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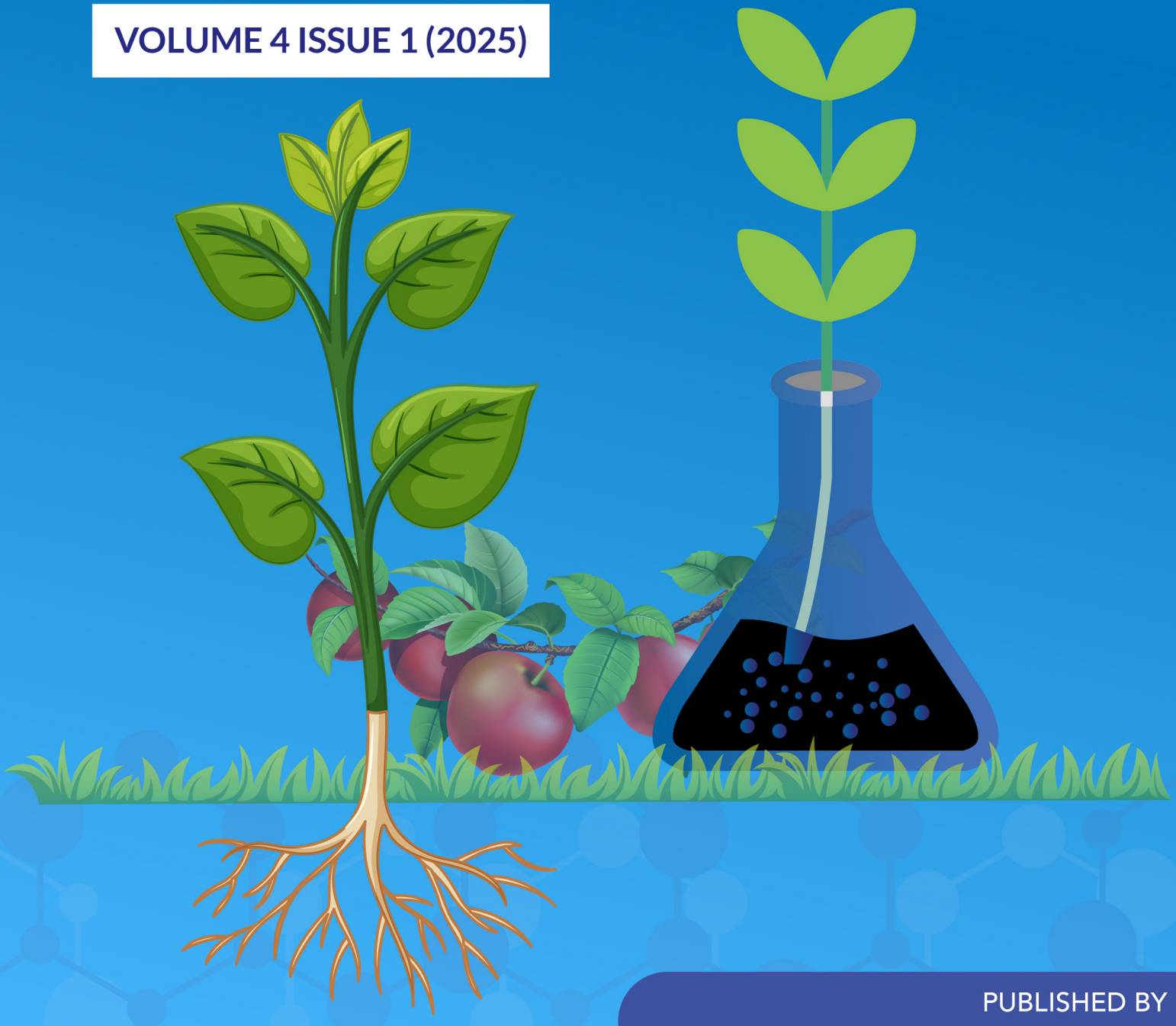

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Triple Fortification Improved the Physicochemical Qualities of Soy-Chocolate Drinks

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ABSTRACT

The effect of triple fortification on the physicochemical qualities of soy-chocolate drinks were evaluated. Triple fortification of soy-chocolate drinks with 0.15 mg potassium iodide, 2.0 mg ferrous sulphate, and 1.6 mg pro-vitamin A (retinol palmitate) / 100g sample was used as recommended by the World Health Organization (WHO) fortification guidelines. Four soy-chocolate drinks comprising of non-fortified plain (NFPSCD), fortified plain (FPSCD), non-fortified sweetened (NFSSCD) and fortified sweetened (FSSCD) were formulated. Soy-chocolate drinks were formulated and analyzed using standard procedures. pH ranged from 6.12 to 6.86, TTA varied from 0.62 to 0.89 % lactic acid, and specific gravity from 1.02 to 1.07. The vitamin content increased significantly ($p< 0.05$)., retinol palmitate varied from 0.14 to 1.66 mg/ 100g, while vitamin B1 ranged from 0.20 to 0.35 mg/ 100g, vitamin B2 from 0.50 to 0.72 mg/ 100g, vitamin B3 1.03 to 1.22 mg/ 100g, vitamin B6 from 0.21 to 0.23 mg/ 100g, vitamin K range between 2.18 to 3.37 mg/ 100g, Vitamin E from 0.81 to 0.96 mg/ 100g. Mineral composition of soy-chocolate drinks were calcium which was 92.43 to 94.36 mg/ 100g, sodium 80.06 to 83.26 mg/100g, potassium 306.43 to 329.52 mg/100g, magnesium 46.04 to 47.12 mg/ 100g, phosphorus 120.62 to 123.54mg/100g, zinc 2.01 to 2.69, iron 3.71 to 3.88 mg/ 100g, iodine 0.18 to 0.24 mg/100g. It was observed from this research that soy-chocolate nutrient quality was improved because of fortification.

INTRODUCTION

Soymilk is a stable aqueous extract of whole soybean (Glycine max) seeds (Iwe, 2003). It is a highly refreshing food drink which contains about 6 % protein, 4 % fat, 5 % carbohydrate, 1 % fibre, vitamins, minerals and antioxidants which are essential for human health (Adebowale, 2019) . Soy milk, kunu-zaki, zobo, coconut milk, and tigernut milk are some of the local aqueous non-alcoholic drinks in Nigeria. Nevertheless, soymilk's ease of production and adaptability are credited to its versatility as a beverage around the world (Ariahu, 2019). As this drink is cholesterol free and low in energy, it could enhance health benefits in terms of reducing body weight and blood lipids (WHO, 2021). It is available as a plain, sweetened, unflavored beverage or in a variety of flavored beverages including chocolate, vanilla and almond.

Cocoa powder is a product of dry cocoa solids with 10-12 % phenolic compounds (phytonutrients), commonly referred to as nutraceuticals or phytochemicals, which are used in food supplementation (FAO, 2020). Polyphenols have antioxidant properties that takes part in the reduction of diseases by preventing damage during aerobic respiration. It prevents cardiovascular diseases, cholesterol, modulate immune function and stop the production of low-density lipoprotein (LDLP) (Achinehwu, 2019). Cocoa is rich in flavonol that regulates platelet which aids in blood clotting.

Soy-chocolate drinks are aqueous blends of liquid soymilk and varying levels of cocoa powder which may be plain or sweetened. These non-alcoholic drinks combine the nutritional and health benefits of aqueous extractives of soybean and cocoa bean in a punch. The benefits include high protein contents, predominance of polyunsaturated fatty acids, phytochemicals as well as low lactose and cholesterol content (Ariahu, 2019). Chocolate drinks are popular among adults and children, especially those of school age and holds promise as appropriate vehicle in food fortification programmes for addressing micronutrients deficiency (MND).

Protein energy malnutrition (PEM) and micronutrients deficiency (MND) are prevalent in the third world countries including Nigeria (Ashaver *et al.*, 2023). PEM in general is defined by the World Health Organization as a cellular imbalance between the supply of nutrients and energy and the body's demand for them to ensure growth, maintenance, and specific functions (Ball, 1999). According to Codex (2022) malnutrition is lack of essential vitamins and minerals required in small amounts by the body for growth and development. These nutritional deficiencies are more prevalent among low-income people, the invalids and those living in IDP camps.

Food fortification is defined as the addition of one or more essential nutrients to a food, with the purpose of addressing a given deficiency in a population (FAO, 2002). The nutrients of critical concern in MND fortification programmes are iron, iodine and vitamin A (Yasmine, 2019). Food fortification is often considered the most economical approach to reduce nutritional deficiencies in settings where suitable food vehicles are available. The control of micronutrients malnutrition, notably vitamin A deficiency, iodine deficiency disorders and iron-deficiency

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anemia, presently occupies the attention of nutrition and public health workers throughout the developing world. The food fortified are those commonly consumed by the population at risk. This has demonstrated to be a cost-effective food-based strategy for the control of micronutrients deficiencies (FAO, 2020).

Soy-chocolate drinks can be employed for addressing PEM and a vehicle for MND fortification programmes. Maximum limits by standard and least cost of production used in this research can be employed to serve as baseline data and standardization for soy-chocolate drinks.

MATERIALS AND METHODS

About 10kg Soybean (Glycine max) seeds was bought from Benue Agriculture and Rural Development Agency (BNARDA) Makurdi while a 500g pack of cocoa powder (Nestle Nigeria Plc) was purchased from a popular supermarket in Makurdi, Benue State. Pro- vitamin A (retinol palmitate), ferrous sulphate and potassium iodide used as fortificants were purchased from a chemical store (Emole Nig Ltd Makurdi Benue State, Nigeria).

Soy-Chocolate Drinks Formulation

The soy-chocolate aqueous drink was produced using the method described by Illinois with modifications as shown in Figures 1, 2 and 3 (Illinois, 2020, Blackman *et al.*, 2010).

Essentially, soybeans were sorted and cleaned to remove stones and damaged, deformed seeds. Then the dry soybean was washed and soaked in water overnight (500g in 1 Litre) for 12 hours. It was then rinsed and blanched in 0.5 % sodium bicarbonate for 30 minutes. The soybean seeds were ground in blender and expressed in the ratio of 3:1 (water to beans on a weight basis) to remove the okara or soy pulp. The obtained milk was then boiled and formulated by adding cocoa powder (0.1, 0.2, 0.3, 0.4 %) and sugar (0, 2, 4, 6 %).

The milk was then pasteurized at the temperature of 65°C for 15 seconds and subsequently bottled and refrigerated. This yielded 16 experimental groups which were promptly subjected to sensory evaluation. The most preferred plain and sweetened formulations and were each subjected to triple fortification using 0.15 mg potassium iodide, 2.0 mg ferrous sulphate and 1.6 mg/100 g sample pro-vitamin A as recommended by the world health organization (WHO) fortification guide respectively. This yielded four working samples comprising of non-fortified plain soy-chocolate drink (NFPSCD), fortified plain soy-chocolate drink (FPSCD), non-fortified sweetened soy-chocolate drink (NFSSCD) and fortified sweetened soy-chocolate drink (FSSCD) (Regulations, 2021).

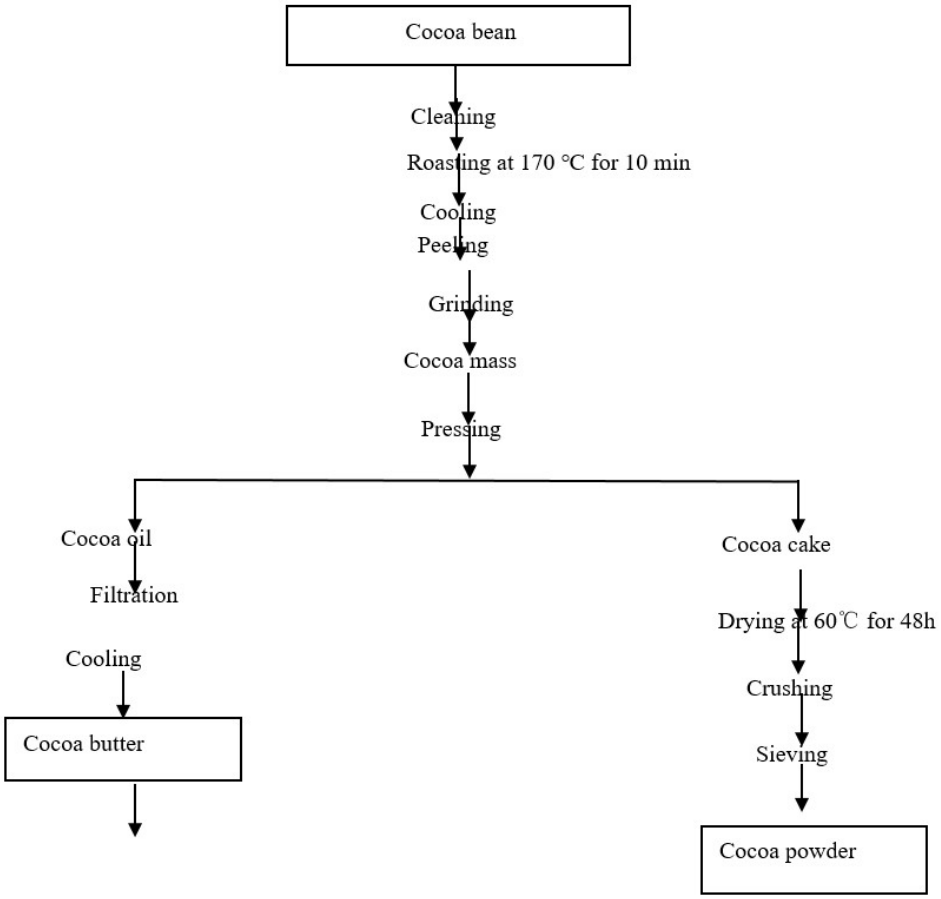

Figure 1: Flow chart for the production of cocoa powder by Nestle Nig. plc
Source: Illinois, 2020

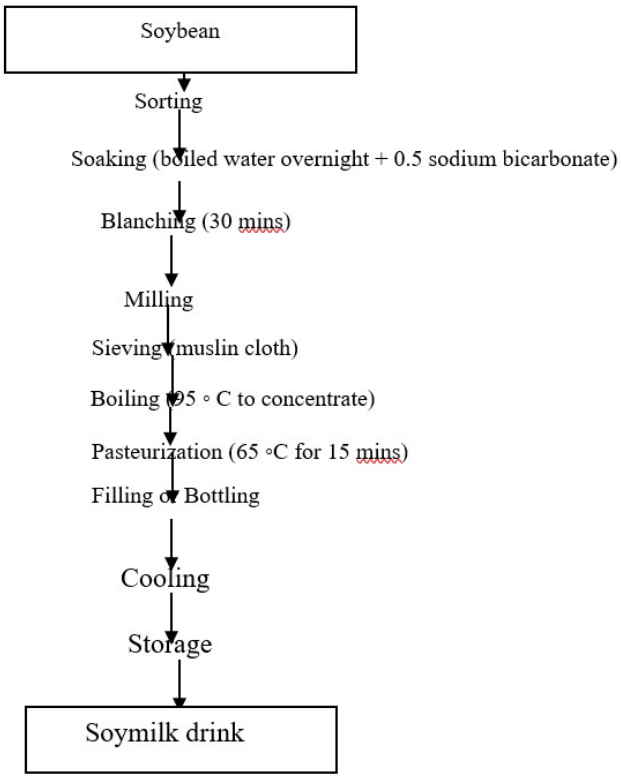

Figure 2: Flow chart for Production of soymilk Drink
Source: Illinois, 2020

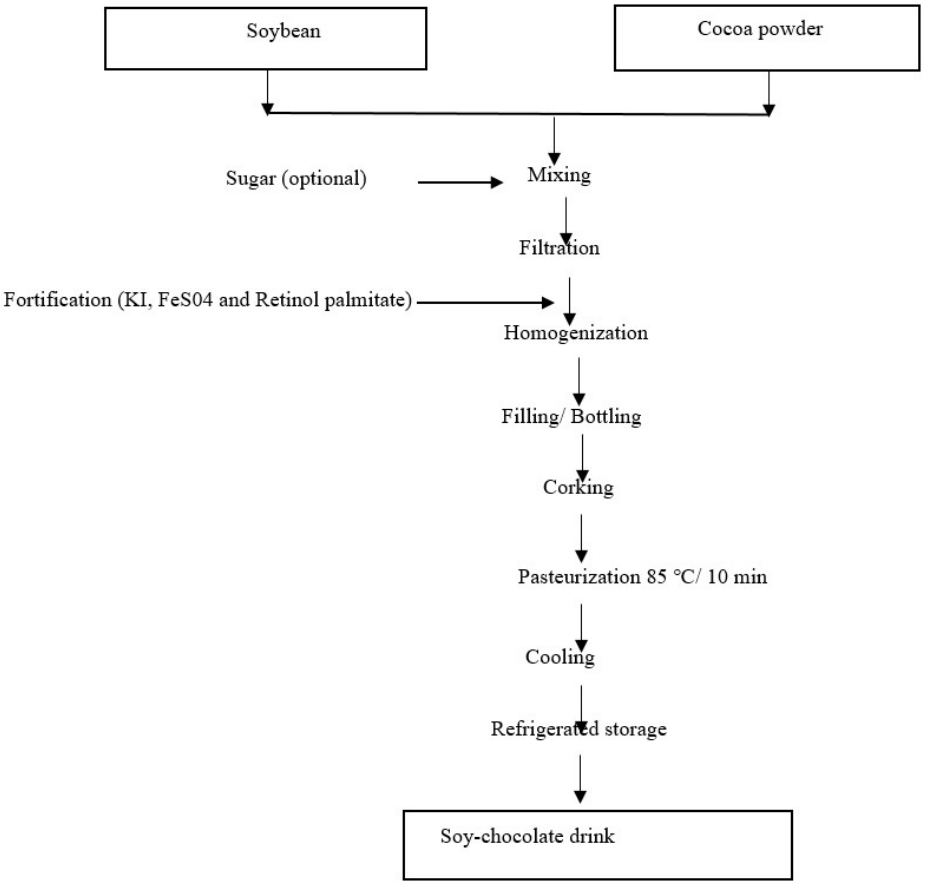

Figure 3: Flow chart for the production of soy-chocolate drink
Source: Abadi et al., 2023

Analyses

Physical Analysis of Fortified Soy-Chocolate Drinks

The pH of the soy-chocolate drink samples was measured using Jenway pH meter (model 3015, serial number 1647, UK). 2 g of each formulated sample was poured in a beaker. The pH electrode which was previously standardized using buffer of pH 4.01 and 9.20 and rinsed with deionized water. The electrode was dipped into the homogenate allowing sufficient time for equilibrium before taking readings. Determinations were carried out in triplicate for each sample.

Chemical Analysis of Fortified Soy-Chocolate Drinks

The proximate composition of soy-chocolate drinks was analyzed for moisture, protein, fats, ash and crude fiber using A.O.A.C (2017). Carbohydrate was determined by difference (subtracting crude protein (%), moisture (%), fat (%), crude fiber (%) and ash (%) contents of the soy-chocolate drinks from 100) and the energy value by Atwater procedure. The mineral content of drinks was analyzed using Spectrophotometric method to determine the mineral content of each sample (AOAC, 2005). Also, Vitamin A, B1, B2, B3, B6, E and K content of soy-chocolate aqueous drinks were determined using colourimetric methods as described by Ball (2020).

Statistical Analysis

Data were subjected to one way analysis of variance (ANOVA) with separation of means by Duncan's Multiple Range test at 0.05 of significance using statistical package for social sciences SPSS version 28.

RESULTS AND DISCUSSION

Physicochemical Properties of Fortified Soy-Chocolate Drinks

The physicochemical properties of soy-chocolate drinks are shown in Table 1. There was a significant ($p<0.05$) difference among formulated samples.

pH of Fortified Soy-Chocolate Drinks

The effect of sugar, cocoa powder, and fortificants on the pH of soy-chocolate drinks is shown in Table 1. The research showed that the pH increased from 6.12 to 6.86 mg/100g for soy-chocolate drinks. The fortified drinks, FPSCD (6.42) and FSSCD (6.86) had higher pH values than the non-fortified drinks NFPSCD (6.12 mg/100g) and NFSSCD (6.63 mg/100g) respectively. Soy-chocolate drinks exhibited slightly acidic to neutral pH which is ideal for soy-chocolate beverages (Dogan & Kayacier, 2019). The slightly neutral pH and low acidity observed in this research could be due to low acidity ingredients (cocoa powder and sugar) used in sample formulation as well as readily non-fermentable sugars (Ijarotimi & Ashipa, 2019). pH plays a vital role in the quality, stability, and nutritional value of soy-chocolate drinks.

Total Titratable Acidity of Fortified Soy-Chocolate Drinks

As expected, the titratable acidity (g lactic acid/ 100g sample) decreased as pH increased. The titratable acidity of NFPSCD and NFSSCD were 0.89 and 0.71 % lactic acid while FPSCD and FSSCD scored 0.81 and 0.62 % lactic acid. Lactic acid is used as an index of activity of certain bacteria like Streptococcus, Leuconostoc and Lactobacillus species. These microorganisms referred to as lactic acid bacteria (LAB) produce lactic acid in considerable amounts and are used in the manufacture of acid foods (FAO/WHO/UNU, 2002). TTA is essentially the total acid concentration in the food system. It is used as a parameter to measure acid's impact on texture, stability and food flavour (Ismail *et al.*, 2020).

Specific Gravity of Fortified Soy-Chocolate Drinks

The effect of treatment on the specific gravity of soy-chocolate drink is shown in Table 1. There was significant difference ($p<0.05$) among samples. Non-fortified sweetened (NFSSCD) soy-chocolate drink had the highest (1.78 mg/100g) score while fortified plain (FPSCD) had the least (1.68 mg/100g) score. The specific gravity of soy-chocolate drinks varied significantly ($p<0.05$) among samples. Specific gravity (SG) is the ratio of a substance's density to the density of water. It is an important indicator of texture, consistency and shelf life in various food products. The sweetened samples (NFSSCD and FSSCD) had the highest (1.07 and 1.06) values while the plain samples (NFPSCD and FPSCD) had the least (1.05 and 1.02) values. This could be due to the influence of sugar and cocoa powder concentration. These values are within recommended values for soymilk related beverages (Yasmine, 2019).

Energy Content of Fortified Soy-Chocolate Drinks

The energy content of soy-chocolate drinks was 79.03 kcal for non-fortified plain soy-chocolate drink (NFPSCD), 85.52 kcal for fortified plain soy-chocolate drink (FPSCD), 78.19 kcal for non-fortified sweetened soy-chocolate drink (NFSSCD) and 87.97 kcal for fortified sweetened soy-chocolate drinks (FSSCD). Energy values are a function of protein, fat and carbohydrate contents of formulated food products. The higher the values of these nutrients, the higher the energy values. The observed differences in the energy levels of the samples could be due to variation in protein, fat and carbohydrate content. The results showed variation between the non-fortified and the fortified samples. The energy values of aqueous drinks were within permissive values. The results obtained from this study are below that of (Yakum *et al.*, 2024) who reported higher energy values from fortified coconut milk supplemented with cocoa powder.

Table 1: Physicochemical Qualities of Soy-chocolate Drinks

Nutrients(mg/100g)	Products			
	NFPSCD	**FPSCD**	**NFSSCD**	**FSSCD**
pH	6.12 ^{d}± 0.04	6.42^{c}±0.02	6.63^{b}±0.02	6.86^{a}±0.01
TTA(% lactic acid)	0.89^{a}±0.01	0.81^{b}±0.02	0.71^{c}±0.03	0.62^{d}±0.10
Specific gravity	1.05^{b}±0.03	1.02^{c}±0.01	1.07^{a}±0.02	1.06^{a}±0.01
Energy (kcal/100g)	79.03^{d}±0.17	85.52^{c}±0.56	78.19^{e}±0.07	87.97^{a}±0.16

Results are means of ± s.d of triplicate expressed on wet weight bases. Means with common superscripts are not significantly (p>0.05) different within each column

Key: NFPSCD = non fortified plain soy-chocolate drink, FPSCD = fortified plain soy-chocolate drink, NFSSCD = non fortified 6 % sweetened soy-chocolate drink, FSSCD = fortified 6 % sweetened soy-chocolate drink.

Proximate Composition of Fortified Soy-Chocolate Drinks

The effect of sugar, cocoa powder and fortificants on the proximate composition of soy-chocolate drinks is shown in Table 2. The proximate compositions of non-fortified plain soy-chocolate drink(NFPSCD), fortified plain soy-chocolate drink (FPSCD), non-fortified sweetened soy-chocolate drink (NFSSCD) and fortified sweetened soy-chocolate drink (FSSCD) showed significant difference ($p<0.05$) among samples. The significant ($p<0.05$) variations in proximate compositions between the aqueous drinks could be due to the effects of sugar, cocoa powder and fortificants.

Moisture Content of Fortified Soy-chocolate Drinks

The result of the moisture content ranged from 77.71 % for vitamilk, 81.87 % FSSCD, 82.79 NFSSCD, 83.37% for FPSCD and 83.00 % for NFPSCD. All formulated samples showed significant differences except for FPSCD (82.37%) and NFSSCD (82.79%). The moisture content of the samples ranged from 77.71- 83.00 % for soy-chocolate drinks were higher than the value for 'vitamilk' (control). The non-fortified plain (NFPSCD) had high moisture (83.00 %) while vitamilk had low moisture content (77.71 %). This might be due to the influence of increased concentration of cocoa powder and sugar (solids) (FAO/WHO,1995). The moisture content of fortified samples (FPSCD and FSSCD) had less moisture (81.87- 82.37 %). The moisture content of all aqueous drinks reported in this study were within recommended moisture content of beverages (Dogan & Kayacier, 2019). Moisture is significant in sensory qualities like texture and mouthfeel, flavour profiling, stability and emulsification (Iwe, 2003).

Protein Content of Fortified Soy-chocolate Drinks

There was no significant difference for protein content of vitamilk (6.40%) and FPSCD (6.40 %) while the other samples NFSSCD (6.20%), FSSCD (6.90%), NFPSCD (6.25%) showed significant differences ($p<0.05$). These values were higher than the control (vitamilk) that scored 6.40 %. This is of great importance in reducing protein energy malnutrition (PEM) as a result of high cost of animal protein (WHO, 2021). Plant based protein sources are cheaper than animal-based protein therefore soy-chocolate drink could serve as cheap alternate source of protein. Protein is important for growth and tissue replacement (Muhimbula, 2011). The values obtained from this research are within daily recommended values for soy-chocolate drinks.

Fat Content of Fortified Soy-Chocolate Drinks

The fat content ranged from 3.31- 4.57 % with significant difference among all the samples. The FPSCD, vitamilk and FSSCD had the highest fat content of 4.44, 4.33 and 4.57 % while NFPSCD and NFSSCD had the least values of 3.31 and 3.39 % respectively. For the crude fat content, maximum mean value (4.57 %) was recorded in FSSCD while the minimum mean value was 3.31 % (NFSSCD). Statistical analysis showed that the crude fat content of aqueous drinks significantly ($p<0.05$) increased with fortification. This result agrees with the earlier report by (Yakum *et al.*, 2024) on physicochemical properties of fortified coconut milk-based chocolate-like drinks as influenced by cocoa powder and sugar levels. The relatively high fat content of the samples is due to the fact that soybean is an oil seed as well as fortification with retinol palmitate – an oil-based fortificant (Yakum *et al.*, 2022). Fat increases energy density and provides essential fatty acids needed in the body for proper neural development (Yakum *et al.*, 2022).

Ash Content of Fortified Soy-Chocolate Drinks

The ash content showed significant differences among all the samples ranging from 0.72 to 1.60 %. The ash content of samples increased with fortification from 0.72 % to 1.60 % which is within the recommended values. Ash content of a food material is used as an index of mineral constituents of food (NIH, 2022). There was significant difference (($p<0.05$) among all samples. Vitamilk had higher (1.60 %) ash content than the rest of the samples. This could be due to fortification of aqueous drink with macro-nutrients/minerals. The ash content obtained in this research was higher than that of (Ashaver *et al.* 2023) on fortified tigernut milk and moringa seeds based aqueous drinks. This can be attributed to supplementation with cocoa powder.

Crude Fibre Content of Fortified Soy-Chocolate Drinks
The crude fibre showed significant difference ($p<0.05$) among all the samples. Vitamilk (control) recorded the highest value (4.15 %) followed by NFSSCD (1.03 %) while FSSCD had the least value (0.89). The fibre contents of formulated aqueous drinks were within recommended value for beverages (Codex, 2021). NFPSCD and NFSSCD scores were 1.01and 1.03 % while FPSCD and FSSCD were 0.89 and 0.92 % respectively. Fibre is important for the regulation of bowel movement, prevents constipation and supports healthy gut bacteria. This observed low fibre in the research will enable children of school age to consume more of the drink and will give them an opportunity to meet their daily energy and other vital nutrient requirements. The values obtained in this study were higher than the crude fibre (0.02 – 0.06 %) of fortified chocolate-like drink from coconut milk and cocoa powder reported by (Yakum *et al.*, 2024). The crude fibre content of the non-fortified samples (NFPSCD and NFSSCD) was higher (1.01 and 1.03 %) than that of the fortified (FSSCD and FPSCD) samples (0.89- 0.93 %).

Carbohydrate Content of Fortified Soy-Chocolate Drinks
The carbohydrate content of the soy-chocolate drinks ranged from 4.81 to 5.90 g/100g. The carbohydrate values were NFPSCD (5.43%), FPSCD (4.99%), NFSSCD (5.90%), FSSCD (4.81%) and vitamilk (5.76%). The increase in carbohydrate content of samples could be attributed to the proportions of sugar and cocoa powder. The carbohydrate content of the non-fortified plain sample was higher (5.90 g/100g) than the fortified sweetened (4.81 g/100g) which was least among the treatment. This could be due to the separation, solubility and dilution in the concentration of starch molecules. Carbohydrates such as sugar and starch are of nutritional benefits because energy is required for daily activities. The values were lower (6.00-9.01 %) than that of tigernut milk and moringa seeds based aqueous drinks (Ashaver *et al.*, 2023).

Mineral Composition of Fortified Soy-Chocolate Drinks

Table 2: Proximate composition of soy-chocolate drinks

Nutrient(g/100g)	Products				
	NFPSCD	**FPSCD**	**NFSSCD**	**FSSCD**	**Vitamilk**
Moisture	$83.00^{a}\pm0.093$	$82.37^{b}\pm0.047$	$82.79^{b}\pm0.332$	$81.87^{c}\pm0.364$	$77.71^{d}\pm0.015$
Ash	$0.72^{c}\pm0.06$	$0.91^{c}\pm0.025$	$0.77^{d}\pm0.012$	$0.93^{b}\pm0.012$	$1.60^{a}\pm0.006$
Fat	$3.59^{d}\pm0.367$	$4.44^{b}\pm 0.131$	$3.31^{e}\pm0.021$	$4.57^{a}\pm0.015$	$4.33^{c}\pm0.021$
Fibre	$1.01^{c}\pm0.04$	$0.92^{d}\pm0.26$	$1.03^{b}\pm0.11$	$0.89^{e}\pm0.02$	$4.15^{a}\pm0.02$
Protein	$6.25^{c}\pm0.05$	$6.40^{b}\pm0.02$	$6.20^{d}\pm0.06$	$6.90^{a}\pm0.17$	$6.40^{b}\pm0.02$
CHO	$5.43^{c}\pm0.06$	$4.99^{d}\pm0.03$	$5.90^{a}\pm0.01$	$4.81^{e}\pm0.02$	$5.76^{b}\pm0.01$

Results are means of ± s.d of triplicate expressed on wet weight bases. Means with common superscripts are not significantly ($p>0.05$) different within each column
Key: NFPSCD = non fortified plain soy-chocolate drink, FPSCD = fortified plain soy-chocolate drink, NFSSCD = non fortified 6 % sweetened soy-chocolate drink, FSSCD = fortified 6 % sweetened soy-chocolate drink

Drinks
The result of the mineral composition of the aqueous drinks are shown in Table 3. There were variations in the mineral content of the samples with statistical analysis showing significant ($p<0.05$) differences among samples.

Calcium Content of Fortified Soy-Chocolate Drinks
The calcium content of soy-chocolate was relatively high, and values ranged from 92.43 to 94.36 mg/100g. NFPSCD scored 92.43 mg/100g, FPSCD had 94.36 mg/100g while NFSSCD 92.84mg/100g and FSSCD scored 94.05 mg/100g calcium content. The result showed that the fortified plain soy-chocolate drink (FPSCD) had the highest value while the non-fortified plain soy-chocolate drink (NFPSCD) had the least value as shown above. The observed high content of calcium in soy-chocolate drink might be due to supplementation with cocoa powder and fortification (Yakum *et al.*, 2024). Calcium is important for blood clotting, muscle contraction, healthy bones and teeth (Food and Nutrition Bulletin, 2020).

Sodium Content of Fortified Soy-Chocolate Drinks
Sodium content of soy-chocolate drinks increased significantly ($p<0.05$) with fortification and supplementation with cocoa powder. Values ranged from 80.16 to 83.26 mg/100g. The FPSCD recorded 83.26 mg/100g, NFSSCD had 80.06 mg/100g, NFPSCD 80.12 mg/100g and FSSCD mean score was 83.16 mg/100g. These values were below the required daily amount (RDA) of 100 mg/100g for young children and adults. There was a significant difference ($p<0.05$) among all the samples. Sodium controls blood pressure and volume regulations (FAO, 2002).

Magnesium Content of Fortified Soy-Chocolate Drinks
Magnesium content of soy-chocolate drinks increased with cocoa powder and fortification. The NFPSCD was the least (46.04 mg/100g), FPSCD had 47.12 mg/ 100g while NFSSCD had 46.12 mg/100g and FSSCD scored 47.11 mg/100g. These values were higher than those of Ashaver *et al.* (2023) who reported on fortified tigernut and moringa seed based aqueous drinks. These values

were below recommended daily allowance of 200- 400 mg per day. Magnesium is required for normal nerve and muscle function, immune system and for maintenance of blood glucose levels (Ismail *et al.*, 2020).

Phosphorus Content of Fortified Soy-Chocolate Drinks

The phosphorus content of soy-chocolate drink is presented in Table 3. The non-fortified plain soy-chocolate drink (NFPSCD) had 120.73 mg/ 100g, fortified plain soy-chocolate drink (FPSCD) had 123.73 mg/100g, non-fortified sweetened soy-chocolate drink (NFSSCD) had 120.62 mg/ 100g and fortified sweetened soy-chocolate drink (FSSCD) was 123.54mg/100g. There was no significant difference between the fortified samples and as well as the non-fortified samples. Fortification and Supplementation improved the phosphorus content of soy-chocolate drinks.

Phosphorus contents of soy-chocolate drinks were relatively high ranging from 120- 123 mg/ 100g with FSSCD having high values and NFSSCD having the least value. The values obtained in this study were higher than those obtained from fortified coconut milk-based chocolate-like drinks influenced by cocoa powder and sugar levels reported by (Ismail *et al.*, 2020). Phosphorus is an important nutrient that plays a significant role in the formation of adenosine triphosphate (ATP) in the body (Muhimbula *et al.*, 2011).

Potassium Content of Fortified Soy-Chocolate Drinks

Fortification, cocoa powder and sugar levels were seen to improve the potassium content of soy-chocolate drink. The fortified samples (FPSCD and FSSCD) had scores ranging from 329.52 to 327.84 mg/100g while the non-fortified samples (NFPSCD and NFSSCD) had the least values ranging from 307.61 to 306.43 mg/100g. There were variations in the mineral content of the samples with potassium content of fortified plain (FPSCD) being the most abundant (329 mg/100g) macro-mineral for formulated samples. These observations are similar to earlier findings by (Omary *et al.*, 2019) and (UNICEF, 2021) who reported potassium to be the most abundant mineral in Nigerian agricultural products.

Iron Content of Fortified Soy-Chocolate Drinks

The NFPSCD had significantly ($p<0.05$) the highest iron content (3.88 mg/100g) while FSSCD had the least (3.71 mg/100g) iron content. This might be due to the dilution effect of iron in aqueous solutions. The FPSCD had 3.73 mg/100g and NFSSCD was 3.82 mg/100g. Iron is a component of myoglobin, a protein that provides oxygen to muscles and supports metabolism in human (Muhimbula *et al.*, 2011). Regular consumption of foods rich in iron has the potential to prevent anaemia in infants and young children.

Zinc Content of Fortified Soy-Chocolate Drinks

The zinc content of the soy-chocolate drinks ranged from 2.01 to 2.69 mg/ 100g. Zinc supports normal growth and development during pregnancy, childhood and adolescence. The formulated soy-chocolate drinks had NFPSCD scored 2.69 mg/100g, FPSCD had 2.01 mg/100g, while NFSSCD scored 2.62 mg/100g and FSSCD scored 2.04 mg/100g. Plants have higher zinc content than animal sources and fortification improved the zinc content of soy-chocolate drinks (Yakum *et al.*, 2024).

Iodine Content of Fortified Soy-Chocolate Drinks

The iodine content of soy-chocolate drink ranged from 0.18 to 0.21mg/ 100g. The non-fortified samples (NFPSCD and NFSSCD) had higher (0.21 to 0.24 mg/ 100g) values than the fortified (FPSCD and FSCCD) samples having the least (0.18 to 0.18 mg/ 100g) respectively. Iodine is essential for thyroid function and can be used to enhance nutritional profile as well as support public health.

Vitamin Composition of Fortified Soy-Chocolate Drinks

Table 3: Mineral Composition of Soy-chocolate Drinks

Nutrients(mg/100g)	Products			
	NFPSCD	FPSCD	NFSSCD	FSSCD
Calcium	92.43 ^{d}± 0.02	94.36^{a}±0.03	92.84^{c}±0.03	94.05^{b}±0.01
Sodium	80.12^{c}±0.12	83.26^{a}±0.11	80.06^{d}±0.22	83.16^{b}±0.13
Magnesium	46.04^{c}±0.21	47.12^{a}±0.13	46.12^{b}±0.11	47.11^{a}±0.12
Phosphorus	120.73^{d}±2.2	123.37^{c}±1.15	120.62a±2.1	123.54^{b}±3.1
Potassium	307.61^{c}±2.5	329.52^{a}±1.5	306.43^{d}±2.2	327.84^{b}±3.5
Iron	3.88^{a}±0.02	3.73^{b}±0.02	3.82^{a}±0.01	3.71^{c}±0.02
Zinc	2.69^{a}±0.06	2.01^{c}±0.01	2.62^{b}±0.02	2.04^{c}±0.03
Iodine	0.21 ^{b}±0.02	0.18^{c} ±0.01	0.24^{a}±0.02	0.18^{c}±0.01

Results are means of ± s.d of triplicate expressed on wet weight bases. Means with common superscripts are not significantly ($p>0.05$) different within each column

Key: NFPSCD = non fortified plain soy-chocolate drink, FPSCD = fortified plain soy-chocolate drink, NFSSCD = non fortified 6 % sweetened soy-chocolate drink, FSSCD = fortified 6 % sweetened soy-chocolate drink

Pro- vitamin A, vitamin B1, B2, B3, B6, E and K contents of aqueous drinks are shown in Table 4. There was significant ($p<0.05$) difference among the samples.

Vitamin K content of Fortified Soy-Chocolate Drinks

Vitamin k (phylloquinone) content was high compared to the rest of the vitamins analyzed. The NFPSCD had a relatively higher (3.37 mg/100g) value, FPSCD (2.18 mg/100g), FSSCD (2.23 mg/100g) while FPSCD had the least value (2.18 mg/100g). There was significant ($P<0.05$) difference among the samples. Increase in the concentration of cocoa powder increases the vitamin k in soy-chocolate drinks. Required daily amount (RDA) of 120 mcg is recommended for adults. The results of this research have shown that soy-chocolate drinks can supply the amount of vitamin k required by the body. This result is higher than that of (FAO, 2010). Vitamin k is relatively unstable vitamin, especially when exposed to light, heat, moisture and oxidation. It is responsible for blood clotting and for healthy bones (Indrawati & Otgonbayar, 2017).

Vitamin B1(thiamin) Content of Fortified Soy-Chocolate Drinks

Vitamin B1 coenzymes are needed for energy metabolism and are important for nerve functions and normal vision (Ishiwu & Onyeji, 2019). It is a water-soluble vitamin, hence the values obtained from this research. NFPSCD has 0.27 mg/100g, FPSCD mean score was 0.20 mg/100g, NFSSCD had 0.35 mg/ 100g and FSSCD 0.22 mg/100g. Cocoa powder increased the vitamin B1 content of soy-chocolate drinks. It is needed in the body for the breakdown of carbohydrate to energy, muscle contraction and conduction of nerve signal.

Pyridoxine Content of Fortified Soy-Chocolate Drinks

Pyridoxine (B6) scores were low for soy-chocolate drinks. The non fortified samples NFPSCD and NFSSCD had 0.23 mg/ 100g and 0.23 mg/ 100g while FPSCD and FSSCD mean score were 0.21 mg/ 100g and 0.23 mg/100g respectively. Pyridoxine (B6) showed no significant difference ($p<0.05$) among samples except for FPSCD. Vitamin B6 is needed in the production of red blood cells as well as for brain function and development. It is also important for regulation of blood glucose and maintaining nerve function. Increase in concentration of cocoa powder increased the vitamin B6 content. The required daily amount of 0.1- 0.3 mg/ day for young children has shown that soy-chocolate drink is healthy for young children.

Vitamin B2 (Riboflavin) Content of Fortified Soy-Chocolate Drinks

Vitamin B2 metabolizes carbohydrate, fats and protein into glucose for energy. It is also an antioxidant for skin and hair. The NFPSCD had 0.72 mg/100g, FPSCD 0.58 mg/100g, NFSSCD value was 0.71 mg/100g and FSSCD had 0.61 mg/100g. The non-fortified formulated samples had the highest score compared to the fortified formulated samples. This could be as a result of the dilution effect on fortified samples.

Vitamin B3 (Niacin) Content of Fortified Soy-Chocolate Drinks

Vitamin B3 showed no significant ($p<0.05$) difference among samples. Its content ranged from 1.22 mg/100g (NFPSCD), 1.03 mg/100g (FPSCD), 1.18 mg/ 100g, and 1.07mg/100g (FSSCD). The non-fortified samples had higher vitamin B3 content than the fortified formulated samples. Niacin content was below the RDA for young children and adults (2 to 14 mg) (Ochanda *et al.*, 2020). Vitamin B3 produces stress related hormones in the adrenal gland and is involved in circulation.

Pro-vitamin A (Retinol Palmitate) Content of Fortified Soy-Chocolate Drinks

The provitamin A content of soy-chocolate drinks ranged from 0.14 mg/100g (NFPSCD), 1.63 mg/100g (FPSCD), 0.19 mg/100g (NFSSCD) to 1.66 mg/100g (FSSCD). Pro-vitamin A showed no significant difference ($p<0.05$) between NFPSCD and NFSSCD as well as FPSCD and FSSCD. Values obtained were lower than those of (Ashaver *et al.*, 2023) on fortified tigernut milk and moringa based aqueous drink. Pro-vitamin A is needed for reproduction, growth and development, acting as antioxidant and for healthy eye. Provitamin A is called retinol because it produces pigment in the retina of the eye. Responsible for healthy teeth, skeletal and soft tissues, mucus membranes and skin (Terhemba *et al.*, 2024).

Vitamin E (Tocopherol) Content of Fortified Soy-Chocolate Drinks

Vitamin E values ranged from 0.82 mg/100g to 0.92 mg/ 100g (FSSCD and NFPSCD) and 0.81mg/ 100g to 0.96 mg/100g (FPSCD and NFSSCD) respectively. Vitamin E is a powerful antioxidant required for healthy heart, skin, boost immune system, cancer prevention and brain function. Observable scores were below the RDA of 4 to 5 mg/100g for infants, 6 to 15 mg/100g for children and adults (Zilic *et al.*, 2017).

CONCLUSION

Table 4: Vitamin Composition of Soy-chocolate Drinks

Nutrients(mg/100g)	Products			
	NFPSCD	FPSCD	NFSSCD	FSSCD
Pro vitamin A	0.19^{b} ±0.02	1.66^{a} ± 0.01	0.14^{b} ±0.10	1.63^{a} ±0.01
B1	0.27^{b} ±0.06	0.20^{d} ±0.05	0.35^{a} ±0.01	0.22^{c} ±0.15

B2	0.72^{a} ±0.01	0.58^{c} ±0.01	0.71^{b} ±0.015	0.61^{c} ±0.01
B3	1.22^{a} ±0.01	1.03^{c} ±0.01	1.18^{b} ±0.01	1.07^{c} ±0.01
B6	0.23^{a} ±0.01	0.21^{b} ±0.01	0.23^{a} ±0.01	0.23^{a} ±0.02
E	0.92^{b} ±0.02	0.81^{c} ±0.01	0.96^{a} ±0.01	0.82^{c} ±0.02
K	3.37^{a} ±0.01	2.18^{a} ±0.02	3.36^{a} ±0.03	2.23^{c} ±0.01

Results are means of ± s.d of triplicate expressed on wet weight bases. Means with common superscripts are not significantly (p>0.05) different within each column.

Key: NFPSCD = non fortified plain soy-chocolate drink, FPSCD = fortified plain soy-chocolate drink, NFSSCD = non fortified 6 % sweetened soy-chocolate drink, FSSCD = fortified 6 % sweetened soy-chocolate drink

Soy-chocolate drink can be produced with the adaptation of fortificants (ferrous sulphate, potassium iodide and retinol palmitate) used in this research for addressing PEM and MND. Soy-chocolate drinks could serve as affordable nutritious beverage for vulnerable and malnourished groups.

Fortification, cocoa powder and sugar improved the physicochemical, minerals, proximate and vitamin qualities of soy-chocolate drinks therefore can be employed as vehicle for micronutrient's fortification programmes.

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