AMERICAN JOURNAL OF FOOD SCIENCE AND TECHNOLOGY (AJFST)

ISSN: 2834-0086 (ONLINE)

VOLUME 3 ISSUE 1 (2024)

PUBLISHED BY
E-PALLI PUBLISHERS, DELAWARE, USA

American Journal of
Food Science and Technology (AJFST)

Volume 3 Issue 1, Year 2024
ISSN: 2834-0086 (Online)
DOI: https://doi.org/10.54536/ajfst.v3i1.2573
https://journals.e-palli.com/home/index.php/ajfst

Physicochemical Properties of Fortified Coconut Milk Based Chocolate - Like Drinks as Influenced by Cocoa Powder and Sugar Levels

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Article Information

Received: April 17, 2024

Accepted: May 08, 2024

Published: May 13, 2024

Keywords

Coconut Milk, Cocoa Powder, Fortification, Physicochemical

ABSTRACT

The physicochemical, proximate, vitamins and minerals composition of fortified drinks produced from coconut milk, cocoa powder, and sugar was evaluated. Drinks samples were formulated with different concentration of coconut milk, cocoa powder and sugar levels. Samples includes: "k1 (Coconut milk 100 %), k2 (Coconut milk 99.8 % cocoa powder 0.2 %), k3 (Coconut milk 99.6 %, cocoa powder 0.4%), k4 (Coconut milk 98 %, sugar 2%), k5 (Coconut milk 97.8 %, cocoa powder 0.2%, sugar 2%), k6 (Coconut milk 97.6 %, cocoa powder 0.4%, sugar 2%), k7 (Coconut milk 96 %, sugar 4%), k8 (Coconut milk 95.8 %, cocoa powder 0.2%, sugar 4%), k9 (Coconut milk 95.6 %, cocoa powder 0.4%, sugar 4%)". The samples were produced and subjected to physicochemical, proximate, vitamins and minerals analysis using standard methods. Physicochemical composition, pH ranged from 6.50 (k1) to 6.72 (k9), TTA from 0.23 (k9) to 0.41 % (k1), specific gravity from 1.03 % (k1) to 1.13 % (k9), total solid from 18.91(k1) to 22.52 g/100g (k9), SNF from 7.23 (k2) to 10.25 g/100g (k8) and energy values from 124.63 (k1) to 148 Kcal/100g (k9). The proximate composition; moisture from 77.48 % (k9) to 81.09 % (k1), protein from 3.42 (k1) to 3.96 % (k9), ash from 0.71(k1) to 0.98 %(k9), crude fiber from 0.02 % (k1) to 0.06 % (k9), fat from 10.23 % (k1) to 12.27% (k9) and carbohydrate from 4.82 to 5.58% for k1 and k9. Vitamin composition, vitamin A from 1.725 to 2.469mg/100g for samples k1 and k2, Vitamin B1 from 0.044 mg/100g (k1) to 0.205 mg/100g (k9), B2 from 0.028 to 0.0114 mg/100g for k1 and k9, vitamin C from 2.981 to 5.751mg/100g for k1 and k9 and vitamin K from 0.141 to 1.137 mg/100g for k1 and k9. Mineral composition of drinks: Calcium ranged from 16. 31 to 27.05mg/100g for k1and k9, Sodium from 15.25 to 16.99 mg/100g for k1 and k9, Magnesium from 37.20 to 72.64 mg/100g for k1 and k9, Zinc from 0.677 to 3.18 mg/100g for k1 and k9, Iron from 2.87 to 3.38 mg/100g for k1 and k2, Iodine from 0.16 to 0.28 mg/100g for k1 and k9.The Cocoa powder and sugar levels improved the physicochemical, proximate, vitamins, minerals and overall nutritional profile of fortified coconut milk based chocolate drinks.

INTRODUCTION

Coconut palm (Cocos nucifera) is a member of the family Arecacaeis found in tropical and sub-tropical environments for decoration as well as for its many culinary and non-culinary purposes (Belewu *et al.*, 2014). The term coconut can refer to the entire coconut palm, the seed, or the fruit, which is not a botanical nut (Adhikari, 2018). Coconut milk is an opaque, white liquid extracted from the meat of a mature coconut. The traditional method for making coconut milk involves grating coconut meat, mixing it with hot water, and pressing the liquid through a cheesecloth. Commercially processed coconut milk, the kind you'll find in cans at the grocery store, is grated and pressed mechanically, and often stabilized with the addition of gum (Tulashie *et al.*, 2022). Coconut water which contains sugar, dietary fiber, proteins, antioxidants, vitamins and minerals provides an isotonic electrolyte balance (Belewu *et al.*, 2014).

Although cow milk has been known for decades for its nutritional benefits, coconut milk can also be used as a substitute for it due to its certain minerals and vitamins such as iron and folate, as well as several other biomolecules (amino acids) (Abdullah *et al.*, 2022). Coconut milk is one of the most popular plant-based milk alternatives to replace animal-based milk. The increasing demand for coconut milk worldwide is contributed by several main factors, i.e., increasing veganism, increasing demand for lactose-free milk, and the discovery of the health benefits of coconut milk fats and vitamins(Matin *et al.*, 2020). Lactose intolerance is a digestive problem characterized by difficulty digesting lactose. Symptoms include bloating, diarrhea, and stomach pain (Klis *et al.*, 2023). Population growth and rising health consciousness drive this increasing demand for dairy products (Tulashie *et al.*, 2022).

Cocoa drinks are made from processed cocoa powder (Rojo-poveda *et al.*, 2020). Powdered cocoa drink are easily soluble in water, is convenient to serve, and has an extended shelf life. Cocoa powder, a semi-finished product derived from cocoa beans, is the primary ingredient in producing cocoa drinks.(Indiarto *et al.*, 2022).

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Chocolate Milk is a great source of calcium and other important nutrients. Flavorings like chocolate can be added to make milk taste better (Hanks *et al.*, 2014). Chocolate milk is a key source of many nutrients, vitamins and minerals including high quality protein, calcium, vitamins A & D, B-12, riboflavin, phosphorus, magnesium, and zinc (Aribah *et al.*, 2020). The my-pyramid recommendation for milk is 2-3 cups of fat-free or low-fat milk per day. Drinking chocolate milk can make it easier to meet those recommendations while providing children with many important nutrients. Children with lactose intolerance may be better able to digest chocolate milk because the cocoa may slow digestion. (Hanks *et al.*, 2014). One serving of plain fat-free milk has 85 calories, and chocolate milk has 140 Calories (Hardiyanti & Sari, 2020).

Food fortification or enrichment is the process of adding micronutrients to food and food materials above the level that is normally present. It can be carried out by food manufacturers or by governments as a public health policy which aims to produce the number of people with dietary deficiencies within a population (Saleh *et al.*, 2018). WHO defines food fortification as the practice of deliberately increasing the content of one or more micronutrients (i.e., vitamins and minerals) in a food or condiment to improve the nutritional quality of the food supply and provide a public health benefit with minimal risk to health (Regulations, 2021). The World Health Organization (WHO) and the United Nations Food and Agriculture Organization (FAO) have adopted four main strategies for improving dietary intake: food fortification, micronutrient supplementation, nutrition education, and disease control measures. The fortification of staple foods is one strategy that has a proven history in improving dietary diversity and effectively decreasing micronutrient deficiencies (Regulations, 2021).

MATERIAL AND METHODS

The material used for the processing of drink samples includes coconut fruits, cocoa beans and sugar. These were purchased from modern market Makurdi Benue state Nigeria for processing.

Preparation of Cocoa Powder

Cocoa powder was produced from cocoa beans as shown on figure 1. The cocoa beans were sorted and cleaned to removed dirt and foreign particles. The beans were roasted at a temperature of 150-190 ℃ for 5 to 15 min. (Setiadi *et al.*, 2021) . The roast beans were peeled and the shells removed by winnowing. The seeds were then crushed and ground for oil extraction. The cocoa mass / liquor was pressed using a hydraulic press to extract the cocoa butter. The mass of the roast beans after the cocoa butter was extracted was dried for the production of cocoa butter. As the pressing does not remove all the cocoa butter, the particles will remain coated with a thin layer of cocoa butter with fat content of cocoa powder varying from 8% to 26%. The cake was then further dried at 60 ℃ for 24 h and then crushed and grind finely to very small particle sizes. The powder was then sieved with a sieve of particle size < 0.5 mm to obtain a fine powder. The cocoa powder was packaged and stored for further processing into chocolate-like drink.

Preparation of Coconut Milk

Coconut milk was prepared from grated meat or endosperm by mechanically expressing the milk (figure 2). The husk of matured coconut used was removed, exposing the hard shell. The shell of the coconut was removed manually by cracking the shell open with a knife or hitting it against a hard surface. Paring was done by scraping away the brown skin attached to the coconut meat to give white coconut meat using a knife. The paired coconut was rinsed with clean water to remove specks of dirt and impurities attached to the coconut meat. The clean coconut meat was cut into smaller sizes with the use of a knife. The coconut cut was pulverized/ground into smaller particles using a blender with added potable water. Milk was extracted by pressing the ground coconut to extract the milk. A cheesecloth was used to squeeze out milk from the blended coconut. The extracted milk was filtered to remove any form of sediments. Extracted coconut milk was pasteurized at 70 °C for 15 min. Cooled, filled into plastic bottles, sealed and labeled and stored under refrigerated conditions (2-4) ℃ (Adhikari, 2018).

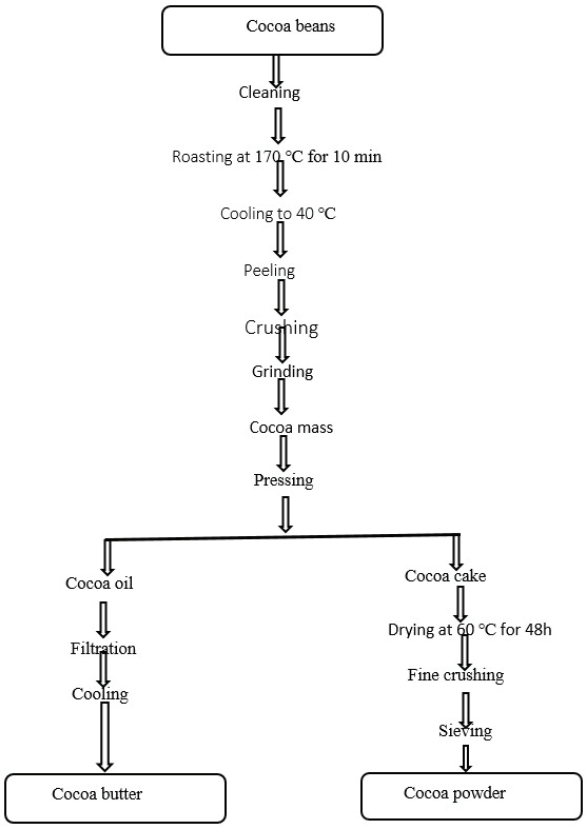

Figure 1: Flow chart for the production of cocoa powder

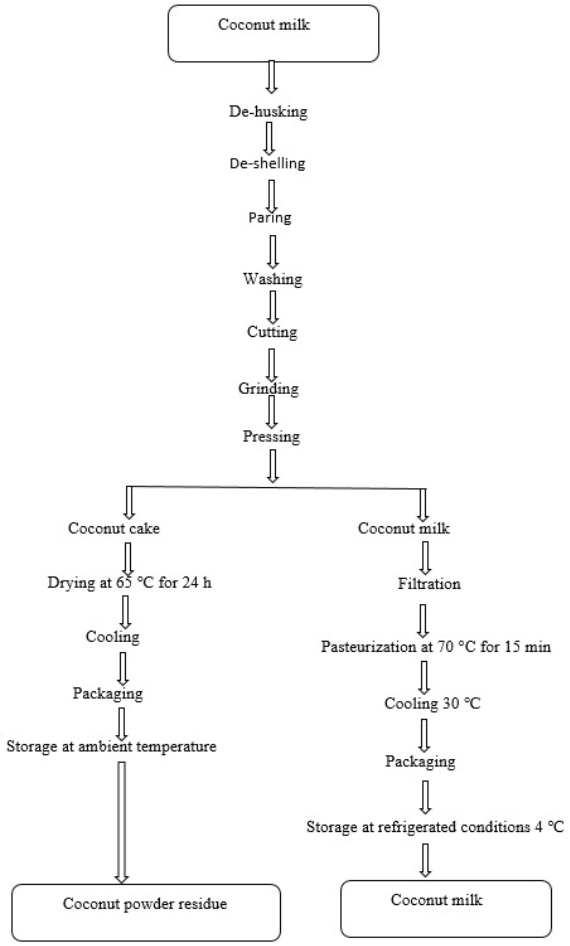

Figure 2: Flow chart for the production of coconut milk

Chocolate-like Drink Formulation and Sampling

Drink samples was formulated by varying the proportions of coconut milk, cocoa powder and sugar using 1 x 3 x 3 experimental design comprising 3 levels of cocoa powder (0 %, 0.2 %, 0.4 %) and 3 levels of sugar (0 %, 2 %, and 4 %) which yielded 9 experimental samples, where 100 % coconut milk was used as control. The drinks were subjected to nutritional quality analysis using standard methods (AOAC, 2012).

Production of Coconut Milk Based Chocolate-like Drink

Coconut based chocolate drink was produced by blending coconut milk and cocoa powder in different proportions to obtain the formulated sample that was subjected to analysis as seen on figure 3. Coconut milk and cocoa powder was mixed during which sugar (Optional) was added. The blend was filtered to get rid of any foreign particles that might have gained entering during the mixing. The mixture is homogenized to have uniform distribution of particles and also to achieve a uniform consistency. The drink was then pasteurization at the temperature of 85 to 90 ℃ for 3-5min to get rid of pathogenic and food spoilage microorganisms. The drink was cooled to 10-15 and packaged in airtight containers for storage.

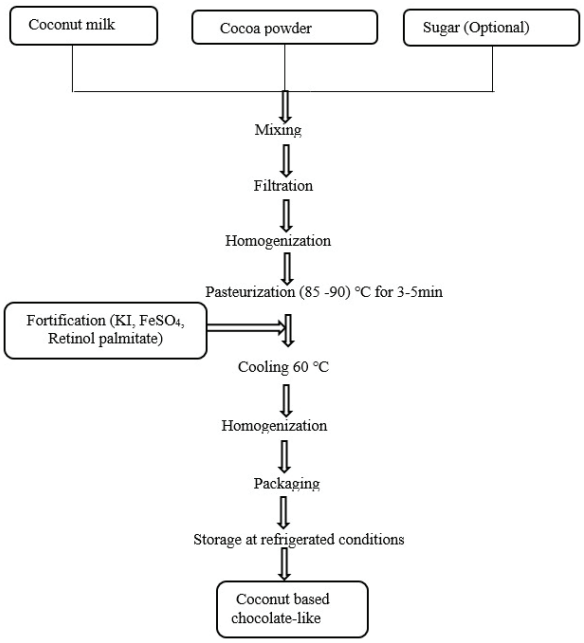

Figure 3: Figure 3: Flow chart for the production of coconut-based chocolate drink
Source: (Abadl et al., 2023)

Analysis

Physical Analysis of Fortified Coconut Milk Based Chocolate Drinks

Drinks were analyzed for the following physicochemical properties. The pH of the drinks was determined using a digital pH meter, where 15ml of samples was measured into a beaker. The pH meter was deepened into the sample and the pH value read and recorded as described by Yakum (Yakum *et al.*, 2022). The specific gravity was determined using a digital hydrometer. A 10 ml sample was measured into a beaker, the hydrometer was placed in the drink sample and allowed to settle and stop bubbling before the reading is taken. The readings are taken in triplicate and recorded. (Khuenpet *et al.*, 2016).

Chemical Analysis of Fortified Coconut Milk Based Chocolate Drinks

Proximate analysis of moisture, ash, protein, fat, crude fiber were determined in triplicate using the method of (AOAC, 2012). Total carbohydrate was determined by differences between 100 and total sum of the percentage of fat, moisture, ash, crude fiber and protein content. Solid non-fat content of the sample was obtained by subtracting fat content from dry matter. The energy was calculated using standard methods. Vitamin content of the drink samples was determined using the spectrophotometric method, the determination of Vitamins A, B1, B2, C and K of drinks samples was done using the method described by (Moyouwou *et al.*, 2017). The mineral content (Ca, Na, Mg, Zn, Fe and I) of the drink samples was determined as described by Njoya (Amadou *et al.*, 2020).

Statistical Analysis

Data were subjected to analysis of variance (one-way ANOVA) where it was appropriate and means separated by Duncan's Multiple Range test (DMRT) at 0.05 level of significance. Using the statistical package for social sciences SPSS version 28 as described by (Yakum *et al.*, 2022).

RESULTS AND DISCUSSIONS

Physicochemical Properties of Fortified Coconut Milk Based Chocolate Drink

The physicochemical properties of drink samples produced from coconut milk and cocoa powder components are presented in table 1.

Table 1: Physicochemical properties of fortified coconut milk based chocolate-like drink

Samples	PH	TTA (%)	Specific gravity	Total solid (g/100 g)	SNF (g/100 g)	Energy (Kcal)
K1	$6.50^{e}\pm0.10$	$0.41^{a}\pm0.02$	$1.03^{f}\pm 0.21$	$18.91^{g}\pm0.12$	$8.68^{b}\pm0.32$	$124.63^{c}\pm0.84$
K2	$6.54^{d}\pm0.03$	$0.25^{e}\pm0.17$	$1.05^{e}\pm0.01$	$18.98^{f}\pm0.07$	$7.23^{c}\pm0.17$	$139.42^{b}\pm0.57$
K3	$6.63^{c}\pm0.20$	$0.31^{c}\pm0.32$	$1.08^{d}\pm0.24$	$20.33^{c}\pm0.05$	$9.08^{b}\pm0.21$	$145.07^{a}\pm0.37$
K4	$6.54^{d}\pm0.11$	$0.29^{d}\pm0.02$	$1.05^{e}\pm0.13$	$18.95^{f}\pm0.12$	$8.61^{b}\pm0.11$	$126.57^{c}\pm0.56$
K5	$6.51^{e}\pm0.05$	$0.28^{d}\pm0.13$	$1.08^{d}\pm0.20$	$19.42^{e}\pm0.04$	$7.66^{c}\pm0.15$	$141.15^{b}\pm0.34$
K6	$6.63^{c}\pm0.01$	$0.39^{d}\pm0.08$	$1.08^{d}\pm0.04$	$19.94^{d}\pm0.12$	$7.68^{c}\pm0.20$	$146.37^{a}\pm0.85$
K7	$6.51^{e}\pm0.12$	$0.28^{d}\pm0.01$	$1.09^{e}\pm0.12$	$19.95^{d}\pm0.01$	$9.52^{ab}\pm0.04$	$128.49^{c}\pm1.20$
K8	$6.66^{b}\pm0.15$	$0.25^{e}\pm0.11$	$1.11^{b}\pm0.05$	$21.06^{b}\pm0.21$	$10.32^{a}\pm0.13$	$143.12^{b}\pm0.23$
K9	$6.72^{a}\pm 0.01$	$0.23^{e}\pm0.02$	$1.13^{a}\pm0.04$	$22.52^{a}\pm0.02$	$10.25^{a}\pm0.25$	$148.71^{a}\pm0.12$

Mean values within the same column having the same letter are not significantly different at p> 0.05

Key:
K1: Coconut milk 100 %
K2: Coconut milk 99.8 % cocoa powder 0.2 %
K3: Coconut milk 99.6 %, cocoa powder 0.4%
K4: Coconut milk 98 %, sugar 2%
K5: Coconut milk 97.8 %, cocoa powder 0.2%, sugar 2%
K6: Coconut milk 97.6 %, cocoa powder 0.4%, sugar 2%
K7: Coconut milk 96 %, sugar 4%
K8: Coconut milk 95.8 %, cocoa powder 0.2%, sugar 4%
K9: Coconut milk 95.6 %, cocoa powder 0.4%, sugar 4%
All drinks samples are fortified with 0.15 mg KI, 2.0 mg $FeSO_4$, and 1.6 mg Retinol palmitate per 100g of samples

PH of Fortified Coconut Milk Based Chocolate Drink

The pH values of the drink samples ranged from 6.50 (coconut milk 100 %) to 6.72 (coconut milk 95.6 %, cocoa powder 0.4%, sugar 4%). The samples were significantly different at $p>0.05$. The pH content increased with increased cocoa powder concentration. The result in this study was within the range of the standard ≥ 5.9 for coconut milk (Codex Alimentarius Commission, 2022). The pH of milk is the measure of the acidity of the product and this serves as a major contributor to the overall taste and keeping quality of milk drinks. Generally pH is the concentration of hydrogen ions in a substance. It measures the acidity and the alkalinity of a solution on the scale of 14 (Kliks *et al.*, 2019; Moyouwou *et al.*, 2017).

Total Titratable Acidity Of Fortified Drink Samples

The total titratable acidity (TTA) of the various drink types ranged between 0.23 % to 0.41 % lactic acid with significant difference ($P<0.05$) between the samples. Drinks from 100% coconut milk (K1) had the highest TTA value while K9 (coconut milk 95.6 %, cocoa powder 0.4%, sugar 4%) had the lowest. The TTA decreased with increased cocoa powder concentration. The values of TTA in this study were within the range with that of the codex standard for milk drink. The results were also similar to 0.62-0.66 % TTA obtained by (Ashaver *et al.*, 2023) on aqueous drinks using tiger nut and moringa Seeds. Drinks samples with higher cocoa powder concentrations had lower TTA, this may be due to the antimicrobial properties of cocoa powder which turns to reduce the activity of lactic acid bacteria in the fermentation of milk and thus decrease in % lactic acid. The TTA is essentially the total acid concentration contained within a food system(Standards of Identity for Dairy Products; Usman & Bolade, 2020)

Specific Gravity of Fortified Drink Samples

The specific gravity of drink samples ranged from 1.03 (100 % coconut milk) to 1.13 (coconut milk 95.6 %, cocoa powder 0.4 %, sugar 4 %) with significant difference ($p<0.05$) between the samples. The specific gravity increased with increase in cocoa powder and sugar concentration.

The results for specific gravity in this study was in line with 1.64 to 1.89 obtained by (Ashaver *et al.*, 2023) who worked on aqueous drinks using tiger nuts and moringa Seeds.

Total Solid Contents of Fortified Drink Sample

The total solids ranged from 18.91g/100 g (100% coconut milk) to 22.52 g/100g (coconut milk 95.6 %, cocoa powder 0.4 %, sugar 4 %). There was a significant difference between the samples at $p<0.05$.The results in this study were within the standard for coconut drink of 12.7 - 25.3 g/100g (Codex Alimentarius Commission, 2022). Similar to the findings of (Yakum *et al.*, 2022) who reported values for soybean and tiger nut milk yogurt spiced with ginger powder ranging from 18.72 g/100g to 19.96 g/100g. Cocoa powder has 88-91 % total solids

so addition of f cocoa powder was indirectly adding dry matter to drinks thus high contents of total solid (N. Amadou *et al*., 2017). The total solids of food are basically the dry matter that remains after moisture removal (Bristone *et al*., 2018). Therefore, the total solids can be used as a quality indicator to know whether a liquid food product is over-diluted or not. Solid nonfat is basically dry matter or total solid minus fat content (Bristone *et al*., 2018).

Solid Nonfat Contents of Fortified Drink Samples

The solid nonfat (SNF) of drink samples ranged from 7.23 g/100g to 10.25 g/100g for sample K2 (Coconut milk 99.8 % cocoa powder 0.2 %) and K8 (Coconut milk 95.8 %, cocoa powder 0.2%, sugar 4%) with significance difference at P<0.05. The values in this study closely agreed with FDA (food code Service, 2013) who stated that milk drinks should contain not less than 8.25 g/100g. The solid nonfat of the samples increased with increase in cocoa powder concentrations. This could be because cocoa powder contains more fat than sugar, deducting the fat content turns out to lower the contents in samples with high sugar concentrations.

Energy Contents of Fortified Drink Samples

The energy content of drink samples ranged from 124.63 Kcal (100 % coconut milk) to 148.71 Kcal (coconut milk 95.6 %, cocoa powder 0.4 %, sugar 4 %) with significant difference (p<0.05) between the samples. There was an increase in energy content with increased fat content of drink samples. The energy content in drink samples were slightly different from 325.22 to 332.10 325.22 Kcal obtained by (Belewu *et al*., 2014) who worked on date coconut drink. This difference could be due to variation in dilution factor and the fat content of coconut milk.

Approximate Composition of Fortified Coconut Milk Based Chocolate-Like Drinks

The proximate composition of different drinks samples produced from the blends of coconut milk, cocoa powder and sugar at different concentrations is presented in table 2.

Table 2: Proximate compositions of fortified coconut milk based chocolate drinks

Samples	Moisture (%)	Protein (%)	Ash (%)	Fiber %	Fat (%)	CHO (%)
K1	$81.09^{a}\pm0.02$	$3.42^{c}\pm0.09$	$0.71^{c}\pm0.02$	$0.02^{d}\pm0.01$	$10.23^{c}\pm0.02$	$4.82^{c}\pm0.01$
K2	$81.02^{b}\pm0.01$	$3.62^{b}\pm0.03$	$0.83^{b}\pm0.02$	$0.03^{cd}\pm0.01$	$11.75^{b}\pm0.03$	$4.82^{c}\pm0.01$
K3	$79.67^{e}\pm0.02$	$3.85^{a}\pm0.62$	$0.97^{a}\pm0.01$	$0.05^{ab}\pm0.01$	$11.25^{a}\pm0.03$	$4.83^{c}\pm0.02$
K4	$81.15^{b}\pm0.01$	$3.46^{c}\pm0.06$	$0.72^{c}\pm0.01$	0.03d±0.01	$10.24^{c}\pm0.01$	$5.03^{b}\pm0.01$
K5	$80.58^{c}\pm0.00$	$3.65^{b}\pm0.07$	$0.84^{b}\pm0.01$	$0.04^{bc}\pm0.01$	$11.76^{b}\pm0.02$	$5.04^{b}\pm0.02$
K6	$80.06^{d}\pm0.02$	$3.89^{a}\pm0.03$	$0.98^{a}\pm0.01$	$0.05^{a}\pm0.02$	$12.26^{a}\pm0.01$	$5.05^{b}\pm0.03$
K7	$80.25^{d}\pm0.03$	$3.46^{c}\pm0.06$	$0.72^{c}\pm0.01$	0.03d±0.00	$10.24^{c}\pm0.02$	$5.53^{a}\pm0.02$
K8	$78.94^{f}\pm0.01$	$3.65^{b}\pm0.07$	$0.85^{b}\pm0.01$	$0.04^{ab}\pm0.03$	$11.76^{b}\pm0.02$	$5.55^{a}\pm0.01$
K9	$77.48^{g}\pm0.04$	$3.96^{a}\pm0.05$	$0.98^{a}\pm0.00$	$0.06^{a}\pm0.00$	$12.27^{a}\pm0.01$	$5.58^{a}\pm0.01$

Mean values within the same column having the same letter are not significantly different at p> 0.05

Key:
K1: Coconut milk 100 %
K2: Coconut milk 99.8 % cocoa powder 0.2 %
K3: Coconut milk 99.6 %, cocoa powder 0.4%
K4: Coconut milk 98 %, sugar 2%
K5: Coconut milk 97.8 %, cocoa powder 0.2%, sugar 2%
K6: Coconut milk 97.6 %, cocoa powder 0.4%, sugar 2%
K7: Coconut milk 96 %, sugar 4%
K8: Coconut milk 95.8 %, cocoa powder 0.2%, sugar 4%
K9: Coconut milk 95.6 %, cocoa powder 0.4%, sugar 4%
All drinks samples are fortified with 0.15 mg KI, 2.0 mg $FeSO_4$, and 1.6 mg Retinol palmitate per 100g of samples

Moisture Content of Fortified Coconut Milk Based Chocolate Drinks Samples

The moisture content of all the drinks ranged between 77.48 g/100g (coconut milk 95.6 %, cocoa powder 0.4 %, sugar 4 %) to 81.09 g/100g (100% coconut milk) with significant difference (P<0.05). There was decreased moisture content as cocoa powder and sugar increased in concentrations. The results in this study were lower than 86.34 to 94.11 g/100g for soy yogurt by Akusu *et al*,(Akusu & Wordu, 2017). The relatively low moisture content of the drink samples could be because of added fortificants and also due to high dry matter content of cocoa powder which has very low moisture content of <10% weight basis, so adding it to the drink reduced the moisture content of the drink samples. The implication of high moisture content is that the food product has a tendency of very low shelf stability as high moisture content in food provides a suitable medium for food spoilage and pathogenic microorganisms activities and thus reduced shelf life (Khan *et al*., 2016).

Protein Contents of Fortified Coconut Milk Based Chocolate Drinks

The protein contents of the drink samples ranged from 3.42 g/100g (100% coconut milk) to 3.96 g/100g (coconut milk 95.6 %, cocoa powder 0.4 %, sugar 4 %). There was an increase in protein content with an increased in cocoa powder concentrations. Studies done by Yakum *et al*.,(Yakum *et al*., 2022) showed a range of

3.73 g/100g to 4.82g/100g for plant based yogurt like drinks from cow milk, soybean milk and tiger nut milk. The result in this case was slightly lower than that range. This could be because soybean milk contains higher protein than coconut milk (Kaushal *et al*., 2017). Soy bean also contains most of the essential amino acids required for human nutrition and thus, a good source of dietary protein and can be considered as good substitutes for animal protein (Hymavathi *et al*., 2020).

Ash Content of Fortified Coconut Milk Based Chocolate Drinks Samples

The results were slightly higher than the findings of Njoya *et al*,(N. Amadou *et al*., 2017) who reported ash content of 0.68g/100g to 0.76g/100g in ginger spiced yogurt. This was also slightly higher than the range (0.67 to 0.7 g/100g) of the ash content of milk according to FDA (food code Service, 2013). This could be because drinks samples were fortified with 0.15 mg KI, 2.0 mg $FeSO_4$, and 1.6 mg Retinol palmitate per 100g of samples which boosted up the mineral contents of the drinks and also acted as a vehicle for food fortification. Cocoa powder also contains about 8g/100g ash, thus adding cocoa powder to drink was a sort of enriching drink with minerals such as P, Na, K, Fe (Gonzlez-Tenorio *et al*., 2012).

Crude Fiber Contents of Fortified Coconut Milk Based Chocolate Drinks

Drinks samples had low fiber contents compared to the study by Gambo *et al.* (Gambo & Da'u, 2014), for tiger nut milk which ranged from 0.24 g/100g to 0.33 g/100g. Cocoa powder contributed to the fiber content of the drinks samples. Fiber is beneficial to keep the digestive system in a perfect shape and combating constipation problems (Ilesanmi Adeyeye, 2016)

Fat Contents of Fortified Coconut Milk Based Chocolate Drinks

Fat contained was high in samples that content high concentration of cocoa powder. This is because coconut is regarded as oily nuts with high fat content, but this is an advantage because the fat in coconut is short chain trans fatty acids, polyunsaturated and monounsaturated fats and does not lead to the deposition of fat in the blood vessels and the heart and thus does not lead to heart diseases (Giri & Mangaraj, 2012). According to (Codex Alimentarius Commission, 2022), coconut milk contains a minimum of 10 g of fat per 100g of coconut milk. The drinks in this study felt in this category. Excessive intake of High fat and high sugar foods can lead to health problems.

Carbohydrate Contents of Fortified Coconut Milk Based Chocolate Drinks

The results in this study agreed with Badau *et al.*(Bristone *et al*., 2018) on the quality of yogurt- like drinks from plant based sources with values ranging from 3.77g/100g to 9.27g/100g. These values were relatively low and therefore, drink as a product cannot be regarded as a good source of this nutrient. Nevertheless, most people consume drink not as a main food but as a dessert drink, snack, or as a probiotic food drink in between mills for the re-establishment and refreshment of body fluid (Priyanka Aswal, 2012).

Vitamins Contents of Fortified Coconut Milk Based Chocolate-Like Drinks

The vitamin content of drinks samples are presented in table 3.

Table 3: Vitamin compositions of fortified coconut milk based chocolate drinks

Sample	Vitamin A (mg/100g)	Vitamin B1 (mg/100g)	Vitamin B2 (mg/100g)	Vitamin C (mg/100g)	Vitamin K (mg/100g)
K1	$1.725^{c}\pm0.012$	$0.044^{c}\pm 0.017$	$0.028^{c}\pm0.001$	$2.981^{c}\pm0.018$	$0.141^{c}\pm0.010$
K2	$1.981^{b}\pm0.058$	$0.081^{b}\pm0.052$	$0.061^{b}\pm0.003$	$3.388^{b}\pm0.052$	$0.634^{b}\pm0.045$
K3	$2.455^{a}\pm0.86$	$0.203^{a}\pm0.025$	$0.112^{a}\pm0.002$	$5.678^{a}\pm0.025$	$1.135^{a}\pm0.028$
K4	$1.732^{c}\pm0.010$	$0.044^{c}\pm0.058$	$0.028^{c}\pm0.005$	$2.991^{c}\pm0.058$	$0.148^{c}\pm0.055$
K5	$1.985^{b}\pm0.049$	$0.082^{b}\pm0.010$	$0.062^{b}\pm0.058$	$3.401^{b}\pm0.010$	$0.636^{b}\pm0.036$
K6	$2.462^{a}\pm0.010$	$0.204^{a}\pm0.023$	$0.113^{a}\pm0.028$	$5.688^{a}\pm0.023$	$1.136^{a}\pm0.032$
K7	$1.739^{c}\pm0.012$	$0.045^{c}\pm0.021$	$0.029^{c}\pm0.058$	$3.028^{c}\pm0.021$	$0.152^{c}\pm0.085$
K8	$1.992^{b}\pm0.010$	$0.083^{b}\pm0.011$	$0.061^{b}\pm0.015$	$3.408^{b}\pm0.011$	$0.636^{b}\pm0.026$
K9	$2.469^{a}\pm0.011$	$0.205^{a}\pm0.050$	$0.114^{a}\pm0.053$	$5.751^{a}\pm0.050$	$1.137^{a}\pm0.058$

Mean values within the same column having the same letter are not significantly different at p> 0

Key:
K1: Coconut milk 100 %
K2: Coconut milk 99.8 % cocoa powder 0.2 %
K3: Coconut milk 99.6 %, cocoa powder 0.4%
K4: Coconut milk 98 %, sugar 2%
K5: Coconut milk 97.8 %, cocoa powder 0.2%, sugar 2%
K6: Coconut milk 97.6 %, cocoa powder 0.4%, sugar 2%
K7: Coconut milk 96 %, sugar 4%
K8: Coconut milk 95.8 %, cocoa powder 0.2%, sugar 4%
K9: Coconut milk 95.6 %, cocoa powder 0.4%, sugar 4%
All drinks samples are fortified with 0.15 mg KI, 2.0 mg $FeSO_4$, and 1.6 mg Retinol palmitate per 100g of samples

Vitamin A Contents of Fortified Coconut Milk Based Chocolate Drinks

Vitamin A of fortified drink samples ranged from 1.725 to 2.469 mg/100g for sample K1 (100% coconut milk) and K9 (Coconut milk 95.6 %, cocoa powder 0.4%, sugar 4%) respectively. There was a significant difference at $p<0.05$. Vitamin A content increased with increased cocoa powder concentration. Pro vitamin A content in drinks samples was similar to 0.94 to 2.48mg/100g obtained by Ashaver *et al.*, 2023 on fortified tiger nut milk and moringa milk blend drinks. Drinks pro- vitamin A concentration could serve as a useful source of antioxidants and it is recommended for children and the elderly due to its high antioxidant advantages in the cell membrane. Vitamin A aids in the maintenance of excellent vision and eye health, supports skin cell health, it also supports cell growth, immune function, fetal development and the prevention of certain eye illnesses(Ashaver *et al.*, 2023).

Vitamin B1 (Thiamine) Contents of Fortified Coconut Milk Based Chocolate Drinks

Vitamin B1 content ranged from 0.044 mg/100g to 0.205mg/100g in samples K1 (100% coconut milk) and K9 (Coconut milk 95.6 %, cocoa powder 0.4%, sugar 4%). There was a significant difference ($P<0.05$) between the samples. The values of B1 increased with increased cocoa powder concentrations. Studies by McClements *et al* (McClements *et al.*, 2019) reported 0.04 mg/100g to 0.08mg/100g content of B1 in soy yogurt. The range obtained from this study was higher. Increase in cocoa powder concentration increased the vitamin B1 content. This is because cocoa powder contains a high content of B1. This value was less than the standard value of 1.1-1.2 mg per day for RDA (Recommended Daily Allowance) for adult male and female. Vitamin B1 is essential for glucose metabolism and it plays a key role and helps prevent complications in nerve muscle, and heart function (Yadav *et al.*, 2015).

Vitamins B2 Contents of Fortified Coconut Milk Based Chocolate Drinks

Vitamin B2 contents of the drinks samples ranged from 0.028mg/100g to 0.114mg/100g for sample k1 (100% coconut milk) and k9 (Coconut milk 95.6 %, cocoa powder 0.4%, sugar 4%) with significant difference ($P<0.05$) between the samples. Vitamin D content increased with increased cocoa powder levels. These results compared with 0.19mg/100g to 0.30mg/100g in plant based drinks (McClements *et al.*, 2019) fall within the range. The content was higher in the samples that had higher concentration of cocoa powder. Vitamin B2 RDA is 1.1 to 1.3 mg per day. Vitamin B2 (Riboflavin) is used as a dietary supplement. It is required by the body for cellular respiration. Riboflavin is a heat stable vitamin and is not affected by severe heat treatment (Donovan & Shamir, 2014).

Vitamin C (ascorbic acid) Contents of Fortified Coconut Milk Based Chocolate Drinks

Vitamin C contents ranged from 2.981mg/100g for K1 (100% coconut milk) to 5.751 mg/100g K9 (Coconut milk 95.6 %, cocoa powder 0.4%, sugar 4%). There was an increased in vitamin C content as the concentrations of cocoa powder increased with a significant difference at $p<0.05$. Studies on soybean milk reported 0 to 1.5mg/100g vitamin C content (McClements *et al.*, 2019). The range in this study was higher possibly because coconut milk contains more vitamin C than soy bean milk. Cocoa powder also contained vitamin C and thus improved vitamin C content in samples that had higher concentration of cocoa powder (Kaushal *et al.*, 2017). This range was far below the RDA of vitamin C which is 45-120 mg per day. Ascorbic acid (vitamin C) is necessary for the growth, development and repair of all body tissues. It is involved in many body functions, including formation of collagen, absorption of iron, the proper functioning of the immune system, wound healing, and the maintenance of cartilage, bone and teeth , Vitamin C has anti-infective qualities, may stimulate the immune system, and aids in the prevention of infections (Donovan & Shamir, 2014).

Vitamins K Contents of Fortified Coconut Milk Based Chocolate Drinks

The contents of vitamin K in drink samples ranged from 0.141 mg/100g to 1.137 mg/100g. For sample K1 (100% coconut milk) and sample K9 (Coconut milk 95.6 %, cocoa powder 0.4%, sugar 4%) had the highest. There was a significant difference ($p<0.05$) between the samples. Increase in the concentrations of cocoa powder increased vitamin K content of drink samples. Vitamin K (Phytonadione and Menaquinones) values in the drinks ranged from 0.141 to 1.137 mg/100 g, which is lower than the FDA's recommended daily intake levels. Although vitamin K insufficiency is uncommon, it can have long-term effects on the body. A daily dose of 120 mcg of vitamin K is usually sufficient for adult males and less for females and children(Business & Act, 2021). Hence indicating that the vitamin k content in the formulated product from this study are adequate for human nutrition purposes. Vitamin K is needed by the body for blood clothing, bone development and it can also reduce risk of fractures, blood loss in the event of an injury. Insufficient vitamin K in the body can cause bleeding, increased calcium deposition which can lead to coronary artery calcification and the development of heart disease (Tulashie *et al.*, 2022). Although vitamin K insufficiency is uncommon, it can have long-term effects on the body. A daily dose of 120 mcg of vitamin K is usually sufficient for adult males and less for females and children. Hence indicating that the vitamin k content in the formulated product from this study are adequate for human nutrition purposes (Donovan & Shamir, 2014). Vitamins help

in the body to break down food (Carbohydrates) into fuel (glucose) which the body uses to produce energy. They also help the body to metabolize fat and protein. All selected vitamins of this study are water soluble (Donovan & Shamir, 2014; Yadav *et al.*, 2015).

Mineral Contents of Fortified Coconut Milk Based Chocolate-Like Drinks

The selected mineral profile of drinks samples are presented in table 4.

Table 4: Mineral compositions of fortified coconut milk based chocolate-like drinks

Samples	Ca (mg/100g)	Na (mg/100g)	Mg (mg/100g)	Zn (mg/100g)	Fe (mg/100g)	I (mg/100g)
K1	16.31c±0.36	15.25c±0.30	37.20c ±0.30	0.677c±0.57	2.87c±0.15	0.16c±0.01
K2	21.44b ±0.28	16.13b±0.20	54.57b±0.45	1.137b±0.20	2.96b±0.26	0.23b±0.01
K3	27.03a±0.15	16.97a±0.57	72.62a±0.26	2.95a±0.32	2.99ab±0.20	0.27a±0.05
K4	16.32c±0.28	15.26c±0.32	37.21c±0.31	0.68c±0.21	2.88c±0.57	0.17c±0.07
K5	21.45b±0.10	16.14b±0.77	54.58b±0.35	2.96b±0.52	2.97b±0.32	0.22b±0.03
K6	27.04a±0.26	16.98c±0.30	72.63a±0.15	3.11a±0.10	3.03ab±0.28	0.27a±0.04
K7	16.33c±0.25	15.27c±0.15	37.21c±0.32	0.69c±0.57	2.98c±0.57	0.18c±0.05
K8	21.46b±0.57	16.15b±0.57	54.59b±0.14	1.72b±0.10	3.07b±0.52	0.24b±0.01
K9	27.05a±0.77	16.99a±0.30	72.64a±0.17	3.18a±0.11	3.38a±0.20	0.28a±0.05

Mean values within the same column having the same letter are not significantly different at p> 0.05

Key:
K1: Coconut milk 100 %
K2: Coconut milk 99.8 % cocoa powder 0.2 %
K3: Coconut milk 99.6 %, cocoa powder 0.4%
K4: Coconut milk 98 %, sugar 2%
K5: Coconut milk 97.8 %, cocoa powder 0.2%, sugar 2%
K6: Coconut milk 97.6 %, cocoa powder 0.4%, sugar 2%
K7: Coconut milk 96 %, sugar 4%
K8: Coconut milk 95.8 %, cocoa powder 0.2%, sugar 4%
K9: Coconut milk 95.6 %, cocoa powder 0.4%, sugar 4%
All drinks samples are fortified with 0.15 mg KI, 2.0 mg $FeSO_4$, and 1.6 mg Retinol palmitate per 100g of samples.

Calcium (Ca) Contents of Fortified Coconut Milk Based Chocolate Drinks

The calcium (Ca) concentration in the drinks samples ranged between 16.31 mg/100 g (100 % coconut milk) to 27.05 mg/100 g (Coconut milk 95.6 %, cocoa powder 0.4 %, sugar 4 %) with significant differences (P<0.05). There was an increase in the Ca content as the concentrations of cocoa powder increased. The values in this study were lower than the range of 119 mg/100g to 225 mg/100g reported by McClements *et al.*(McClements *et al.*, 2019) For plant based milk. There was an increase in Ca content as cocoa powder concentration increased. This is because cocoa powder contains a considerable amount of Ca which turns to burst up the Ca content of drink samples. Ca in human nutrition helps to improve healthy bone and teeth. An inadequate intake of Ca in human diet can lead to such disease conditions as osteoporosis, hypercholesterolemia and high blood pressure (Oladele & Aina, 2007).

Sodium (Na) Contents of Fortified Coconut Milk Based Chocolate Drinks

The sodium (Na) concentration in the various drinks types ranged between 15.25mg/100g (100 % coconut milk) to 16.99 mg/100g (Coconut milk 95.6 %, cocoa powder 0.4%, sugar 4%) respectively with significant differences (P<0.05). Similar studies on yogurt had 111.08 mg/100g to 111.42 mg/100g(Amadou *et al.*, 2020) which is higher than the range obtained from these studies. There was an increase in Na content as cocoa powder content increased. This could be because cocoa powder contains a high content of Na up to 245 to 235 mg/100g dry basis(Usman & Bolade, 2020). The RDA of Na is 2300 to 3400 mg per day (Usman & Bolade, 2020). The principal role of Na in human physiology is related to the maintenance of physiological fluids such as blood pressure (Usman & Bolade, 2020).

Magnesium (Mg) Contents of Fortified Coconut Milk Based Chocolate Drinks

The magnesium (Mg) content of the drink types had a range of 37.20 mg/100g to 72.64 mg/100 g with significant differences (P<0.05). The highest value was recorded for sample K9 (Coconut milk 95.6 %, cocoa powder 0.4%, sugar 4%) and the lowest for sample K1 (100 % coconut milk).

Studies on plant based milk showed Mg contents of 20 mg/100g to 49 mg /100g (Mazumder & Hongsprabhas, 2016). The range in this study was high. This could be because coconut milk and cocoa powder contain high content of Mg up to 51 mg/100g to 56.3 mg/100g. These values are far below the recommended daily allowance (RDA) of 200-400 mg per day (Oladele & Aina, 2007). Coconut milk based chocolate drink is usually consumed as a snack drink, it may be regarded as a good complementary source for Mg. In human nutrition, Mg has been implicated in energy metabolism, release of neurotransmitters and endothelial cell functions. It is also a co-factor of up to about 300 enzymes in the body system. It helps improve bone formation for strength, as well as enzyme, nerve, and heart functions (El-Bialy *et al.*, 2020).

Zinc (Zn) Contents of Fortified Coconut Milk Based Chocolate Drinks

Zinc (Zn) contents of fortified drink samples ranged from 0.677 to 3.13 mg/100g for sample K1 (100% coconut milk) and K9 (Coconut milk 95.6 %, cocoa powder 0.4%, sugar 4%) respectively. There was a significant difference ($P<0.05$) between the samples. Zn content of samples increased with increased cocoa powder concentration. A similar study on ginger spiced drinks ranged from 0.39mg/100g to 0.44 mg/100g Amadou *et al*, (Amadou *et al*., 2020). The values in this study were higher than that. Studies on plant based milk drink showed a range of 0.38mg/100g to 0.75mg/100g for Zn (Oladele & Aina, 2007), which was in line with the result obtained in this study. This is because Zn is higher in plant sources than animal sources (Amadou *et al*., 2020). These values were below the Recommended Dietary Allowance (RDA) which was 8-11mg/day(Oladele & Aina, 2007). Zn is needed in human nutrition for the body's defensive (immune) system to properly work. It plays a role in cell division, cell growth, wound healing and the breakdown of carbohydrates (Oladele & Aina, 2007).

Iron (Fe) Contents of Fortified Coconut Milk Based Chocolate Drinks

Iron (Fe) contents exhibited a range from 2.87mg/100g to 3.38 mg/100g with significant difference at $p<0.05$. Sample K9 (Coconut milk 95.6 %, cocoa powder 0.4%, sugar 4%) had highest while K1 (100 % coconut milk) had lowest. The Fe content of the samples increased with increased cocoa powder concentrations. A study conducted by Oladele, *et al*., (Oladele & Aina, 2007), indicated that plant based milk Fe content ranged from 0.05 mg/100g to 0.84mg/100g. The result in this study was higher. This was because milk is an excellent source of Fe, and has as much iron as red meat (El-Bialy *et al*., 2020) This can be regarded as being low and cannot meet the recommended daily allowance (RDA) of 8 – 18 mg per day(Usman & Bolade, 2020). The major function of Fe in human nutrition is related to the synthesis of hemoglobin and myoglobin in the blood. Iron participates in several enzyme processes, including those that generate energy from carbohydrate, fat, and protein. It also plays a function in cell division, carbon dioxide and oxygen transport in the blood, and immunity. Inadequate Fe in the diet can lead to a deficiency called anemia (El-Bialy *et al*., 2020).

Iodine (I) Contents of Fortified Coconut Milk Based Chocolate Drinks

Iodine (I) contents of the drinks samples ranged between 0.16 mg/100g and 0.28 mg/100g for sample k1 (100 % coconut milk) and k9 (Coconut milk 95.6 %, cocoa powder 0.4%, sugar 4%). There was significant a difference amongst the samples ($P< 0.05$). The results in this study were slightly higher than 0.00 – 0.15 mg/100 g iodine value in tiger nut and moringa seeds based aqueous drinks (Ashaver *et al*., 2023). This could be because the drinks were fortified with 0.15mg/100g KI, as recommended by standard for food fortification and also because cocoa powder contains a considerable amount of Iodine (Food fortification Regulations, 2021). Iodine is a mineral contained in some foods that the body needs in order to produce thyroid hormones. This hormone regulates the body's metabolism as well as many other vital activities. Thyroid hormones are also required by the body for appropriate bone and brain development during pregnancy and infancy. The dietary reference value (DRV) is 150µg of iodine per day for adults over the age of 18. During pregnancy and lactation, requirements increase to 200µg per day (food code Service, 2013). Fortified coconut milk based chocolate drinks with iodine content of 0.16 to 0.28 mg/100g are adequate to provide the dietary reference value for pregnant women and infants as recommended (Food fortification Regulations, 2021).

CONCLUSION

i. The production of fortified coconut milk based chocolate drinks appears feasible.

ii. The Cocoa powder and sugar levels improved the physicochemical, proximate, vitamins, minerals and overall nutritional profile of fortified coconut milk based chocolate -like drinks.

iii. Fortification of the formulated drinks with potassium iodide, ferrous sulfate and retinol palmitate improved the physicochemical qualities of the drink, making it a good vehicle for micronutrient fortification which can be used to address Protein Energy Malnutrition (PEM) and Micronutrient Deficiency (MND).

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