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Table of Content

Evaluation of antioxidant, nutritional and sensorial properties of novel functional beverage from milk-cocoa powder blends Helen Nwakego AYO-OMOGIE, Esther Emem NWANNA and Esosa Theresa EGUAVOEN	83
Nutritional quality of meals served under the Ghana school feeding programme at the Upper West and Central Region of Ghana Kate Bigson, Edward Ken Essuman, Vida Gyimah Boadu and Gifty Serwaa Otoo	92

Full Length Research Paper

Evaluation of antioxidant, nutritional and sensorial properties of novel functional beverage from milk-cocoa powder blends

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Increasing awareness of health benefits of plant-based food/drinks has resulted in increased preference of consumers for functional beverages as compared to conventional sugar-laden drinks/beverages which only quench thirst but provide little or no nutritional or health benefits. However, most commercially-available functional drinks/beverages are often expensive and not affordable for most people especially low-income earners in developing countries. This study aims to develop low-cost functional yoghurt from milk-cocoa powder blends so as to provide alternative to expensive commercially-available functional drinks and enhance direct consumption of bioactive-rich cocoa powder. Cocoa powder was used to partially replace milk in yoghurt at levels of 10-50%. Standard procedures were used to evaluate triplicate samples of yoghurts for proximate and mineral composition, vitamins, radical-scavenging abilities and phenolic content. Sensory attributes of the yoghurts were evaluated using trained and untrained panels. pH, acidity and brix ranged from 4.29-4.34, 0.67-0.88% and 12-13.5%, respectively. Cocoa powder inclusion significantly increased crude protein (33.7-38.89% DW), fat (0.07-0.14%), ash (0.71-1.01%), fibre (0.1-0.21%), Ca, Mg, K, Zn, Fe, vitamins A, B₁, B₂, B₃, C and E; while vitamin D reduced from 1.64 to 0.72-1.08 mg/L. Similarly phenolic and flavonoid contents, DPPH, FRAP and ABTS increased; values ranged from 0.03-0.16 mg/gGAE; 0.03-0.06 mg/gQUE, 40.12-72.72%, 0.43-1.17 mg/g and 22.49-26.09 mmol/ml, respectively. While the trained panel preferred 50:50 milk-cocoa yoghurt, untrained panel preferred 90:10 milk-cocoa yoghurt, indicating both panels' preference for milk-cocoa yoghurts as compared to the plain yoghurt. Organoleptically acceptable, nutritionally-rich, low-cost functional yoghurt high in bioactive compounds can be developed from milk and cocoa powder. Its production requires no sophisticated machines since yoghurt is already being produced by both rural and urban dwellers/processors in Nigeria. This milk-cocoa yoghurt provides a cheaper alternative not only packed with bioactive compounds from cocoa powder but also high in protein and micro and macronutrients.

Key words: Antioxidant, cocoa, fermented milks, functional foods, Nigeria, radical-scavenging activity, trained panel, yoghurt.

INTRODUCTION

Globally, the increasing demand for foods that provide much more than nutrition but also promote health and

well-being has resulted in astronomical growth of functional foods and preventative/protective foods with

associated health claims in the global market (Mollet and Lacroix, 2007). Diet has been reported to play significant roles in 5 of the ten leading causes of death worldwide and there are established evidences pointing to the protective effects of plant-based diets on degenerative diseases such as cardiovascular disease (CVD) and cancer. This is because bioactive compounds from legumes, cereals, grains, fruits and vegetables are effective in reducing lipid and cholesterol levels, increasing bone mineral density and antioxidant status and possess anticancer properties (Eskin and Tamir, 2006). Hence, new functional food products have been made through fortification or addition of desirable nutrients and bioactives that include vitamins, minerals, antioxidants, omega-3 fatty acids, plant extracts, prebiotics and probiotics, and fibre enrichments, many of which are derived from plants (Smith and Charter, 2010). Coincidentally, many plant products that possess important bioactive compounds with protective roles against oxidative stress that can lead to neuro-degenerative and cardiovascular diseases in humans are still grossly underutilized in areas where they are abundant. Most times, this may be due to possession of objectionable sensorial properties of the plants and their products.

Cocoa powder is one of such plant products that has not enjoyed wide consumer acceptance in Nigeria due to its bitter aftertaste and astringency. It has however, recently received global attention as a functional food product/ingredient in the food and confection industry for numerous applications (Borchers et al., 2000). Cocoa powder has been reported to confer health-promoting benefits including promotion of cardiovascular health, reduction of low density lipoprotein (LDL) cholesterol and oxidation of LDL to prevent atherosclerosis or plaque formation. It also elevates high density lipoprotein (HDL) cholesterol, suppresses decay-causing bacteria and plaque formation; acts as an anti-depressant, has euphoric and stimulant effects and general improvement in health and well-being of elderly men (Taubert et al., 2007; Corti et al., 2009). This is owing to its rich content of natural antioxidants, having been reported to exhibit greater antioxidant capacity than many other flavanol-rich foods and food extracts including red wine, blueberry, garlic, strawberry and green and black tea (Lee et al., 2003). Reported numbers of antioxidants in cocoa and its products (621) triple those in green tea, double those in red wine and are far higher than those in blueberries which are known to be a great source of antioxidants (Cooper et al., 2008; Miller et al., 2008). Nutritionally, cocoa powder is a rich source of protein (22%), contain useful amounts of vitamin A, riboflavin and nicotinic acid, several minerals including iron, calcium, copper,

magnesium, phosphorus, potassium, sodium and zinc (Steinberg et al., 2003). Thus, it may serve the dual purpose of enriching food with vital nutrients and health-promoting bioactive compounds.

Although cocoa production is predominated by countries in the tropical region (West Africa being a major producer with its production alone accounting for approximately 70% of global production), consumption is mostly by countries in temperate regions of the world (Cadoni, 2013). Cocoa is abundant in Nigeria being the world's fourth largest producer after Ivory Coast, Indonesia and Ghana and the third largest exporter after Ivory Coast and Ghana. Unfortunately, most of the cocoa produced in Nigeria is exported to meet the increasing demand in the international market, while very little quantity is used locally for manufacturing of cocoa-based foods, drinks and confections (Cadoni, 2013; Verter and Bečvářová, 2014; Adelodun, 2017). Despite cocoa powder's nutritional and health benefits and abundance in Nigeria, its direct consumption is still very low. This poor acceptance and low consumption have been linked to its bitter aftertaste and astringency. However, for any functional food to benefit the target population group they must be consumed in consumable forms as part of the usual daily diet. Also, consumers expect such foods to have good organoleptic qualities and to be of similar qualities to the traditional foods (Kwak and Jukes, 2001). Hence, to encourage wider direct consumption of cocoa powder so as to harness its nutritional and health benefits, it may be necessary to use it as a functional ingredient in the development of food products which have the ability to mask the bitter aftertaste and astringency. Also, the food must be one that is commonly and frequently consumed.

Beverages are an important group of easily-digestible, commonly-consumed food taken majorly to quench thirst; although some provide nutritional benefits to the consumers. In particular, the functional beverages are used for the delivery of bioactive compounds that impact positively on the health of consumers. Among these is yoghurt, a lactic acid-fermented milk product made using the starters *Streptococcus thermophilus* and *Lactobacillus delbrueckii* spp. *bulgaricus* (FDA, 1998). It is an important, easily-digested fermented milk product popular for its probiotic effect and is one of the foods commonly used for the delivery of bioactives including vitamins, minerals, probiotics, fibre, etc. Yoghurt and other fermented milks are currently the most sought-after functional food products and their consumption worldwide has greatly increased over the past several decades with the most dramatic increase occurring during the 1980s and 1990s (Dannon, 2002). Nigeria is not an exception; yoghurt production and consumption have steadily

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Table 1. Ratios of supplementation of milk powder with cocoa powder and recipe for yoghurt production.

Milk sample	Skimmed milk powder (g)	Alkalised cocoa powder (g)	Sugar (g) ^a	Gelatine (g) ^a	Starter culture (g) ^a
1	160 (control)	-	40	1	0.38
2	144	16 (90:10)*	40	1	0.38
3	128	32 (80:20)	40	1	0.38
4	112	48 (70:30)	40	1	0.38
5	96	64 (60:40)	40	1	0.38
6	80	80 (50:50)	40	1	0.38

*Ratios of skimmed milk to alkalized cocoa powder in parenthesis.

^aSource: Collins et al. (1991).

increased even at the local level, making it an important dairy product that is enjoyed by all (Akinnubi, 1998).

Yoghurt is widely known for its probiotic effect on gastrointestinal tract resulting from activities of the fermenting or additional probiotic microbiota. However, the significant increase in research on bioactive compounds and development of new materials, processes, ingredients and products that can contribute to the development of functional foods (Sanguansari and Augustin, 2010), may have significantly imparted on development of new yoghurt variants in the market. As such, besides meeting the need for desirable sensory and aesthetic properties, fermented milks including yoghurt are supplemented with ingredients that are rich in bioactive compounds. These ingredients possess strong antioxidant capacity, which results mainly from high content of polyphenolic compounds and antioxidant vitamins (C, E, carotenoids). Examples include caffeine, guarana, green tea extract, Q10 coenzyme, ginseng, aloe vera, cranberry, dietary fibre, omega-3 fatty acids, phytosterols and phytosterols as well as prebiotic oligosaccharides (Cossu et al., 2009; Stankiewicz, 2009). Since cocoa powder has been reported as one of the plant products that exhibit the highest antioxidant capacity, incorporating it into yoghurt may enhance its direct consumption and also promote the health of yoghurt consumers in Nigeria. Also, supplementation of milk with cocoa powder for yoghurt production will bring about a new yoghurt variant packed with bioactive compounds with enhanced functionality. This beverage will be a cheaper, affordable functional beverage as compared to the expensive commercially available functional drinks.

Although the use of cocoa powder and chocolate in the supplementation of milk for production of yoghurt has been previously reported (Jayeola et al., 2010; Essia-Ngang et al., 2014), these previous studies only provided information on the physicochemical and sensory properties. Information is however lacking on the antioxidant capacity of yoghurt supplemented with cocoa powder from Nigeria. This is vital to give stronger impetus to the commercialization and consumption of this yoghurt variant. This study has investigated the effect of co-fermenting milk with cocoa powder on the nutritional

composition, antioxidative capacity and consumer acceptability of yoghurt. This present study has provided a more objective sensory evaluation by comparing evaluations from both trained and untrained panels.

MATERIALS AND METHODS

Cocoa powders (both natural and alkalized) were obtained from OLAM Nigeria Limited, Akure, Nigeria. Skimmed powder milk, sugar, and other ingredients were purchased locally from Akure main market, Ondo State, Nigeria, while yoghurt starter culture (Yoghuret - a product of Lyo-San Inc., 500, Aeroparc, C.P 598, Lachute, Quebec, Canada) containing *Lactobacillus bulgaricus* and *Streptococcus thermophilus* was purchased from a commercial dealer in Lagos, Nigeria. A preliminary study to ascertain consumers' preference for the powders in the yoghurt was carried out and actual studies were thereafter done using the alkalized powder since preference for yoghurts made with the alkalized powder was higher, probably due to the astringent flavour of the natural powder which is usually reduced during alkalization process. Alkalization also reduces bitterness and improves solubility and these factors are important for beverage product applications (Miller et al., 2008).

Supplementation of milk with cocoa powder and production of yoghurt

Skimmed milk was supplemented with alkalized cocoa powder at graded levels of 10-50%. Recipe for yogurt production was adopted from Collins et al. (1991) as shown in Table 1, while yoghurt was produced by the method of Bille et al. (2004). Briefly, distilled sterile water (1 L) was boiled, cooled to 40°C and used to mix the ingredients (milk, cocoa powder-milk mixes and sugar) in sterile containers. This was done aseptically to avoid contamination and using clean, sterile materials and utensils. Each milk mix was thereafter heated by raising the temperature to about 50°C for 10 min to dissolve uniformly and filtered by passing through a 75 micro sieve into clean, oven-dried 1 L beakers. The filtered milk mix was homogenized using a blender for 15 min during which 1 g of gelatin was added to each beaker. The beakers were covered with foil paper lid to avoid heat escape and pasteurized at 78 ±2°C (monitored using a digital thermometer) for 30 min with constant stirring to avoid coagulation or sticking to the base. After pasteurization, the samples were cooled to 43-45°C (and monitored to avoid temperatures below 43°C which is the optimal temperature for yoghurt starter culture) using a cooling bath at a set temperature of 40°C. The pasteurized samples were aseptically inoculated with 0.38 g freeze-dried yoghurt starter culture and stirred with a sterile stainless steel spoon. The beakers were incubated at a set

temperature of 45°C. pH of the incubated samples was monitored until it reached 4.2-4.5 after which incubation was stopped. This process took between 5-7 h, depending on the ratio of cocoa powder to milk in each beaker. The yoghurts were aseptically filled into clean sterile plastic bottles (in a sterile environment to avoid cross and post-processing contamination) and labeled appropriately. The bottles were immediately placed in freezers of about 5–7 °C to terminate the fermentation process.

Determination of some physical properties and chemical composition of milk-cocoa powder yoghurt

pH

Triplicate determination of pH was done by the potentiometric method using Jenway pH meter (Model 3505, serial number 03132, Barloworld Scientific Ltd, Dunmow Essex UK). The meter was first calibrated with buffer solutions of pH 4 and 7 and the probe was thereafter placed and the values read digitally.

Titrateable acidity

This was determined by titrating the samples against 0.1N NaOH.

Viscosity

Viscosity was measured using RION viscotester (Model VT04F009, serial number 84311991, manufactured by RION Co, Ltd, China) which measures in deca Pascal (dpa^{-s}). The experiment was carried out according to manufacturer's instruction. Results were read when the values on the digital readout became stable.

Refractive index

This was measured using a refractometer (serial number N-3000, ATAGO, Japan) whose prisms were cleaned with ethanol before being used. The refractometer temperature was maintained at 20°C during the measurement.

Proximate composition of the yoghurts

This was determined using standard AOAC (1990) methods. Crude protein content was determined by the micro Kjeldahl nitrogen method and a conversion factor of 6.25 was used to convert the nitrogen content to protein. Carbohydrate content was estimated by difference (100 – [moisture + total ash + crude fat + crude fiber + protein]).

Mineral element composition

This was determined by official methods described by AOAC (2002) using atomic absorption spectrophotometer for calcium, magnesium, iron, manganese, copper and zinc; while sodium and potassium were determined using the flame photometer.

Determination of vitamin contents

Vitamins A, D and E were determined using methods described by Pearson (1976), while vitamins B₁, B₂ and B₃ were determined by Okwu and Josiah (2006) methods and vitamin C using methods described by Benderitter et al. (1998).

Determination of anti-oxidant potentials and free radical scavenging activity

DPPH free radical scavenging ability

DPPH free radical-scavenging ability of the yoghurt samples was measured using the method of Gyamfi et al. (1999). An aliquot of 2 mL of each sample was mixed with 2 ml of 0.1 mM methanolic DPPH solution and vortexed for 1 min and incubated in the dark at room temperature for 30 min. Absorbance was measured at 517 nm on a JENWAY UV–Visible spectrophotometer (JENWAY Inc.). Radical scavenging abilities of the beverages were calculated with reference to the control which contains all the reagents with exception of the test sample. The percentage DPPH inhibition was calculated with the following equation:

$$\text{DPPH radical scavenging ability (\%)} = \frac{\text{Abs}_{\text{Control}} - \text{Abs}_{\text{Sample}}}{\text{Abs}_{\text{Control}}} \times 100 \quad (1)$$

ABTS scavenging activity

The ABTS scavenging activity of the extract was determined according to the method described by Re et al. (1999). The ABTS was generated by reacting an ABTS aqueous solution with K₂S₂O₈ (2.45 M/l final conc.) in the dark for 16 h and adjusting the absorbance at 734 nm to 0.700 with ethanol. 0.2 ml of the appropriate dilution of the extract was then added to 2.0ml of ABTS solution and the absorbance was read at 732 nm after 15 min. The TROLOX equivalent antioxidant capacity was subsequently calculated (264.32 g).

Total phenolic content (TPC)

TPC of the samples was determined using Singleton et al. (1999) methods with slight modification with gallic acid as standard. Yoghurt samples were diluted appropriately with water and 0.25 ml was oxidized with 2.5 ml of 10% Folin–Ciocalteu's reagent (v/v). The reaction was allowed to proceed for 5 min at room temperature and neutralized using 2 ml of 7.5% sodium bicarbonate (Na₂CO₃). Thereafter, the mixture was incubated in the dark for 40 min at 37°C and the absorbance measured at 750 nm in a JENWAY UV–Visible spectrophotometer. Total phenolic content of the beverages was subsequently calculated from the standard curve of absorbance of gallic acid and reported as gallic acid equivalent per millilitre.

Flavonoid content

Flavonoid content was determined using the aluminum chloride colorimetric assay of Meda et al. (2005) with slight modifications. Briefly, 0.5 ml of the diluted sample was added to 0.5 ml methanol, 10% AlCl₃ (50 µl), 1 M potassium acetate (50 µl) and water to a total volume of 2.5 ml and incubated for 40 min at room temperature. Absorbance was measured at 415 nm. Total flavonoid content was determined using standard plot with rutin (0-50 mg/L) and expressed as milligram rutin equivalent per millilitre of the beverage.

Ferric reducing antioxidant property (FRAP)

The ferric reducing antioxidant property of the beverages was determined using the method of Pulido et al. (2003). Sample quantity of 2.5 ml was mixed with equal volumes of 0.2 M

Table 2. Physical properties of yoghurt as affected by cocoa powder supplementation.

Milk:cocoa powder (%)	Viscosity (dpa ^{-s})	Brix (% at 20°C)	pH	TTA(% lactic acid)
90:10	0.33±0.00 ^b	13.50±0.70 ^a	4.30±0.03 ^a	0.88±0.01 ^a
80:20	0.31±0.01 ^c	13.50±0.70 ^a	4.34±0.03 ^a	0.87±0.00 ^a
70:30	0.29±0.00 ^d	13.00±0.00 ^a	4.32±0.03 ^a	0.86±0.01 ^{ab}
60:40	0.28±0.00 ^d	12.50±0.00 ^{ab}	4.29±0.03 ^a	0.78±0.16 ^{abc}
50:50	0.28±0.00 ^d	12.00±0.00 ^b	4.30±0.03 ^a	0.86±0.16 ^{ab}
100:0	0.35±0.00 ^a	12.00±0.00 ^c	4.30±0.03 ^a	0.67±0.28 ^{abcd}

Each value is a mean ± standard deviation, n = 3; values in the same column with different letter(s) are significantly different at p≤0.05.

phosphate buffer (pH 6.6) and 1% potassium ferricyanide [K₃Fe(CN)₆] and incubated for 20 min at 50°C. Thereafter, 2.5 ml of freshly prepared 10% trichloroacetic acid was added and centrifuged at 600 rpm for 10 min. The supernatant (5 ml) was mixed with equal volume of distilled water and 1 ml of 0.1% FeCl₃. Absorbance was immediately read at 700 nm using a UV-visible spectrophotometer, with ascorbic acid used as standard and the ferric reducing power was determined as ascorbic acid equivalent per milliliter of the sample extract.

Sensory evaluation of yoghurt samples

Sensory evaluation of the yoghurts was done using two sets of 15 panelists each; the first set of untrained panelists was selected from among students and staff of the Department of Food Science and Technology, Federal University of Technology, Akure, Nigeria who are familiar with yoghurt. The second set of trained panelists was made up of assessors of OLAM Nigeria Ltd trained by Nestle Nigeria Plc sensory team who are part of the sensory evaluation team of OLAM. They were trained through the assessment of different cocoa beverages, where they made use of their perception to touch, taste and aroma over a period of 2-4 weeks. The complex sensations that result from interaction of their taste are used to measure the food quality and their ability to taste. The training procedure used involved the following:

- (i) Panelists must be objective, precise and reproduce judgment.
- (ii) Panelists must refrain from smoking, chewing gum, eating or drinking for at least 30 minutes before testing.
- (iii) In selection and screening, pure chemicals were used; e.g. for sweetness (pure sucrose), for saltiness (pure NaCl), for bitterness (quinine or caffeine) and for acidity (tartaric acid).
- (iv) Panelists must have inherent sensitivity to the characteristic being tested and be able to replicate judgment.

The samples were strictly prepared using the same parameters and under the same conditions, except for differences in the blend ratios of milk-cocoa powder. Thereafter, they were labeled differently using 3-digit random numbers and presented to the panelists with a sachet of clean water for palate cleansing between tasting periods. The trained and untrained sessions were conducted in 2 different days in a well-lit room with two replicates per session. A 9-point hedonic scale where 9 represented extremely like and 1 extremely dislike was used to measure attributes including colour (appearance), aroma, mouth feel/texture, taste and overall acceptability of the yoghurts (Larmond, 1977).

Statistical analysis of data

Triplicate data obtained were subjected to Analysis of Variance

(ANOVA) using SSPS version 17.0. Means were separated between the different levels of yoghurt supplemented with cocoa powder by Duncan's Multiple Range Test.

RESULTS AND DISCUSSION

Physicochemical properties of cocoa powder-supplemented yoghurt

Physical properties of the yoghurt as influenced by cocoa powder supplementation are presented in Table 2. pH ranged from 4.29-4.34 showing no significant difference ($p \leq 0.05$). This may indicate that cocoa powder inclusion did not inhibit growth or fermentative ability (to ferment milk sugar, lactose to produce acid) of the fermenting microorganisms. Invariably, cocoa powder may also not hinder probiotic culture potential of yoghurt. This is very important from the standpoint of using yoghurt as a food carrier for probiotics since it is expected that viability of probiotics should be retained during and after processing of food in order to exert their health benefits within the consumer's body. Furthermore, the values obtained in this study are in agreement with those reported by Jayeola et al. (2010). Total titratable acidity (TTA) ranged from 0.67-0.88%, plain yoghurt had the lowest value of 0.67%, while 90:10 milk-cocoa yoghurt had the highest (0.88%). Hence, these yoghurts may be classified as good quality yoghurts since values reported here compare favourably with pH 4.18-4.38 and TTA 0.5-0.87% recommended for good quality yoghurts (Lee and Lucey, 2003).

Viscosity reduced with cocoa powder addition; while plain yoghurt had the highest value (0.35 dpa^{-s}), 60:40 and 50:50 milk-cocoa yoghurts were the lowest (0.28 dpa^{-s}). Casein and whey proteins (alpha lactalbumin and beta lactoglobulins) influence hydrophilic properties and hydration of casein micelle, causing precipitation at pH below 4.6 during fermentation of milk and resulting in thickening and increased viscosity of the product (Lucey et al., 1998). However, reduction observed in this study may be due to dilution resulting from cocoa powder supplementation. A similar reduction was reported by Essia-Ngang et al. (2014). On the other hand, brix increased from 12% in plain milk yoghurt to a range of

Table 3. Proximate chemical composition of yoghurt as affected by cocoa powder supplementation.

Milk:cocoa powder (%)	Moisture content (%)	Crude protein (%)	Crude fat (%)	Total Ash (%)	Crude fibre (%)	Carbohydrate (%)
90:10	83.70±0.78 ^b	6.24 ^d *(38.28 ^b)	0.11 ^d (0.68 ^e)	0.74 ^d (4.54 ^f)	0.10 ^d (0.61 ^d)	9.11 ^e (55.89 ^b)
80:20	83.51±0.04 ^{ab}	6.41 ^c (38.89 ^a)	0.12 ^{cd} (0.73 ^d)	0.87 ^c (5.27 ^e)	0.11 ^c (0.67 ^c)	8.98 ^d (54.42 ^d)
70:30	82.71±0.02 ^{bc}	6.56 ^{bc} (37.92 ^c)	0.14 ^c (0.81 ^c)	0.98 ^b (5.67 ^a)	0.20 ^b (1.16 ^a)	9.41 ^c (54.39 ^e)
60:40	82.42±0.00 ^c	6.66 ^b (37.88 ^d)	0.20 ^b (1.14 ^b)	0.98 ^b (5.58 ^c)	0.21 ^{ab} (1.20 ^b)	9.53 ^b (54.21 ^f)
50:50	82.01±0.00 ^c	6.73 ^a (37.41 ^e)	0.24 ^a (1.33 ^a)	1.01 ^a (5.61 ^b)	0.21 ^a (1.17 ^a)	9.80 ^a (54.48 ^c)
100:0	87.15±0.15 ^a	4.33 ^e (33.70 ^f)	0.07 ^e (0.55 ^f)	0.71 ^e (5.53 ^d)	0.00 ^e (0.00 ^e)	7.74 ^f (60.23 ^a)

Each value is a mean ± standard deviation, n = 3; values in the same column with different letter(s) are significantly different at p≤0.05. *Values in parenthesis are percentage dry matter content.

Table 4. Mineral element composition (mg/l) and vitamin contents (mg/l) of milk-cocoa yoghurt supplemented with cocoa powder.

Parameter	Milk:cocoa powder (%)					
	90:10	80:20	70:30	60:40	50:50	100:0
Ca	50.21±0.01 ^e	52.51±0.01 ^d	100.01±0.01 ^c	101.01±0.01 ^b	110.21±0.01 ^a	39.81±0.01 ^f
Mg	64.07±0.01 ^e	90.10±0.01 ^d	91.69±0.01 ^c	96.83±0.01 ^b	164.71±0.01 ^a	28.63±0.01 ^f
K	81.53±0.04 ^e	91.81±0.01 ^d	408.05±0.07 ^c	521.06±0.08 ^b	711.65±0.07 ^a	40.61±0.02 ^f
Na	22.05±0.07 ^e	22.81±0.01 ^d	54.11±0.01 ^c	112.05±0.07 ^b	120.70±0.00 ^a	17.35±0.07 ^f
P	110.20±0.01 ^e	110.40±0.01 ^d	110.53±0.01 ^c	120.32±0.00 ^b	120.69±0.01 ^a	100.43±0.00 ^f
Zn	5.38±0.00 ^d	8.03±0.21 ^c	8.05±0.02 ^c	8.32±0.01 ^b	17.58±0.00 ^a	1.04±0.01 ^e
Fe	1.47±0.00 ^e	1.90±0.01 ^d	2.85±0.01 ^c	2.97±0.01 ^b	3.42±0.00 ^a	0.08±0.01 ^f
Cu	0.03±0.00 ^b	0.03±0.00 ^b	0.03±0.00 ^b	0.04±0.00 ^b	0.04±0.01 ^{ab}	0.02±0.00 ^c
Vit. A	402.92±0.22 ^e	533.79±0.84 ^d	641.78±1.74 ^c	719.45±0.00 ^b	925.31±0.00 ^a	355.28±1.09 ^f
Vit. B1	0.26±0.003 ^e	0.64±0.002 ^b	0.33±0.004 ^d	0.35±0.00 ^c	0.83±0.00 ^a	0.15±0.002 ^f
Vit. B2	0.27±0.003 ^e	0.53±0.003 ^b	0.33±0.003 ^d	0.38±0.002 ^c	0.72±0.00 ^a	0.18±0.00 ^f
Vit. B3	0.36±0.004 ^e	0.59±0.002 ^b	0.44±0.001 ^d	0.51±0.001 ^c	0.83±0.004 ^a	0.09±0.007 ^f
Vit. C (unit/ml)	0.29±0.00 ^e	0.91±0.01 ^d	1.04±0.01 ^c	1.47±0.00 ^b	2.11±0.02 ^a	0.00±0.00 ^f
Vit. D	1.08±0.03 ^b	0.97±0.00 ^c	0.86±0.02 ^d	0.78±0.00 ^e	0.72±0.00 ^f	1.64±0.01 ^a
Vit. E	0.18±0.01 ^e	0.24±0.01 ^c	0.26±0.01 ^c	0.30±0.00 ^b	0.32±0.01 ^a	0.02±0.00 ^f

Each value is a mean ± standard deviation, n = 3; values in the same row with different letter(s) are significantly different at p≤0.05.

12.5-13.5% as a result of addition of 10-40% cocoa powder, while 50% cocoa addition had no significant effect.

Proximate and mineral element composition of cocoa powder-supplemented yoghurt

Table 3 shows significantly reduced moisture content on cocoa powder addition from 87.15% in the plain yoghurt to 82.01% in 50:50 milk-cocoa yoghurt. This is expected since cocoa powder is a dry product with moisture content of 3-5% (Borchers et al. 2000) and may aid in concentration of other nutrients, give the milk-cocoa yoghurts added body and a storage advantage. Consequently, there was significant increase in crude protein (ranging from 33.7-38.89% DW), crude fat (0.07-0.14%), total ash (0.71-1.01%), crude fibre and carbohydrate contents as cocoa powder supplementation

increased. Increase in crude protein may be attributed to inclusion of cocoa powder which has high protein content of 22.5 g. This may be advantageous in reducing protein energy malnutrition prevalent in developing countries like Nigeria. The consistent increase in crude fibre content due to cocoa powder addition may have health benefits for consumers of this yoghurt since plain yoghurt normally lacks crude fibre. Consumption of fibre-rich foods have been reported to impart positive benefits on health by increasing the volume of faecal bulk, thereby decreasing the time of intestinal transit, reducing cholesterol, glycemic levels and trapping mutagenic and carcinogenic agents (Beecher, 1999).

Results in Table 4 present the trend for mineral elements in the following descending order: K>P>Mg>Ca>Na>Zn>Fe>Cu. Potassium was the most abundant which may be due to inclusion of cocoa powder, being reported as most abundant mineral

Table 5. Antioxidant properties of yoghurt supplemented with cocoa powder.

Milk:cocoa powder (%)	Total Phenol (mg/gGAE)	Total Flavonoid (mg/gQUE)	DPPH (%)	FRAP (mg/g)	ABTS (mmol/ml)
90:10	0.07±0.00 ^c	0.03±0.00 ^d	62.85±4.12 ^d	0.66±0.01 ^e	25.60±0.33 ^b
80:20	0.12±0.00 ^b	0.03±0.00 ^d	62.88±0.05 ^d	0.88±0.00 ^d	25.35±0.11 ^{bc}
70:30	0.16±0.00 ^a	0.04±0.00 ^c	70.48±0.00 ^c	0.92±0.00 ^c	23.95±0.55 ^d
60:40	0.16±0.00 ^a	0.05±0.00 ^b	71.84±0.01 ^b	1.08±0.00 ^b	23.22±0.15 ^e
50:50	0.16±0.00 ^a	0.06±0.01 ^{ab}	72.72±0.11 ^a	1.17±0.00 ^a	26.09±0.02 ^a
100:0	0.03±0.00 ^d	0.03±0.00 ^d	40.12±0.61 ^e	0.43±0.00 ^f	22.49±0.13 ^f

Each value is a mean ± standard deviation, n = 3; values in the same column with different letter(s) are significantly different at p≤0.05.

element in cocoa powder which is generally rich in minerals (Steinberg et al., 2003). Except for Cu, there was a consistent increase in mineral contents as cocoa powder addition increased. Specifically, nutritionally important mineral elements such as Ca, Mg, K, P and Fe were significantly increased. High calcium content in the samples may be particularly beneficial to young children in preventing rickets, and brittle and weak bones in adults by contributing significantly to strengthening of bones. Pointillart et al. (1986) reported that calcium from yoghurt may lead to greater bone mineralization in animals than calcium from non-fermented dairy products. Furthermore, the significant increase in iron (from 0.08 mg/l to a range of 1.47-3.42 mg/L) may make milk-cocoa yoghurts healthier and more nutritious than the conventional plain milk yoghurt. Similarly, there was consistent increase in most of the vitamins, although there were inconsistent trends in B vitamins (Table 4). Values ranged from 0.15-0.83mg/l (B₁); 0.18-0.72 mg/L (B₂); 0.09-0.83 mg/L (B₃); 355.28-925.31 mg/L (A); 0.00-2.11 unit/ml (C); 0.72-1.64 mg/L (D); and 0.02-0.32 mg/L (E). Vitamin A was the most abundant while vitamin D decreased. This reduction in vitamin D may be due to dilution since milk is a rich source of vitamin D. On the other hand, increase in vitamins C and E is an indication of higher antioxidative potential of the yoghurt since these vitamins are antioxidant nutrients. Thus consumption of these yoghurts may further aid in safeguarding cells from damage by free radicals, among other benefits of antioxidants (Padayatti et al., 2003).

Antioxidative potential of milk-cocoa powder yoghurts

Results presented in Table 5 showed that total phenolic content (ranging from 0.03-0.16mg/gGAE), flavonoids (0.03-0.06 mgQUE/g), FRAP (0.43-1.17 mg/g), DPPH (40.12-72.72%) and ABTS (22.49-26.09 mmol/ml) increased significantly (p< 0.05) with increase in cocoa powder addition. Thus, yoghurt sample with 50% cocoa powder had the highest antioxidative and free radical-scavenging ability. Although yoghurt has been reported to possess large antioxidant capacity resulting from the

presence of different bioactive peptides from milk proteins through proteolysis by LAB (Kudoh et al., 2001), significant increase observed here may be due to the rich antioxidant content of cocoa which has been reported to exhibit greater antioxidant capacity than many other flavanol-rich foods (Lee et al., 2003; Cooper et al., 2008; Steinberg et al., 2003). Since cocoa products have been previously associated with reduction of risk to cardiovascular diseases and blood glucose levels due to its antioxidant capacity (Cooper et al., 2008), consumption of this cocoa powder-supplemented yoghurt may be beneficial in reducing risk to cardiovascular diseases and blood glucose levels. Also, the increase in flavonoid content may be advantageous in improving brain blood flow and impacting cognitive behaviour, thereby offering potential for debilitating brain conditions including dementia and stroke. Flavonoids may also cause modulation and prevent oxidation and increase in LDL which could put a subject at a higher risk of coronary heart disease (Sorond et al., 2008; Osakebe et al., 2001).

Sensory attributes of yoghurt supplemented with cocoa powder

There were significant variations between the evaluations of the untrained (15) and trained (15) panels for the sensory attributes of the yoghurts (Table 6). While the untrained panel scored plain yoghurt highest (8.20) and 50:50 milk-cocoa yoghurt lowest (5.80) for colour/appearance, the trained panel scored yoghurts with 10 and 30% cocoa powder least (6.80) and 50:50 milk-cocoa yoghurt highest (8.20) (Table 6). The preference of the trained panel for colour/appearance of the milk-cocoa yoghurts as compared to plain yoghurt is understandable since they have been trained using cocoa-based products. This may explain why the trained panelists seemed to score yoghurts containing larger amounts of cocoa powder higher than those with less cocoa powder or none at all. This was the trend for all parameters evaluated, except for mouth feel, where the trained panelists scored 90:10 milk-cocoa yoghurt highest, while 80:20 milk-cocoa yoghurt was scored lowest. However, for overall acceptability, the trained

Table 6. Sensory attributes of yoghurt supplemented with cocoa powder as evaluated by untrained and trained panelists.

Milk:cocoa powder (%)	Colour	Taste	Aroma	Mouthfeel	Overall Acceptability
90:10	6.80±1.47 ^{bc}	7.40±1.17 ^a	7.50±0.70 ^{ab}	8.10±0.99 ^a	7.90±1.28 ^a
80:20	7.80±0.78 ^{ab}	6.70±1.25 ^{ab}	7.20±1.22 ^{ab}	7.50±0.84 ^{ab}	7.50±1.43 ^{ab}
70:30	6.80±1.31 ^{bc}	5.60±2.27 ^{bc}	6.80±0.91 ^b	6.30±1.70 ^{bc}	6.00±1.88 ^{bc}
60:40	7.20±1.03 ^{ab}	5.10±1.72 ^c	6.60±1.17 ^b	6.50±1.35 ^{bc}	5.50±1.71 ^c
50:50	5.80±1.31 ^c	4.70±1.82 ^c	6.40±1.71 ^b	5.90±1.44 ^c	5.30±1.94 ^c
100:0	8.20±0.91 ^a	7.60±1.07 ^a	8.10±0.99 ^f	6.80±1.56 ^{bc}	6.80±1.93 ^{bc}
Trained panelists' evaluation					
90:10	6.80±1.47 ^{bc}	5.10±1.72 ^c	6.40±1.71 ^b	8.10±0.99 ^a	5.30±1.94 ^c
80:20	7.80±0.78 ^{ab}	5.60±1.27 ^{bc}	6.60±1.17 ^b	6.30±0.84 ^c	5.50±1.71 ^c
70:30	6.80±1.31 ^{bc}	6.70±1.25 ^{ab}	7.20±1.22 ^{ab}	6.80±1.56 ^b	6.80±1.93 ^{bc}
60:40	7.80±0.78 ^{ab}	7.40±1.17 ^a	7.50±0.70 ^{ab}	6.50±1.35 ^{bc}	7.50±1.43 ^{ab}
50:50	8.20±0.91 ^a	7.60±1.07 ^a	8.10±0.99 ^a	7.50±0.84 ^{ab}	7.90±1.28 ^a
100:0	7.80±0.78 ^{ab}	7.40±1.17 ^b	6.80±0.91 ^b	6.50±1.30 ^{bc}	6.80±1.93 ^{bc}

Each value is a mean ± standard deviation, n = 3; values in the same row with different letter(s) are significantly different at $p \leq 0.05$.

panelists had the highest preference for the 50:50 milk-cocoa yoghurt. On the other hand, preference of the untrained panel for plain yoghurt in most parameters evaluated shows that the panelists were already used to plain yoghurt. With proper and adequate education, consumers' acceptability for the new milk-supplemented-cocoa yoghurts would improve. This is corroborated by the highest preference of the untrained panelists for overall acceptability of 90:10 milk-cocoa yoghurt. This is an indication that cocoa powder inclusion improved the sensory attributes of yoghurt as shown by preference of both sets of panelists for the milk-cocoa yoghurts as compared to plain milk yoghurt.

Conclusion

Although demand for functional foods/beverages has been on the increase, their high cost has limited affordability especially for rural dwellers in developing countries like Nigeria. Since yoghurt is a popular beverage consumed by both rural and urban dwellers, inclusion of cocoa powder which is abundant in Nigeria may be a cheaper alternative. The present study has shown that supplementation of milk with cocoa powder significantly improved the nutritional composition, antioxidant potential and acceptability of yoghurt. This may serve as impetus to its commercial production; however, adequate enlightenment would encourage its consumption which will contribute to ensuring food security and improved health.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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Full Length Research Paper

Nutritional quality of meals served under the Ghana school feeding programme at the Upper West and Central Region of Ghana

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This research evaluated the nutritional quality of meals that were served to school children under the Ghana School Feeding Programme in Wa and Cape Coast. A cross-sectional and descriptive survey research designs were employed from which purposive and simple random sampling technique was adopted. In all, a total of 720 respondents were selected and that comprised 600 pupils, 60 teachers and 60 kitchen staff. Data were also obtained using questionnaire, observation and unstructured interview instruments. The data were then analysed with database and statistical software such as SPSS, ESHA, FNPD and USDA National Nutrient Database for Standard Reference. Qualitatively, the findings revealed that meals served in the schools had most of the needed food nutrients. However, the mean daily nutritional values intake of the pupils in the schools in both studied areas did not meet the recommended nutrient intake value. It is therefore recommended that the government should enhance the nutritional quality of the meals served to the pupils by supplying vitamin supplements. Again, the government should consult experts in food and nutrition in each region to redraw menu which has nutritional benefits from locally grown foods.

Key words: Variety of food, recommended nutrient intake, nutrients, leafy vegetables.

INTRODUCTION

Malnutrition in school age children (SAC) in Ghana is known to affect the children's school attendance, lower their academic achievement and cognitive levels (Parish and Gelli, 2015), besides causing stunted growth and wasting. To curb the malnutrition and its associated

consequences among the SAC, Government of Ghana adopted a School Feeding Programme (SFP) as a solving tool in the year 2005. This choice which is supported by research findings of Muthayya et al. (2009) had been effectively adopted by many developing

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countries. According to Muthayya et al. (2009) meals served in school always increase the nutritional status of SAC and in a variety of ways. However, after the implementation of the programme in Ghana, very little data have been gathered to verify the milestone covered towards the goal, so as to ascertain whether or not the malnutrition in targeted schools has truly dwindled.

Abdul-Rahman and Agble (2012) revealed that data regarding the nutritional values of the meals served under the programme are scanty and as well, data of responsiveness of the targeted pupils to the programme are very much lacking. Additionally, fewer impact studies that had been undertaken had also yielded contrasting outcomes. For example, Owusu (2013), on one hand, revealed that the SFP by the government did not meet the required standard nutritional values but Parish and Gelli (2015) and Buhl (2010), on the other hand, claimed otherwise. Obviously, the result of impact studies of the programme indicates that the outcome is inconsistent and varies from region to region. One of the reasons for this inconsistency has been attributed to the varying levels of nutrients in indigenous diet that are prescribed in the menu.

For this reason, gaining a clearer picture of the extent of the impact of the programme and its adoption dictates that studies on each and every participating school ought to be thoroughly done. This is because schools are only instructed to provide a nutritious meal daily and in most districts, menus are said to be prepared with assistance from a nutritionist. However, menus are often not displayed and are not always followed (Netherlands Development Organisation, 2007). Currently, there is lack of information regarding how much nutrients and calories are in the meals that are being served to the SAC. It is against this background this study seeks to determine the nutritional contents of the meals that are served in Wa and Cape Coast schools and whether they do meet the required levels that SAC need to be well-nourished.

MATERIALS AND METHODS

Study area

The study was conducted in two major capital towns, Wa and Cape Coast in the Upper West and Central Region of Ghana, respectively. The choice of schools for the study was based on Ghana population and housing census 2010 (Ghana Statistical Service, 2012) data that points to the three northern regions (Upper East, Upper West and Northern Regions) and the Central Region as the poorest regions in Ghana. This, therefore, led to the selection of Wa and Cape Coast in the research study. Schools in Cape Coast include 9 public second cycle institution, 3 private second cycle institution, 120 junior high schools, primary schools and pre-schools belonging to both public and private sectors. There are also 14 schools under the school feeding programme. Each school had an average of 300 students. A major market is located in the Cape Coast Township with market days throughout the week. Smaller markets exist in most communities like Abura and Efutu. Also, the Wa Metropolis has 68 schools participating in the Ghana School Feeding Programme (GSFP) with an average population of 300 pupils in a school.

Study population

The target population included all head teachers, teachers, pupils and kitchen staffs found within schools benefitting from GSFP in the Wa Municipality and Cape Coast Metropolis. The choice of head teachers, teachers, pupils and kitchen staffs, therefore, enabled generation of first-hand information on the nutritional adequacy of meals served under the GSFP.

Sample size

A total of 720 respondents participated in the study. This sample size was computed using Graph Pad Prism Version 16, statistical software. It used the following parameters: standard normal variance (at 5% type 1 error; $P < 0.05$), a critical z-score of 1.96% and at 1% type 1 error ($P < 0.01$) with $95\% \pm 2.58$ confidence interval. P values are considered significant below 0.05.

Sampling techniques and instrumentation

Non-probability sampling using purposive sampling was employed to identify public schools benefitting from the GSFP in both Wa and Cape Coast. Probability sampling using simple random sampling method was used to select 12 schools out of the 68 schools under the School Feeding Programme from Wa, while 8 out of 14 schools were selected from the Cape Coast School Feeding Programme. A pre-tested standardized validated questionnaire consisting of closed-ended questions with multiple choice answers and open-ended questions was used to solicit information on the nutritional quality of meals prepared. An unstructured observational guide was developed to gather additional information.

Nutrient determination in meals

Weights of food ingredients used in preparing the meals per day were measured using a Mettler 346 L weighing scale. These values were obtained by taking the weights of each food ingredient used in preparing the meals, for all the participating pupils in one school per day. The captured weights of the ingredients were then fed into ESHA Food Nutrient Processor Database software to estimate their nutritional values. ESHA spews out weights of nutrients per 100 g of the inputted ingredient. To obtain the actual weights of the nutrients from the meal, the outputs from ESHA were multiplied by the right proportion to make up to the actual weight of the tested meal ingredient. This process was repeated for all the various food ingredients used to prepare each meal throughout the 5 day study period. The mean daily intake of nutrients in meals over the study period was done arithmetically summing all the values for each nutrient from each meal for the 5 day study period. The resulting values were divided by the 5 days followed by the number of the participating pupils. The data were then fed into USDA National Nutrient Database for Standard Reference (2013) to establish the nutritional values of the meals. Also, meals served to the pupils in the schools that fall under the research study were weighed to ascertain whether the meals served to pupils met the weight of food needed to be served to them.

Data analysis

Data cleaning preceded the analysis; this was done using SPSS version 20.0 (2011), Graph Pad Prism (trial version 5), Microsoft Excel 2007; and PAST Statistics/data analysis software. The various nutritional contents of meals were calculated using ESHA results

Table 1. Menu prescription observed in Wa and Cape Coast municipal schools.

Day	Meals served at school	
	Wa municipal	Cape Coast municipal
Monday	Rice and beans with tomato stew or groundnut soup	Rice with tomato stew
Tuesday	Tuo Zaafi with green vegetable soup or dry okro soup	Banku with okro soup or groundnut soup
Wednesday	Gari and beans	Gari and beans
Thursday	Banku and groundnut soup	Gari with palava sauce or tomato stew
Friday	Jollof rice	Rice and beans with tomato stew or Jollof rice

Food Nutrient Processor Database (trial version). Both descriptive and inferential statistical tool was used for data analysis and presented using frequencies and means of the information gathered.

Ethical considerations

Ethical clearance was sought from Ghana Education Service district offices, the head teachers in the various schools under GSFP and the Board of Ethical Clearance Committee of the University of Education, Winneba-Ghana.

RESULTS

Meals served to pupils under the GSFP

Meals served to the schools in both Wa and Cape Coast were about the same regarding the days as shown in Table 1. The meals served in various schools in both towns were made with rice, maize, or cassava. The added stews and soups and their contents differed from time to time in each area. Some of the meals served in the Cape Coast Metropolis schools, for instance, included rice and tomato stew, gari (pinno) or eba (Nigeria) and palava sauce while banku and groundnuts soup, tuo zaafi and ayoyo soup (a popular dish for the people of Ghana) among others were served in the Wa schools. The most common meals served in both schools were gari and beans.

Observation made under the SFP in Wa municipal

It was observed that the meals served in Wa schools usually contained more green leaves and vegetables. Further, the kitchen staff strictly adhered to the menu given by the district office. The caterers prepared and serve meals prior to the time the pupils go out for break for lunch and this was observed in all the schools under this study.

Observation made under the SFP in Cape Coast Metropolis

The situation at Cape Coast schools was somewhat

different. Although the schools had been given a menu, the menu was not strictly followed. However, by the end of the week, all the meals that were on the menu were prepared and served.

Mean daily intake of nutrients in the schools' meals

The mean daily energy and nutritional value of intakes determined in 5 day studies of ingredient per meal served to pupils in both Wa and Cape Coast schools are shown in Table 2.

The resulting nutritional value was compared with one-third of the Recommended Nutrient Intake (RNI) value of WHO/FAO (2004). It was found that the daily nutrients of the meals served to the school going children in both schools in the municipal were below the RNI values.

Types of animal products used in meal preparation

The responses to the type of animal products that the pupils, teachers, and kitchen staff identified to be used to prepare meals in Wa and Cape Coast schools are shown in Table 3. In both Wa and Cape Coast schools, all the respondents (100% of the pupils, teachers, and kitchen staff) stated that fish was used in preparing meals. The animal products used by the caterers in Cape Coast Metropolis' schools were fish powder of herrings and anchovies, tuna and occasionally chicken to prepare the meals while in Wa schools were mainly fish (anchovies). Anchovies are smaller fishes and they further get broken into smaller pieces during the cooking preparation making it not obvious for one to see the presence of the fish in the food. The schools in both Wa and Cape Coast indicated that beef and eggs were not served to them at all, except during the last day of vacation termed "Our Day". It is during this day that the pupils of Cape Coast schools had chicken on their meals and the size was as small as palm kernel.

Observations made under the SFP on types of food ingredients used in meal preparation

From the perspective of the caterers, when an ingredient is scarce for any reason either an alternative ingredient is

Table 2. Mean daily intake of nutrients in meals served for a 5 day study in Cape Coast and Wa municipal schools.

Nutritional component (1/3 RNI)	Mean± SD	
	Wa Municipal	Cape Coast Municipal
Calories (720 kcal)	520.6±30.1	440.8±20.1
Protein (14 g)	10.2±0.9	10.8±0.8
Carbohydrates (43 g)	90.6±6.3	69.3±5.2
Vitamins A (200 µg RE)	726.4±85.2	548.2±75.1
Thiamin (0.4 mg)	0.2±0.1	0.3±0.2
Riboflavin (0.4 mg)	0.1±0.1	0.1±0.2
Vitamin C (13.3 mg)	8.4±0.3	6.7±0.4
Iron (5 mg)	4.0±0.4	3.3±0.3
Calcium (433.3 mg)	84.6±8.3	92.8±9.4
Zinc (3 mg)	1.9±0.2	2.3±0.3

Table 3. Animal products used to prepare meals for school children in Wa and CapeCoast schools.

Animal product	Wa respondents						Cape Coast respondents					
	Pupils (n=360)		Teachers (n=36)		Kitchen staff (n=36)		Pupils (n=240)		Teachers (n=24)		Kitchen staff (n=24)	
	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No
Beef	0	360	0	36	0	36	5	235	0	24	0	24
Fish	360	0	36	0	36	0	240	0	24	0	24	0
Eggs	0	360	0	36	0	36	0	240	0	24	0	24
Chicken	0	360	0	36	0	36	59	181	3	21	0	24
Others	4	356	*NA	NA	NA	NA	3	237	NA	NA	NA	NA

*NA = Not available.

Table 4. Types of legumes and nuts used for meal preparation in Wa and CapeCoast schools.

Legumes and nuts	Wa respondents						Cape Coast respondents					
	Pupils (n=360)		Teachers (n=36)		Kitchen staff (n=36)		Pupils (n=240)		Teachers (n=24)		Kitchen staff (n=24)	
	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No
Black eye beans	360	0	36	0	36	0	240	0	24	0	24	0
Groundnuts	360	0	36	0	36	0	230	10	22	2	24	0
<i>Agushie</i>	3	357	6	30	3	33	126	114	15	9	12	12
Soyabeans	2	358	10	26	12	24	6	234	6	18	5	19
<i>Dawadawa</i>	358	2	34	2	36	0	6	234	2	22	5	19
Palm fruit	0	360	3	33	3	33	10	230	2	22	6	18

used or none at all. An interview with a caterer in Cape Coast revealed that sometimes processed meat like sausages were used to cook for the pupils instead of fish. Table 4 represent the major types of legumes and nuts used for meal preparations and these were beans and groundnuts.

The respondents from Wa schools revealed that *dawadawa* was used in their meals preparation. Soya bean was the least used legume, according to the pupils. However, the teachers in Wa claimed that palm fruit was

the least used ingredient followed by *agushie*, and this claims were supported by the kitchen staff. At Cape Coast, all the respondents stated that beans were the most used ingredient for meal preparations. For *agushie* usage, there was a split decision among caterers and the pupils. The least used ingredients were soybeans and *dawadawa*, according to the pupils and teachers but the kitchen staff claimed that they used soybeans. It was observed that caterers in Wa use soybeans in the form of powder after it has been roasted and milled. The roasted

Table 5. Types of cereals and grains used for meal preparation in Wa and Cape Coast Municipal school.

Cereals and grains	Wa respondents						Cape Coast respondents					
	Pupils (n=360)		Teachers (n=36)		Kitchen staff (n=36)		Pupils (n=240)		Teachers (n=24)		Kitchen staff (n=24)	
	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No
Maize	359	1	36	0	36	0	220	20	24	0	24	0
Rice	356	4	36	0	36	0	240	0	24	0	24	0
Millet	2	358	4	32	2	34	1	239	0	24	0	24
Sorghum	0	360	4	32	2	34	0	240	0	24	0	24

Table 6. Fruits and vegetables used to prepare meals for pupils in Wa and Cape Coast municipal schools.

Fruits and vegetables	Wa respondents						Cape Coast respondents					
	Pupils (n=360)		Teachers (n=36)		Kitchen staff (n=36)		Pupils (n=240)		Teachers (n=24)		Kitchen staff (n=24)	
	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No
Banana	4	356	0	36	0	36	3	237	0	24	0	24
Mango	0	360	0	36	0	36	0	240	0	24	0	24
Local green leaves	360	0	30	6	36	0	97	143	8	16	19	5
Okra	320	40	36	0	36	0	136	104	10	14	20	4
Garden eggs	6	354	10	26	2	34	8	232	5	19	15	9
Tomatoes	355	5	36	0	36	0	228	12	24	0	24	0
Pepper	359	1	36	0	36	0	234	6	24	0	24	0
Onion	344	16	36	0	36	0	240	0	24	0	24	0
Cabbage	2	358	2	34	6	30	2	238	2	22	4	20
Carrot	1	359	0	36	2	34	1	239	0	24	2	22

soybeans powder was mixed with groundnut paste to prepare soup. Again, the pupils in Wa had more soups in their menus due to the abundance of edible local green leaves in the region. In Cape Coast, the researchers again observed two caterers who soaked soya beans overnight, milled them into a paste and used them to substitute *agushie* to prepare palava sauce.

Table 5 represents the grains and cereals used in meal preparation in both Wa and Cape Coast SFP. Almost all the respondents agreed that maize and rice were the most used grains and the least used were millet and sorghum. In Cape Coast, less than 1% reported that millet or sorghum was ever used. The most used cereals and grains were rice and maize. From Table 6, it can be seen that local green leaves were often used in meal preparation in Wa. These local green leaves included cassava leaves, pumpkin leaves, beans leaves and baobao leaves. Not much green leaves were used, according to the pupils in Cape Coast. The kitchen staff, however, indicated that more substantial local green leaves were used contrary to the pupils' claim. It was observed that all the schools' caterers used canned tomatoes rather than the fresh one. According to the caterers, they only used fresh tomatoes during its season and when it is very cheap at the market.

Types of starchy roots (processed) used to prepare food for pupils

Table 7 shows the types of starchy roots (processed) used in meal preparation. Fresh cassava was barely served in the schools. Majority of the respondents in Wa reported that *konkonte* was rather used for the preparation of meals. In Cape Coast, on the other hand, the kitchen staff indicated that *konkonte* was not used at all. It is clear that gari was the most used processed starchy root used in meal preparations.

In Wa Municipal schools, *konkonte* was not served as such but the powder is usually mixed with corn dough to prepare banku and with corn flour to prepare tuo zaafi. It was also observed in Cape Coast schools that fresh cassava was made into dough and mixed with corn dough to prepare banku. Hence in both Wa and Cape Coast, processed cassava was used instead.

Type of fat and oil used to prepare foods for pupils

Table 8 shows the types of fats and oils used in the meal preparation of the SFP. The main oils used in the meal preparation for both schools in Wa and Cape Coast were

Table 7. Starchy roots (processed) used to prepare meal for pupils in Wa and Cape Coast Municipal schools.

Starchy roots	Wa respondents						Cape Coast respondents					
	Pupils (n=360)		Teachers (n=36)		Kitchen staff (n=36)		Pupils (n=240)		Teachers (n=24)		Kitchen staff (n=24)	
	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No
Fresh cassava	6	354	1	35	2	34	6	234	1	23	1	23
<i>Konkonte</i>	329	31	35	1	36	0	36	204	1	23	0	24
Gari	324	36	36	0	36	0	240	0	24	0	24	0
Others	45	315	23	13	10	26	12	228	2	22	7	17

Table 8. Fat and oil used to prepare meals for pupils in Wa and Cape Coast Municipal School.

Fats and oils	Wa respondents						Cape Coast respondents					
	Pupils (N=360)		Teachers (N=36)		Kitchen staff (N=36)		Pupils (N=240)		Teachers (N=24)		Kitchen staff (N=24)	
	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No
Vegetable oil	360	0	36	0	36	0	240	0	24	0	24	0
Coconut oil	5	355	2	34	0	36	10	230	1	23	0	24
Palm oil	360	0	36	0	36	0	240	0	24	0	24	0
Kernel oil	2	358	1	35	0	36	1	239	1	23	0	24
Shea butter	8	352	5	31	15	21	8	232	3	21	4	20
Margarine	1	359	0	36	0	36	3	237	0	24	0	24
Others	1	359	6	30	6	30	1	239	4	20	4	20

Table 9. Mean Weights of meals served in schools in Wa and Cape Coast municipals.

School	Gari balls and tomato stew	Gari and Bean	Rice and tomato stew	Rice and beans with tomato stew	Banku and okro soup	Banku and groundnut soup	Rice with palava sauce	Jollof Rice	Tuo Zaafi with green vegetable soup
	FAO Standard (2012)								
	400 g	310 g	550 g	450 g	650 g	650 g	600 g	450 g	700 g
Meals at Wa 1	NA	210	193	192.5	NA	342	*NA	195	400
Meals at Wa 2	NA	217	191	190.5	NA	347	NA	201	392
Meals at Cape Coast 1	178	184	179	NA	202	NA	188	NA	NA
Meals at Cape Coast 2	180	186	199	NA	199	NA	186	NA	NA

*NA = not available.

vegetable cooking oil and red palm oil, according to the kitchen staff. Shea butter was also used in preparing vegetable soup for tuo zaafi in some of the schools in Wa Municipal.

Mean weights of meals served

The mean weights of meals served in the two schools in both Wa and Cape Coast are shown in Table 9. For the sake of anonymity the schools were given numbers 1 and 2. The results revealed that the mean weight of the meals

served to the pupils was consistently below the FAO standards (2012).

DISCUSSION

Meals served to pupils under the GSFP

The study revealed that varieties of meals were served in both cities. According to Wardlaw et al. (2004), eating a variety of diets is essential to meeting the nutritional needs of an individual. This is because the caterers

incorporate variety of food ingredient in the meal preparation. One critical observation made was that the menus at both places of the study were fundamentally the same but the main meals given to the pupils differed in terms of added stew or soup. However, what is served to complement the stew or soup at both places was mainly from maize, cassava or rice which was consistent with staple food, generally eaten by Ghanaians along the coastal and the middle belts. Meals made from the same staples were also noted by Okae-Adjei et al. (2016) to be served at schools in Akuapem North Municipality. It is however surprising to note that millet and sorghum-based meals were absent from the menu in Wa. This is because, in the northern parts of Ghana including Wa, the staple food of the people is made from *kokonte* (dried cassava), maize, millet and sorghum. This suggests that the menus were possibly designed outside Wa Municipal which did not consider the culture of meals eaten by the indigenous pupils. Cisse et al. (2015) noted that the indigenous staple grains of millet and sorghum were more beneficial than non-traditional grains.

Information also gathered from the kitchen staff and teachers in Cape Coast revealed that jollof rice which ought to be served regularly under the prescribed menu of the school was rather served during special days or sporting activities. Gari, beans and rice were among the most frequently served meals in Wa and Cape Coast municipal schools and which suggests that gari, beans and rice are cheaper and more easily acquired by caterers in Ghana. In Wa, meals usually contained local green leaves and vegetables like baobab leaves, cassava leaves, pumpkin leaves, ayoyo leaves, and spinach which are rich in minerals and vitamins. Meals given to the school children in Wa had more soup, which made the pupils more able to completely consume their meals and this was unlikely in Cape Coast Metropolis schools where the meals served were mostly solid with oily stew. The frequent use of local green leaves may have accounted for the increase in micro-nutrient contents in the meals in Wa schools than Cape Coast schools.

Another observation made was that the schools in Wa Municipality strictly adhered to the menu given by the GSFP secretariat while caterers in Cape Coast did not. An interview with a caterer in Cape Coast revealed irregularity in the payment of the feeding grant which compelled them to prepare meals from ingredients that were available and more easily accessible with their limited purchasing resources. Nonetheless, by the end of the week, all the meals that were on the menu had been prepared when the ingredients were available and acquired. A survey by Abdul-Rahman and Agble (2012) showed that availability of the ingredients used in meals was also dependent on farming seasons, procurement procedure and availability of funds. In the dry seasons when many vegetables were unavailable, caterers resorted to dried vegetables for the meals.

Mean daily intake of nutrients in the schools' meals

Findings in relation to nutritional quality of meals served to upper primary schools revealed that the meals served, as of 2015, in both Wa and Cape Coast Municipals schools did not meet the nutrient intake recommendation based on WHO/FAO (2004), with the exception of carbohydrates and vitamin A which far exceeded the limits. This means that the pupils were not acquiring the needed nutrients that the programme ought to supply. Also, the school feeding programme does not take into consideration the recommended dietary allowance of calories and nutrients of the students based on their gender and age. All the school going children are served the same quantity of meal. These findings were consistent with studies reported by Abdul-Rahman and Agble (2012) who revealed that the meals at some schools in Accra and the Northern Regions of Ghana provided less than 30% of the daily RNI. These agree with Owusu (2013) who confirmed that various nutrients in meals under the GSFP at Sub-urban in Ghana also conform to the findings of this research. The results of this study again, reveal that energy, carbohydrates, vitamin A, and iron contents were high in Wa schools than in Cape Coast schools. In Wa, groundnut soup was usually thickened with soya bean powder besides the usage of green leafy vegetables. It was therefore not surprising that the vitamins in the meals in Wa schools were relatively high than those in Cape Coast schools.

Parish and Gelli (2015) pointed out that meals in Tamale and other cosmopolitan areas close to Wa that had similar socio-environmental characteristics contained more calories than meals in Accra. This study finding reveals that calcium, protein, thiamin, and zinc were higher in Cape Coast than in Wa municipal schools. The high value recorded for calcium intake in meals served to the pupils of Cape Coast could be due to the availability of fish in Cape Coast, hence a cheap source of protein (fish) used in meal preparations; this might be responsible for the differences in the calcium contents despite other calcium sources from green leafy vegetables, nuts and soybeans which were used by caterers in both cities.

Types of food ingredients used in meal preparation

Meals served in Cape Coast schools where the SFP is in operation had more of their protein source from fish. Cape Coast is a coastal city and more likely to have access to cheaper marine fish unlike meals served in Wa schools where there are fewer rivers and streams. Although the pupils of Cape Coast schools eat chicken occasionally, it was woefully inadequate. Although fish is considered as a healthy protein source, the pupils in Wa schools did not have an adequate amount. It is not surprising that the protein content of the meals in Cape

Coast was higher than that in Wa municipal. The choice for the use of fish or chicken is dependent upon the caterers. Chicken in many parts of the country is considered a delicacy but this is eaten by the school children only on special occasions.

The major types of legumes and nuts used for meal preparation were beans and groundnuts. These are two vital ingredients which are of good benefit to human health. Beans are a super healthy, versatile and affordable food high in antioxidants, fibre, protein, B vitamins, iron, magnesium, potassium, copper and zinc. Eating beans regularly may decrease the risk of diabetes, heart disease, colorectal cancer, and helps with weight management (Messina, 1999). Groundnuts are also known to contain health benefit nutrients such as minerals, antioxidants, vitamins, oleic acid and mono-saturated fatty acids. Consumption of mono-saturated fatty acids helps to prevent the risk of coronary artery disease and stroke.

Respondents in Wa municipal schools revealed that *dawadawa* was used to prepare meals for them and its usage was far more than *agushie* and soybeans. This is possible because *dawadawa* is an indigenous food ingredient to the people of Wa. Furthermore, *dawadawa* contains significant amounts of major and minor nutrients needed by the human body. *Dawadawa* serves as a flavouring agent and imparts sensory appeal to foods and possesses medicinal value in addition (Teye et al., 2013).

The pupils, teachers and kitchen staffs identified maize and rice as the main cereals used in food preparation. This was not surprising because they were the main staples of the schools' menu. Nevertheless, it was amazing to see millet and sorghum which are popular grains in the Northern part of the country could not find their place in the school feeding programme menu. The reason for the absence of these cereals in the menu is unclear but it can only be speculated that their absence suggests that the menu was designed from the southern part of Ghana by officials who might not be accustomed to the use of the said grains. It may also be that their prices were high than the other staple foods.

The use of okra in meal preparations was a typical practice of the natives of Wa Municipality. Okra, spinach, cassava leaves, pumpkin leaves, and baobab leaves are staple vegetables used by Wa natives regularly for their meals. This is contrary to natives of Cape Coast who do not actually have a staple vegetable except some occasional use of okra and green leaves in their diets. From these results, a variety of ingredients are used to prepare meals for pupils in both Wa and Cape Coast schools. According to Whitney et al. (2001) using a variety of ingredients in diets contributes immensely to achieving the RNI. It was observed that most of the ingredients, like tomatoes, pepper, and other vegetables were canned and okra and green leaves were sometimes also dried and milled into a powder. The issue with such processed products is that they tend to lose their

nutritional contents during the processing and other unknown effects on the pupils due to the addition of preservatives and additives to extend the shelf life. The uses of processed ingredients like canned tomatoes may also increase the risk of food safety especially when the sources and shelf life of the canned ingredients are not checked or unknown.

Dried cassava or *konkonte* and gari were the starchy roots in a processed form that were used to prepare meals for the school children. It is not a surprise that gari is one of the most used starchy food ingredient for meal preparations. A similar report has been made by Parish and Gelli (2015) on gari and beans as being the most eaten meals in most Ghanaian schools. The combination of beans and gari as a meal is very satisfying when ingested and it is easier to prepare and cheaper than most meals. Majority of the respondents (kitchen staff) in Wa indicated that *konkonte* was the most used starchy product for the preparation of meals but in Cape Coast, it was not used at all. *Konkonte* is one of the main ingredients in the preparation of tuo zaafi, a local traditional dish consumed mostly by the people of the Upper West Region whose capital is Wa.

Shea nut oil which was also identified to be used in preparing vegetable soup for tuo zaafi was used only in Wa but not in Cape Coast probably because the shea nut tree is found only in the Wa area. The oil from the nut is rich in vitamin C and has anti-inflammatory and antioxidant properties. Kao et al. (2016) described its application and healing potency on attenuating knee osteoarthritis of rats and its use to cure arthritis in humans. Palm oil also contains antioxidants, carotenes, vitamins E and A, vital nutrients for sight. Vitamin A deficiency is the leading cause of preventable childhood blindness and lowers cognitive functions (Hornby et al. 1999). Palm oil is a regular component of gari and beans meal which was observed to be the most frequently eaten meal in the GSFP across the country. It is therefore not surprising that vitamin A was the only vitamin that met the RNI of the meals.

Conclusion

Meals served under the GSFP in Wa and Cape Coast Municipal schools contain almost all the major nutritional contents which are protein, carbohydrates, vitamins, iron, calcium, and zinc. This is so because varieties of meals were served at the schools. However, the total nutritional contents of meals served in both Wa and Cape Coast did not meet the recommended dietary intake prescribed by World Health Organization (WHO). It is therefore recommended that government consult experts in food and nutrition in each region to draw menu which has nutritional benefit to the pupils using locally grown foods in each region and ensure strict adherence.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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