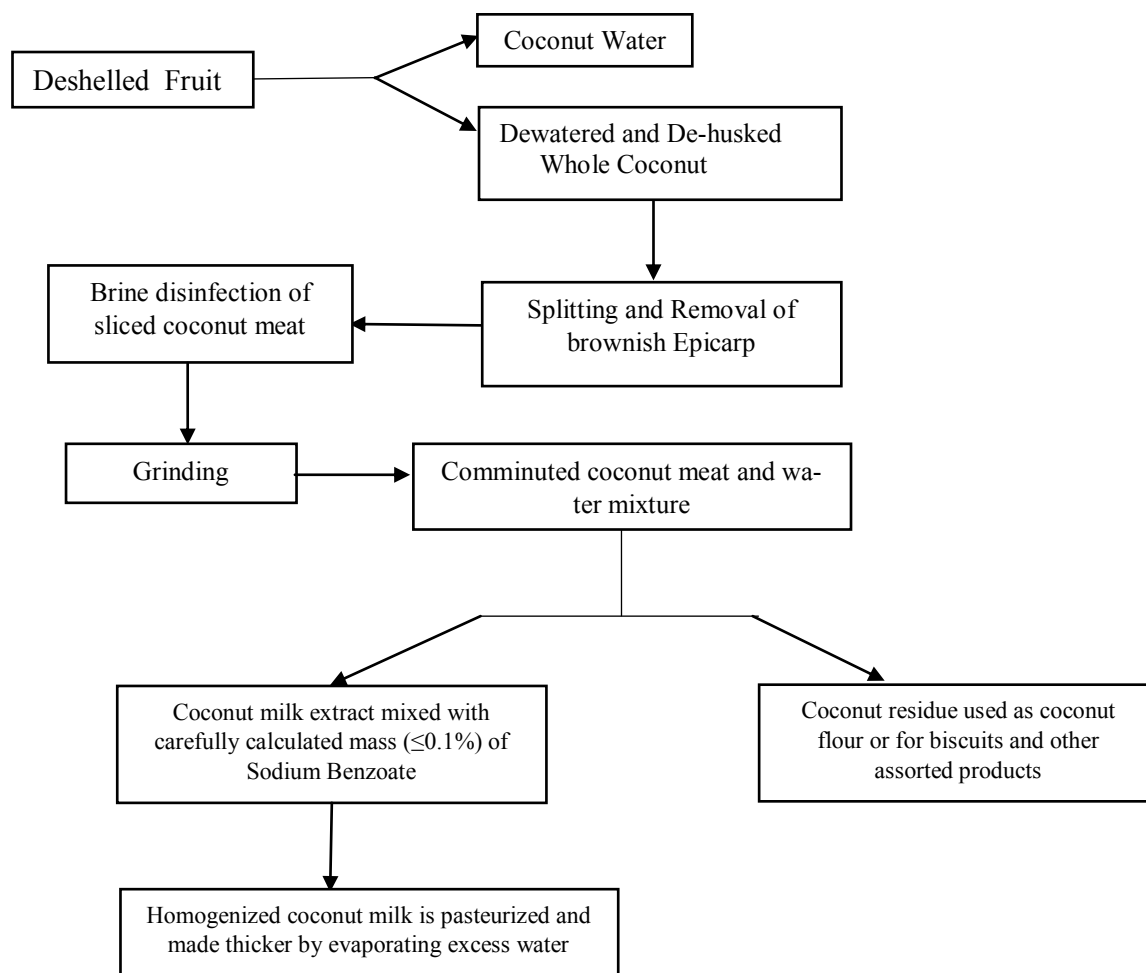
### Coconut milk preparation

Coconut (*Cocos nucifera*) fruit is made up of the husk (with mostly yellow or green outer fibrous layer), shell (mostly hard and brown encasing both the flesh and the water), the flesh (white edible part of the fruit) and the water (clear liquid normally taken raw as a refreshing drink). De-husked coconut fruits were used for this work. The mass of the de-husked co-

conut fruits was taken, and the various parts separated, weighed and the weights recorded. The epicarp (brownish) layer found at the back of the coconut flesh was removed to prevent discoloration of the milk extract. The coconut meat was sliced into smaller sizes and rinsed with a brine solution to neutralize or retard the activity of microbes. The white mass (endocarp) was shredded further to obtain smaller sizes necessary for successful blending. Hot distilled water was added to the shredded coconut mass and blended in a commercial blender, which had been cleaned thoroughly with hot distilled water. This process was done in a batch-wise manner. The coconut and water mixture were blended until the mixture was as smooth as possible.

The fresh coconut milk was neatly strained using the cheesecloth. The blending of the solid after straining was repeated two more times. The total ratio of coconut to water was 1 to 2 (Ahmed *et al.*, 2019). The coconut solids left after straining were dried, milled, and used as flour in coconut cookies production. The volume of the extracted milk was measured to determine the mass of the preservative (Sodium Benzoate) to be added. The maximum allowable amount of sodium benzoate as preservative is 0.1 % of the fruit juice (FAO and WHO, 2014; Gabriel and Salazar, 2014). The extracted milk was subjected to continuous, high temperature short time (HTST) method at about 72 °C for 15 seconds to increase milk safety for the consumer by destroying disease-causing microorganisms (pathogens) that may be present in milk as well as to destroy spoilage microorganisms and increase shelf life of milk (Ali and Fischer, 2002). A homogeniser was used to aid in the thorough fusing of the water and milk components of the extract without a phase division (at a pressure of 12 MPa). The homogenized milk was flash-heated in the evaporator to 85 °C for 3 minutes (Ali and Fischer, 2002) to obtain much thicker milk (Evaporated Coconut Milk). The study was carried out at the Process Development Laboratory of the Department of

Chemical Engineering at Kwame Nkrumah University of Science and Technology. Materials employed in carrying out the preparation of the coconut milk include commercial blender, grater, coconut milk extractor, heat source, fine mesh strainer (cheesecloth), matured dried coconut fruit with brown husk, distilled water, sodium benzoate (preservative), unadulterated honey and white granulated sugar. The entire process for coconut milk production is outlined in Figure 2.



**Figure 2** A flowsheet for coconut milk extraction

### Condensed coconut milk production

The coconut milk produced in this study were divided into 3 portions. The two portions were condensed, and the third portion kept as the evaporated milk. The two types of condensed milk were prepared as follows:

- i) sugar-sweetened condensed milk was prepared by mixing coconut milk and white granulated sugar at a ratio of 3:1.
- ii) The mixture was stirred on a low heat at about 50-55 °C (Ali and Fischer, 2002) until about half of the water content was evaporated. This left the condensed milk thicker, and it was poured in a glass jar and cooled to room temperature.
- iii) The same procedure was repeated for the honey-sweetened condensed coconut milk where the white granulated sugar was replaced with organic honey purchased at the local market. The honey was first strained to remove the brown/black particles from the honeycomb that were present in the honey purchased.
- iv) The three portions obtained were then subjected to various nutritional analysis.

### Nutritional value analysis

#### Vitamin

The vitamins found in the coconut milk include vitamins C, B (1, 3, 5, 6 and 9) and E. Different methods can be used for the determination of the various vitamins found in coconut milk. The methods include High Performance Liquid Chromatography (HPLC) together with UV-Vis or Mass Spectroscopy

(MS), Liquid Chromatography-Mass Spectrometry (LC-MS), Enzyme-Linked Immunosorbent Assay (ELISA) and Titration. These methods mentioned are used for the determination of different vitamins. Vitamin C is comparatively higher in coconut milk than other vitamins; hence, the focus for this research was to check the vitamin C content, as a representation of total vitamins. The vitamin C content is mostly determined by the iodometric titration method as follows:

- i) 5 ml of each milk sample was poured into 3 different flasks with 50 ml of distilled water added.
- ii) 1% starch solution was prepared and boiled with continuous stirring.
- iii) 1 ml of the prepared starch solution was added to the combined solution of the milk and water.
- iv) The above solution was titrated against iodine solution of concentration 0.005 mol/dm<sup>3</sup>.
- v) The titration table is given as: Burette Content: Iodine Solution; Flask Content: Combined solution + Starch solution and colour of the Iodine solution (golden) turns blue-black on completion of titration. The vitamin C content of the coconut milk prepared was calculated from the titre values using Eqn. (1).

#### Fat value

Coconut milk is a high-fat content liquid that contains different types of fats. The major types of fat present in coconut milk are saturated fatty acids, medium-chain triglycerides (MCTs), and lauric acid. The fat content of coconut milk can be deter-

$$\text{Vitamin C (mg/100ml)} = \frac{\text{Titre Value} \times \text{Concentration of Iodine solution} \times \text{Molecular weight of vitamin C} \times 100}{\text{Volume of sample used}} \quad (1)$$

mined using various methods, including Gravimetric method, Gerber method, Mojonnier method and the Near-Infrared Spectroscopy method. In this research, the Gravimetric method was employed as follows:

- i) Two flasks labelled 1<sup>st</sup> and 2<sup>nd</sup> were used.
- ii) 5 ml of distilled water was measured into two separating funnels.
- iii) The mass of the milk sample was weighed and poured into the two flasks.
- iv) 2 ml of Ammonia solution was added.
- v) 40 ml of petroleum ether was added to the solutions in the separating funnels.
- vi) The separating funnels were shaken vigorously for the oil in the sample to dissolve to form an emulsion.
- vii) 10 ml of ethanol was added to break the emulsion. The masses of the separating funnels were weighed, and values noted.
- viii) The solvent and the fat were collected into the labelled flasks and placed inside the oven to evaporate the solvent leaving the fat. The total fat content was estimated using Eqn. (2).

$$\text{Fat (\%)} = \frac{(\text{Mass of fat+flask}) - \text{Mass of flask} \times 100}{\text{Mass of milk used in separating funnel}} \quad (2)$$

$$\text{Nitrogen \%} = \frac{\text{Volume of distilled digested sample} \times \text{Conc. of HCl used} \times \text{Molar Mass of Nitrogen}}{\text{Volume of sample pipetted} \times \text{mass of sample}} \times 100 \quad (3)$$

#### Protein value

The creamy coconut milk contains varied nutrients with protein being one such nutrient. The types of protein that can be found in coconut milk include albumin, globulin, glutelin, prolamin and lectin. It is worth noting that the exact composition of proteins in coconut milk can vary depending on factors such as the type of coconut, the age of the coconut, and the processing methods used to extract the milk. Different method can be employed to determine the protein content of coconut milk such as Kjeldahl method, Biuret method and Lowry method. The Kjeldahl method was used where the percentage nitrogen content of the coconut milk was determined, and the corresponding protein content calculated by multiplying the percentage nitrogen by a factor. The procedure used for the protein for value analysis is as follows:

- i) Two conical flasks and two 50 ml volumetric flasks were used.
- ii) After rinsing them with distilled water, 10 ml of 4 % Boric acid was pipetted and then poured into each of the conical flasks.
- iii) 3 drops of indicator mixture were placed in each of the conical flask containing the acid. The digested sample was poured from the digestion tubes into 50 ml volumetric flask. The tubes were rinsed with distilled water and discharged into the volumetric flasks. Distilled water was added to the volumetric flask to reach the 50 ml mark.
- iv) The volumetric flasks were then swirled to obtain a uniform mixture. 5 ml of the mixture in the volumetric was pipetted into a test tube taken from the distillation unit. This test tube was placed into the unit alongside the conical flask containing the boric acid sample in the test tube and the operation was started. The operation was stopped when the volume in the conical flask rose a little above the 100 ml mark.

- v) 1 litre of the 0.19057 M HCl was prepared by taking 187.5 ml of concentrated hydrochloric acid and then dilute it to 1 L with water in a volumetric flask.
- vi) The solution was then poured into a 50 ml burette and titrated against the base solutions in the conical flasks. The titration was stopped when the colour of the solution changed from light yellow to light pink, and the titre values obtained were recorded. The percentage of nitrogen in the coconut milk sample was calculated using Eqn. (3), and the corresponding percentage protein was multiplied by the multiplier factor of 6.25 for coconut milk.

#### Comparison of the prepared coconut milk with other milk types on the market

After the preparation and all the analyses, the nutritional values of the prepared three variants of coconut milk were compared with four mostly used cowmilk products as well as one imported coconut milk, which is sold on the market. This was to check how well the prepared coconut milk match those commercial variants in terms of vitamins, fat and protein.

#### Questionnaire administration

Questionnaires were administered to ascertain the preference of coconut milk among people of different ages who had tasted the commercial coconut milk at some point in their lives. Random people were approached in and around the KNUST campus, precisely Ayeduase, to participate in the answering of the questionnaires. Overall, 30 volunteers participated in the answering of the questionnaire up to the end and their ages were between 16 and 45 years old.

The questionnaire was developed to collect feedback from those who consume or have consumed coconut milk as well as views from people who have never consumed coconut milk. The questions ranged from broad ones like "Do you use milk or milk products in your diet?" to detailed ones like "Have you ever consumed coconut milk? If so, what did you like or dislike about it? If not, why have you not tried it?" Finally, the Likert scale was employed to determine the enthusiasm of the respondents, who have tried coconut milk, in including it in their diet.

#### Results and Discussion

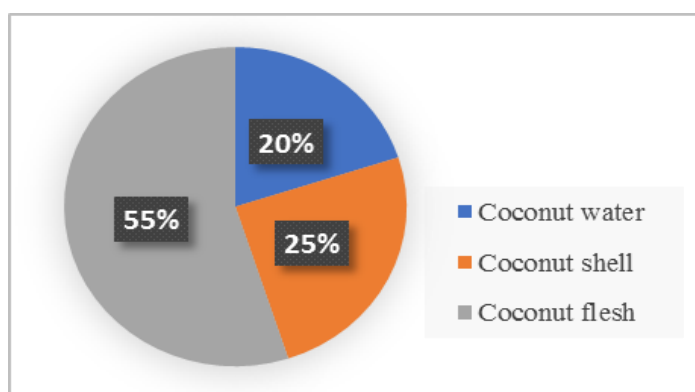
##### Composition of the coconut fruits

The composition of coconut fruits used for the entire work were evaluated to know the quantity of coconut endocarp that would be obtained from each fruit. Table 1 shows the material balance on the coconut fruits used and Figure 3 shows the average composition of the coconut fruit used in this research. Figure 3 shows the available coconut fruit and coconut water that could be used for coconut milk production was about 75 %, indicating that the 25 % cannot be used directly in coconut milk production.



**Table 1** Material balance of coconut fruit used for the coconut milk extraction

Sample	Mass of Coconut flesh + shell + water (g)	Mass of Coconut Water (g)	Mass of Coconut shell (g)	Mass of Coconut flesh (g)
1	650	100	150	400
2	800	300	100	400
3	550	100	150	300
4	550	50	150	350
5	650	150	200	300
6	672	161	172	339
7	731	131	236	364
8	587	78	169	340
9	474	98	100	276
10	607	100	160	357
Total Mass (g)	6271	1268	1577	3426
Average Mass (g)	627.1	126.8	157.7	342.6
Percentage (%)	100	20	25	55

**Figure 3** Composition of the coconut fruit**Nutritional value analysis**

The vitamins content of the three coconut milk variants prepared at the laboratory are estimated by titration and the titre values are displayed in the Table 2. The vitamin C content of the produced coconut milk was calculated from the titre values using Equation 1 and the results are shown in Table 3. This vitamin content of the coconut milk products was then compared to commercial cow milk products on the market as well as a sample commercial coconut milk as shown in Figure 4. From Figure 4, the vitamin content of the three prepared coconut milk variants had comparatively higher vitamin contents.

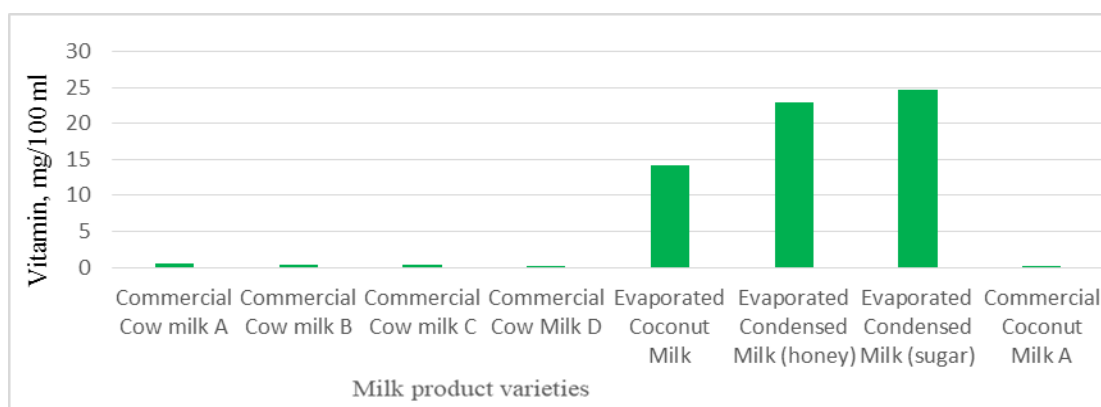
Cow milk is widely used as a dietary fat source (DebMandal and Mandal, 2011; Karunasiri *et al.*, 2020) because of the believe that plant-based fat are healthier than the animal-based fat. The estimated total fat contents of the coco-

**Table 2** Nutritional value analysis of vitamin C

Burette Readings (ml)	Evaporated milk			Condensed milk (Honey)			Condensed milk (Sugar)		
	I	II	III	I	II	III	I	II	III
Final	9.00	9.00	10.60	5.90	7.20	8.20	2.10	3.40	4.20
Initial	8.20	8.20	9.70	4.20	5.90	7.20	0.00	2.10	3.40
Titre	0.80	0.80	0.90	1.70	1.30	1.00	2.10	1.30	0.80

**Table 3** The contents of vitamin C, fat and protein in the various milk samples

Sample	Vitamin C (mg/100 ml)	Fat (%)	Protein (%)
Evaporated Coconut Milk	14.1	8.7	1.8
Condensed Coconut milk (Honey)	22.9	7.6	1.6
Condensed Coconut milk (White sugar)	24.7	11.2	1.4

**Figure 4** Vitamin content of different milk products

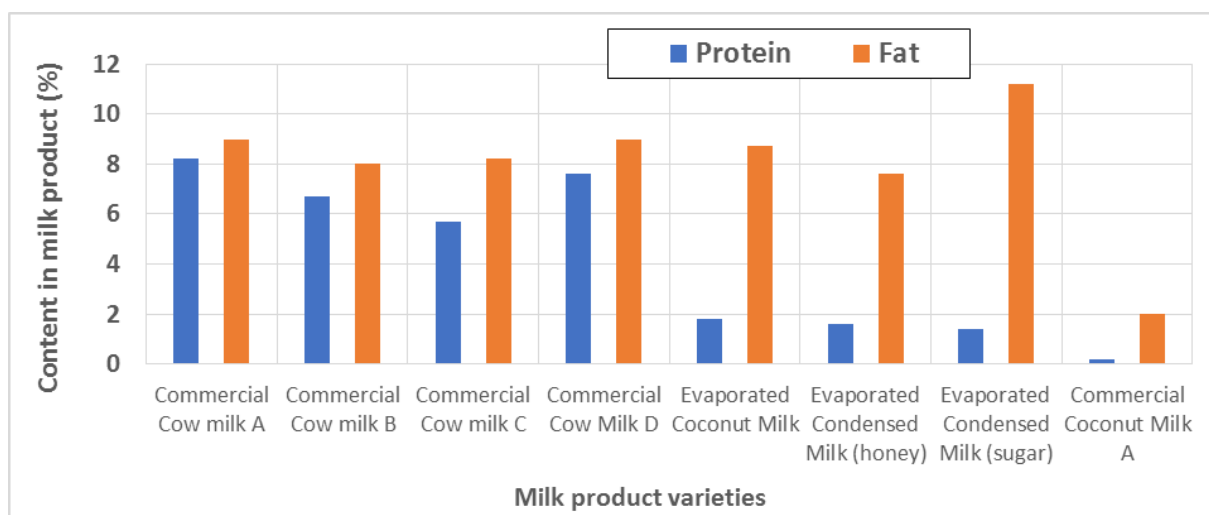


Figure 5 The content of fat and protein in the different milk varieties

nut milk are shown in Table 4. The fat content of the coconut milk products was then compared to commercial cow milk products as well as a sample commercial coconut milk. Figure 5 shows the fat comparison between all the products in this study. It is expected that the coconut milk products should have a much higher fat content compared to the corresponding cow milk. However, Figure 5 shows that the fat content of the evaporated coconut milk and the honey-sweetened coconut milk have a comparable fat content closer to the cow milk brands. The commercial coconut milk however had a lower fat content.

Table 3 indicates the protein content of the coconut milk produced in this study using Equation 3 from the Kjeldahl method based on nitrogen. The protein content of the coconut milk products compared to commercial cow milk products as well as a sample commercial coconut milk are shown in Figure 5. The protein levels in the coconut milk are comparatively lower compared to the commercial cow milk. This clearly shows that one may get a substantial quantity of proteins from consuming cow milk compared to the coconut milk produced. However, the three prepared variants of the coconut milk have a higher protein content compared to the commercial coconut milk. These are relatively better variants compared to the commercial coconut milk on the Ghanaian market. Therefore, the use of coconut milk will mean that other protein sources may

be needed to provide the recommended daily protein requirement. According to (Wu, 2016), based on short-term nitrogen balance studies, the Recommended Dietary Allowance of protein for a healthy adult with minimal physical activity is currently 0.8 g protein per kg body weight (BW) per day.

**Preference for coconut milk**

Figure 6 shows the preference and the social-demographics of the respondents. A lot of the respondents (73.3 %) did not enjoy meals with coconut milk. These respondents were used to their cow milk alternative. However, due to the health benefits of plant-based nutrients, these categories of respondents were open to give coconut milk a try again and make the conscious effort to develop the taste for it.

On the other hand, the 26.7 % who liked the coconut milk, preferred it to be taken as a refreshing drink, as is done in the case of soymilk and other plant-based milk. These respondents did not like the taste of coconut milk with beverages or porridges but taken as a chilled refreshing drink as a snack.

**Conclusion**

Coconut is a fruit widely enjoyed by many in Ghanaian communities; hence, incorporating it into the traditional cuisines is possible and laudable. The nutritional values obtained from the research showed that coconut milk has the needed nutrients such as fat, vitamins, and protein. Most of the Ghanaian populace who do not have any issues with cow milk have grown a lot of taste for it and its replacement with coconut milk is quite minimum.

Generally, the raw coconut, is highly patronized and widely used in a lot of local and continental dishes served in the country. The few people who liked coconut milk (26.7 %) did not prefer to add it to porridges or beverages because the taste with beverages and porridges were not great for them. Coconut milk consumption is likely to be a slow adaptation, and this is likely to affect the commercial production and use of coconut milk in Ghana.

In this study, it is observed that the coconut milk compares very well with cow milk and can, therefore, be incorporated into diets. Dietary adjustment is therefore encouraged among Ghanaians to incorporate coconut milk in everyday meals or take it as a refreshing snack to gain the numerous health benefits associated with it.

**Acknowledgment**

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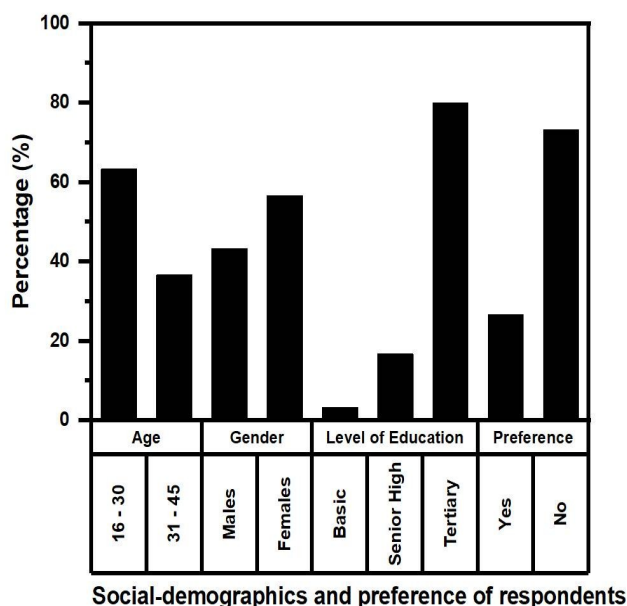


Figure 6 Preference of coconut milk and social-demographics of respondents

### Conflict of Interest Declarations

The authors declare that there is no conflict of interest regarding this manuscript. This is purely an academic research work.

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