Original Article

Impact of Cowpea Fortified Cookies on Anthropometric and Micronutrient Status of Primary School Children: A Randomized, Single-blind Controlled Trial

Rufina N B Ayogu, Tochukwu P Onah

Department of Nutrition and Dietetics, University of Nigeria, Nsukka, Nigeria

Abstract

Background: Micronutrient deficiencies are public health problems among school children. Food-to-food fortification may reduce the prevalence of these deficiencies. **Aim:** To assess the impact of cowpea (*Vigna sinensis*) fortified cookies on weight, height, body mass index (BMI), hemoglobin, serum vitamin A, and zinc status of primary school children aged 6–12 years. **Methods:** A randomized single-blind controlled trial was conducted for 4 weeks among 17 pupils who were voluntarily recruited and randomly assigned to experimental (Group A) and control (Group B) groups. Group A was fed wheat cookies incorporated with cowpea in a ratio of 60:40, while Group B received 100% wheat cookies. Data were collected through questionnaire, anthropometry, and biochemical analysis. Statistical analysis involved descriptive statistics and *t*-test. Significance was set at $P < 0.05$. **Results:** The study involved 17 school children out of which 10 (58.8%) were boys and 7 (41.2%) were girls; 12 (70.6%) were 10–12 years old and 4 (23.5%) were in lower primary (1–3). Group A had increases in hemoglobin (15.5%), serum ferritin (28.3%), serum zinc (38.9%), weight (3.0%), BMI (3.4%), and serum vitamin A (26.3%); only increases in hemoglobin, serum ferritin, and vitamin A attained significance ($P < 0.05$). Though there was increase in weight (6.1%), BMI (5.4%), hemoglobin (5.0%), serum ferritin (16.4%), zinc (20.8%), and vitamin A (17.5%) of Group B, these increases were not significant ($P > 0.05$). Group A had significantly ($P < 0.05$) higher serum ferritin (51.3 μg/L) than Group B (44.7 μg/L). **Conclusion:** Consumption of cowpea fortified cookies had significant positive effects on hemoglobin, serum ferritin, and vitamin A levels of school children and should be encouraged at household and industrial levels.

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Introduction

Causes of micronutrient deficiency among children are multidimensional and prominent among them is inadequate food and nutrient intakes. Morris[1] asserted that every year, hunger and under-nutrition claim more than 10 million lives—more than the deaths from AIDS, malaria, and tuberculosis combined. Micronutrient deficiency is only one form of under-nutrition with its characteristic invisibility. Iron deficiency is the most common micronutrient deficiency in the world, affecting more than 30% of the world's population.[2] Over two billion people globally are at risk of vitamin A deficiency.[3] About 17% of the global population is also at risk of zinc deficiency due to dietary inadequacy.[4] Among school children in Nigeria, iron, vitamin A, and zinc deficiencies have also been reported as problems of public health significance with prevalence rates above

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Address for correspondence: Dr. Rufina N B Ayogu, Department of Nutrition and Dietetics, University of Nigeria, Nsukka, Nigeria.
E-mail: rufina.ayogu@unn.edu.ng

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5%.[5-8] A child deficient in micronutrients may be able to go to school and carry on with school activities but the output is far from satisfactory as a result of the consequences of these deficiencies on growth, development, and the entire body physiologic processes.

Different intervention strategies aimed at controlling micronutrient deficiencies have been implemented but nutrition remains the most powerful adaptable environmental exposure to target in order to reduce the burden of diseases and death accruing from these deficiencies.[9] Food-based nutrition interventions have potentials to achieve this. Pulses/legumes are nutrient dense[10] and when incorporated into cereals enhance the amino acid and micronutrient profile of their food products. Consumption of cereal foods such as cookies and bread is very popular in Nigeria, especially among the snack consuming population (children and adolescents).[11] Without fortification, these cereal foods remain poor sources of protein and micronutrients. Copenhagen consensus of 2012 asserted that flour fortification with iron and folic acid is globally recognized as one of the most effective and low-cost micronutrient interventions[12] but in many settings, more than one micronutrient deficiency exists, suggesting the need for simple approaches that address multiple micronutrient deficiencies.[3]

The use of cookies produced from a combination of wheat and a local cowpea—*apama* to improve the iron, vitamin A, and zinc status of school children is one of these simple approaches. This study evaluated the impact of cowpea fortified cookies on hemoglobin, serum ferritin, vitamin A, and zinc status of school children (6–12 years) as a readily available and acceptable food-based strategy to fight multiple micronutrient deficiencies. This was based on iron (2.0 g) and protein (10.4 g) in wheat flour,[14] which are lower than iron (6.49 g) and protein (20.88%) of cowpea flour.[13]

Materials and Methods

Study setting

The study took place at St Andrew's Nursery and Primary School Ibagwa Aka in Igbo-Eze South Local Government Area (LGA), Enugu State, Nigeria. Ibagwa Aka is a rural community whose inhabitants are mainly farmers and traders. Agro products such as yam, palm oil, cassava, cocoyam, bambara groundnuts, cowpea, and livestock are produced, consumed, and traded on.

Subjects and study design

Participants for this study were recruited voluntarily from the general school population. The chart showing the selection process is shown in Figure 1. This randomized, single-blinded, controlled trial was performed with two parallel arms: A and B. All the participants were asked to maintain their habitual diet and food intake. They were also asked to remain in their usual home environment throughout the study period and to report any change in environment and new/unusual foods in their menu. Group A received cookies into which cowpea was incorporated in the ratio of 60:40 (fortified cookies), whereas Group B received 100% wheat cookies (unfortified cookies). The two types of cookies were produced with the same recipe and were similar in shape and size. Formulation of the cookies was based on 56 g protein basis to give similar protein intakes in the two groups. The nutritional value of the cookies[15] is presented in Table 1. The cookies were produced in the Diet Therapy Laboratory of the Department of Nutrition and Dietetics, University of Nigeria, Nsukka on weekly basis to ensure freshness and crispiness. These were wrapped in labeled polyethylene bags and supplied to the school. Four teachers were recruited, trained, and assigned two per group to ensure that the cookies were served and that the school children did not share their cookies. The cookies were served the pupils with water in two separate classrooms every school day for 4 weeks. No intervention took place during weekends. Children were not allowed to leave the classroom or return to their original seats before they had finished their cookies and water. The teachers ensured compliance and recorded attendance to school and daily participation in the trial, complaints of ill health, and desire to discontinue in a record book provided for this purpose. Both the teachers and the pupils were blinded to the type of biscuits served and consumed. The quantity of cookies fed to the children was based on one-third of the protein requirement[16] for age and gender of children aged 6–12 years, as shown in Table 2. Prior to commencement of the intervention, the children were dewormed with oral albendazole 200 mg stat. A total of 17 out of 21 school children who started the trial completed the study.

Exclusion criteria

Exclusion criteria were applied only to children who gave consent. The exclusion criteria included overweight/obesity and low body mass index (BMI)-for-age, low hemoglobin (<11.5/12.0 g/dL), low serum zinc (<65 µg/dL), ferritin (<15 µg/L), and vitamin A (<20 µg/dL) levels.

Ethical approval and informed consent

Ethical approval for the study was obtained from the Ethical Committee of Enugu State Ministry of Health (MH/MSD/EC/0225). Written and informed consent was obtained from the school authority, parents/guardians of the pupils, and the pupils themselves. A laboratory technologist was employed to ensure that blood collection was safe and accurate.

Data collection methods

Questionnaire: Structured and validated questionnaire was used to obtain data on general characteristics of the school children.

Anthropometry: Weight and height of the school children were taken according to methods described by Dabone *et al*.[17] BMI was calculated from these values and related to age according to WHO child growth standard[18] for age and gender. They were classified as thin if their Z-scores of BMI-for-age were low (≤ −2 SD); that is below the WHO median.

Three-day food record: Parents and their children were taught how to keep records of every meal and snack consumed within and outside the home for 3 days using a format developed for this purpose. The format included date, item consumed, the form in which it was consumed, ingredients in the food if known, and meal in which it was consumed (breakfast, lunch, supper), and if consumed as snack. The foods consumed were grouped into different food groups according to Ene-Obong.[35]

Biochemical tests: A laboratory technologist collected 5 mL of venous blood from the subjects prior to and at the end of the trial. Blood was collected in two separate specimen bottles. One (2 mL) with ethylenediaminetetraacetic acid was used for hemoglobin determination by cyanmethemoglobin method. Anemia was defined as hemoglobin concentration of <11.5 and <12.0 g/dL for children <12 and 12 years, respectively.[19] Blood (3 mL) in the screw capped glass vials without anticoagulant was allowed to coagulate. Both labeled bottles were put in a cooler lined with frozen ice packs and sent to the laboratory within 2 h of collection. The coagulated blood was centrifuged at 3000 rpm for 10 min to obtain clear serum. Serum vitamin A was determined by colorimetric method using trifluoroacetic acid.[20] Cut-off for vitamin A deficiency was <20 µg/dL.[19] Atomic absorption spectrophotometric method was used to determine serum ferritin[21] and zinc levels.[22] Cut-off for iron and zinc deficiencies were <15 µg/L[23] and <65 µg/dL,[24] respectively.

Statistical analysis

Statistical Product and Service Solution (Armonk, NY: IBM Corp) version 21 was used for statistical analysis of data. Results of descriptive statistical analysis were presented in frequencies and percentages. Differences within and among groups were evaluated with *t*-test. Significance was accepted at $P < 0.05$.

Results

Table 3 illustrates the personal characteristics of the subjects. The study population was made up of 10 (58.8%) males and 7 females (41.2%); 12 (70.6%) school children were aged 10–12 years; only 5 (29.4%) were 6–9 years old. School children in primary 4–6 were 13 (76.5%), while those in primary 1–3 were 4 (23.5%). More than half (52.9%) of the children had lower birth order of 1–3. Majority (52.9%) had meal frequency of three times daily and 47.1% did not consume snacks at school.

Table 4 shows the household characteristics of the subjects. A few (29.4%) had household size of 1–3 persons. About 6% came from households with monthly income of 21,000 Naira (66.68 USD) and above and 88.2% came from monogamous family.

Data from 3-day food intake record of the subjects are shown in Table 5. The food group with the highest frequency for breakfast 64.7% and lunch (70.6%) was cereal, starchy root, fruit, and tuber. Fat and oil had

Table 1: Nutritional value of the cookies per 100 g

Variables	Wheat (100%)	Wheat: cowpea (60:40)
Proximate composition		
CHO (g)	61.86±0.92	64.94±0.03
Protein (g)	12.82±0.36	14.67±0.47
Crude fat (g)	12.12±0.82	8.56±0.07
Crude fiber (g)	0.00±0.00	0.20±0.002
Ash (g)	2.25±0.25	3.49±0.02
Moisture (g)	10.95±0.27	8.14±0.52
Energy Kcal (KJ)	407.81 (1747.83)	395.48 (1695.03)
Micronutrient composition		
Sodium (mg)	107.27±3.14	67.00±3.95
Phosphorus (mg)	92.96±2.17	137.90±0.77
Potassium (mg)	426.41±31.36	385.70±14.36
Calcium (mg)	49.00±1.00	82.00±2.00
Zinc (mg)	0.57±0.02	0.82±0.24
Iron (mg)	0.98±0.05	0.40±0.12
Vitamin A (RE)	11.25±4.29	8.34±6.85
Vitamin B_1 (mg)	4.42±0.50	3.10±0.66
Vitamin C (mg)	4.44±1.01	3.38±0.63
Vitamin E (mg)	9.77±2.13	5.83±4.03

Source: Ayogu *et al*.[15]

Table 2: Quantity of cookies consumed daily

Age/sex	Protein RNI (g)	Quantity consumed (g)	
		Group A	Group B
6-9 years			
Male	27	61	70
Female	27	61	70
10-12 years			
Male	34	77	88
Female	36	82	94

Group A=intervention; Group B=Control; RNI=Recommended Nutrient Intake Source of protein requirement: FAO/WHO/UNU[16]

Table 3: Personal characteristics of the school children

Variables	Intervention group *N* (%)	Control group *N* (%)	Total *N* (%)
Sex			
Male	5 (55.6)	5 (62.5)	10 (58.8)
Female	4 (44.4)	3 (37.5)	7 (41.2)
Total	9 (100.0)	8 (100.0)	17 (100.0)
Age			
6-9 years	2 (22.2)	3 (37.5)	5 (29.4)
10-12 years	7 (77.8)	5 (62.5)	12 (70.6)
Total	9 (100.0)	8 (100.0)	17 (100.0)
Class			
Primary 1-3	2 (22.2)	2 (25.0)	4 (23.5)
Primary 4-6	7 (77.8)	6 (75.0)	13 (76.5)
Total	9 (100.0)	8 (100.0)	17 (100.0)
Child birth position			
1-3	5 (55.6)	4 (50.0)	9 (52.9)
4-6	4 (44.4)	4 (50.0)	8 (47.1)
Total	9 (100.0)	8 (100.0)	17 (100.0)
Meal frequency per day			
Once	0 (0.0)	1 (12.5)	1 (5.9)
Twice	0 (0.0)	7 (87.5)	7 (41.2)
Thrice	9 (100.0)	0 (0.0)	9 (52.9)
>Thrice	0 (0.0)	0 (0.0)	0 (0.0)
Total	9 (100.0)	8 (100.0)	17 (100.0)
Consumption of snacks at school			
Yes	4 (44.4)	5 (62.5)	9 (52.9)
No	5 (55.6)	3 (37.5)	8 (47.1)
Total	9 (100.0)	8 (100.0)	17 (100.0)

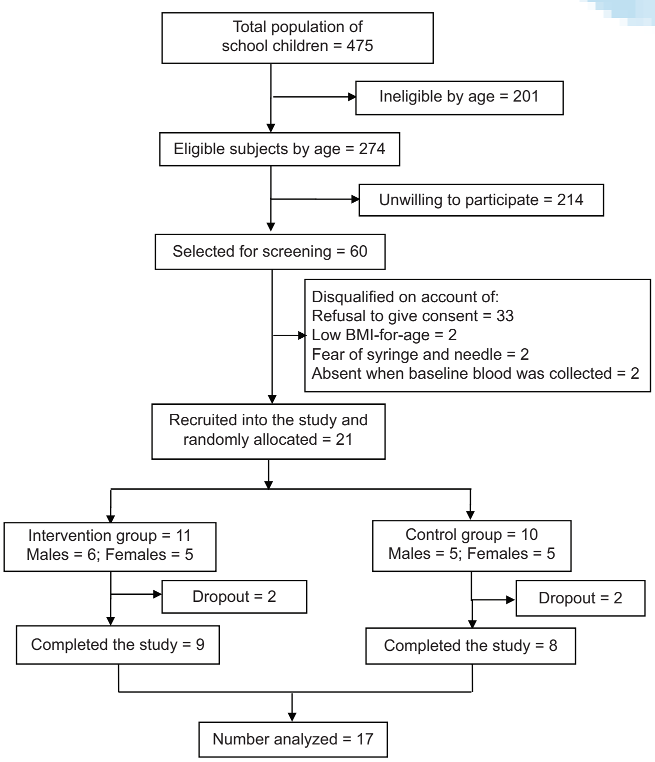

Figure 1: Procedure for recruitment and retention of subjects

Table 4: Household characteristics of the school children

Variables	Intervention group *N*(%)	Control group *N*(%)	Total *N*(%)
Household size (persons)			
1-3	2 (22.2)	3 (37.5)	5 (29.4)
4-6	4 (44.5)	2 (25.0)	6 (35.3)
>6	3 (33.3)	3 (37.5)	6 (35.3)
Total	9 (100.0)	8 (100.0)	17 (100.0)
Bread winner's occupation			
Farming	5 (55.6)	1 (12.5)	6 (35.3)
Civil servant	3 (33.3)	0 (0.0)	3 (17.6)
Trading	1 (11.1)	7 (87.5)	8 (47.1)
Total	9 (100.0)	8 (100.0)	17 (100.0)
Monthly income (N)			
≤20,000	8 (88.9)	8 (100.0)	16 (94.1)
≥21,000	1 (11.1)	0 (0.0)	1 (5.9)
Total	9 (100.0)	8 (100.0)	17 (100.0)
Bread winner's highest educational level			
None	1 (11.1)	1 (12.5)	2 (11.8)
Primary education	2 (22.2)	5 (62.5)	7 (41.2)
Secondary education	4 (44.4)	1 (12.5)	5 (29.4)
Tertiary education	2 (22.2)	1 (12.5)	3 (17.6)
Total	9 (100.0)	8 (100.0)	17 (100.0)
Family type			
Monogamy	9 (100.0)	6 (75.0)	15 (88.2)
Polygamy	0 (0.0)	0 (0.0)	0 (0.0)
Single parent	0 (0.0)	2 (25.0)	2 (11.8)
Total	9 (100.0)	8 (100.0)	17 (100.0)
Family food consumption pattern			
Eating together at the same time	5 (55.6)	4 (50.0)	9 (52.9)
Separately	4 (44.4)	4 (50.0)	8 (47.1)
Total	9 (100.0)	8 (100.0)	17 (100.0)

the highest consumption for supper (64.7%). Fruits and vegetables had low frequency of 11.8% for breakfast and 11.8% for lunch and 5.9% for supper.

The impact of the cookies on weight, height, and BMI of the subjects is presented in Table 6. No increase in height was observed at the end of the study for both groups. Both weight and BMI increased for the two groups, but these did not attain significance ($P > 0.05$).

The impact of the cookies on hemoglobin, serum vitamin A, ferritin, and zinc levels of the subjects is presented in Table 7. There were significant differences in mean hemoglobin ($P < 0.05$), serum ferritin ($P < 0.01$), and serum vitamin A ($P < 0.05$) levels of the subjects in Group A (experimental group) with end line values being higher. Though the end line values of hemoglobin, serum ferritin, vitamin A, and zinc in the control group were higher than the baseline, the differences were not statistically significant ($P > 0.05$).

Table 5: Consumption of food groups by the subjects

Variables	Intervention group *N*(%)	Control group *N*(%)	Total *N*(%)
Breakfast			
Fat and oil	7 (77.8)	3 (37.5)	10 (58.8)
Fruit and vegetable	0 (0.0)	2 (25.0)	2 (11.8)
Meat, fish, nut, and legume	2 (22.2)	2 (25.0)	4 (23.5)
Cereal, starchy roots, fruits, and tubers	7 (77.8)	4 (50.0)	11 (64.7)
Lunch			
Fat and oil	7 (77.8)	5 (62.5)	12 (70.6)
Fruit and vegetable	0 (0.0)	2 (25.0)	2 (11.8)
Meat, fish, nut, and legume	2 (22.2)	1 (12.5)	3 (17.6)
Cereal, starchy roots, fruits, and tubers	7 (77.8)	5 (62.5)	12 (70.6)
Supper			
Fat and oil	5 (55.6)	6 (75/0)	11 (64.7)
Fruit and vegetable	0 (0.0)	1 (12.5)	1 (5.9)
Meat, fish, nut, and legume	5 (55.6)	1 (12.5)	6 (35.3)
Cereal, starchy roots, fruits, and tubers	4 (44.4)	6 (75.0)	10 (58.8)

Source of food groups: Ene-Obong[35]

Table 6: The impact of the cookies on the anthropometric measurements of the subjects

Variables	Baseline	End line	Mean increase	Percentage increase	**P*
Weight (kg)					
Intervention group	33.3±5.672	34.3±6.118	1.0	3.0	0.702
Control group	31.1±6.143	33.0±7.012	1.9	6.1	0.545
***P*-value	0.506	0.612			
Height (m)					
Intervention group	1.4±6.001	1.4±5.116	0.0	0.0	0.811
Control group	1.4±6.112	1.4±6.212	0.0	0.0	0.941
***P*-value	0.944	0.896			
Body mass index (kg/m^2)					
Intervention group	17.8±1.416	18.4±3.118	0.6	3.4	0.491
Control group	16.7±2.114	17.6±3.015	0.9	5.4	0.248
***P*-value	0.412	0.381			

**P* values obtained through *t*-test analysis compares values within group ***P* values obtained through *t*-test analysis compares values between groups

Table 7: The impact of the cookies on the micronutrient levels of the school children

Variables	Baseline	End line	Mean increase	Percentage increase	**P*
Hemoglobin (>11.5/12.0 g/dL)					
Intervention group	14.8±1.328	17.1±2.453	2.3	15.5	0.026*
Control group	16.1±1.231	16.9±1.206	0.8	5.0	0.239
***P*-value	0.051	0.833			
Serum ferritin (>15 µg/L)					
Intervention group	40.0±8.484	51.3±6.457	11.3	28.3	0.006**
Control group	38.4±6.688	44.7±5.873	6.3	16.4	0.063
***P*-value	0.657	0.042*			
Serum zinc (≥65 µg/dL)					
Intervention group	70.5±15.848	97.9±61.611	27.4	38.9	0.215
Control group	58.7±26.121	71.0±47.713	12.3	20.8	0.536
***P*-value	0.271	0.333			
Serum vitamin A (>20 µg/dL)					
Intervention group	28.9±5.739	36.5±5.446	7.6	26.3	0.011*
Control group	27.5±7.171	32.3±5.784	4.8	17.5	0.166
***P*-value	0.677	0.144			

**P* values obtained through *t*-test analysis compares values within group $P<0.05$; **$P<0.01$ ***P* values obtained through *t*-test analysis compares values between groups Normal hemoglobin was defined as values >11.5 g/dL for children <12 years and ≥12.0 g/dL for≥ 12 years Normal serum ferritin was defined as values ≥15 µg/L Normal serum zinc was defined as values ≥65 µg/dL Normal serum vitamin A was defined as values >20 µg/dL

Discussion

The low income of the households is a cause of worry and a problem in low income countries where majority live below poverty line. This agrees with the findings of Ibeanu *et al*.[25] where 66.5% households earn between 10,000 and 15,000 Naira (31.75–47.62 USD). Low income is one of the causes of food insecurity and poor health status resulting from inability to access good food and health care services.

This study also showed that the most consumed food group is the cereal, starchy root, fruit, and tuber group. This was expected because these are readily available and affordable staple foods of the people. Cereal, starchy roots, fruits, and tubers are rich carbohydrate sources that are low in protein and micronutrients. They contribute to energy intake and excessive intake may result in overweight and obesity. Wasting (thinness) is a consequence of low energy intake. As most staples are consumed with stews, sauce, and soups prepared with crayfish, fermented African oil bean, oil, and vegetables, it implies that the children had chances of obtaining micronutrients from these sources. No child reported egg and milk consumption.

Results from this study showed that most of the subjects ate three times a day. Higher frequency of food intake may be positively related with higher nutrient intake. This is highly commendable and is consistent with the report of Olumakaiye *et al*.[26] on food consumption patterns of Nigerian children. Nwamarah *et al*.[27] also showed that school children had three meals per day (97.5% for breakfast, 90.7% for lunch, and 95% for supper). This may be one of the reasons for the high hemoglobin and serum ferritin level observed at baseline. Eating three times daily gives the children the opportunity to gain from the ingredients in the food. This may imply better food and nutrient intakes and therefore better nutritional status of the school children.

Differences in weight and BMI of the children which were not significant ($P > 0.05$) agreed with the findings of van Stuijvenberg *et al*.[28] They assessed the micronutrient status of 115 children (6–11 years) before and after consumption of biscuits fortified with iron, iodine, and beta carotene and reported no significant difference in height and weight, height-for-age, and weight-for-age Z-scores between the intervention and control groups over the 12 months study period. A systematic review of 201 studies conducted on food fortification by Das *et al*.[29] showed that multiple micronutrient fortification had no significant ($P > 0.05$) effects on height-for-age, weight-for-age, and weight-for-height Z-scores, although they showed positive trends. This affirms that the problems of low weight, height, and BMI are particularly problems of energy intake and not micronutrient.

The higher percentage increase in hemoglobin and serum ferritin of the children in Group A of this study was a surprise. This was because the wheat flour bought and used in this study to produce the cookies was fortified with iron and vitamin A by the manufacturers and one would expect Group B that received 100% wheat cookies to have a higher percentage increase but this was contrary to our finding. This result may be due to the interaction among hematinic nutrients in the two flours, which may have given a better amino acid profile and micronutrient boost than wheat alone despite its acclaimed fortification. Besides, amino acids and micronutrients (iron, zinc, vitamins A, B_1, B_6, and B_{12}) play vital role in erythropoiesis and hemoglobin synthesis.

All biomarkers (hemoglobin, serum ferritin, zinc, and vitamin A) of micronutrient status showed improvement in their mean values for both the experimental and control groups. According to Goyle,[30] this could be attributed to the fact that both groups received supplementation in the form of cookies. It is obvious to notice that though they all improved, the mean difference in the experimental group (Group A) was higher than observed in the control group. Although there were positive changes in the mean value of the nutrient biomarkers, further statistical analysis revealed that the changes in the experimental group were significant ($P < 0.05$) for hemoglobin, serum ferritin, and vitamin A and not for zinc [Table 7]. This result stands in agreement with van Stuijvenberg *et al*.[28] who reported a significant increase in serum retinol, serum ferritin, serum iron, transferrin saturation, urinary iodine, hemoglobin, and hematocrit of their experimental group. A study carried out by Winichagoon *et al*.[31] on 569 children aged 5–14 years from 10 schools in Thailand revealed that multi-micronutrient-fortified seasoning powder enhanced hemoglobin, and iodine status of school children. Studies by Goyle and Prakash[32] on 46 girls aged 10–16 fed micronutrient fortified biscuits for 75 days in 4 months in Jaipur, India, which resulted in increase in their vitamin A status as the supplementation augmented the percentage of adolescent girls in the "normal" category from 56.1 to 73.2% and decreased the percentage of adolescent girls in the "low" category from 41.5 to 26.8%. Jood *et al*.[33] also studied the effect of supplementation on serum retinol levels in 66 school children 10–12 years of age from Hisar, India, for a period of 4 months. Hundred grams of cauliflower leaves powder supplements using biscuits were fed 33 deficient subjects. An increase of 33.27%

was observed in the serum retinol levels after a period of 4 months. The lower percentage increase observed in this study may be attributed to duration of the study. The systematic review of 201 studies conducted on food fortification by Das *et al*.[29] revealed that fortification for children showed significant impact in increasing serum micronutrients such as iron, folate, and vitamin A concentrations. Similar review by Liu *et al*.[34] on food fortification in India showed that out of 47 papers, of which 25 were randomized controlled trials, 38 involved children less than 12 years, food vehicles used were 6 cereals, 18 oils and salts, and 23 others (e.g., school meals). Improvements in more than one biological markers were reported in all 35 papers (22 multiple micronutrients, 9 iron, and 4 iodine). More specifically, iron or hemoglobin improvements were noted in all studies with multiple micronutrients fortification. Most of the reports cited here were outcome of studies conducted on micronutrient-deficient children, in contrast to the children in this study who had normal values and still showed improvement. It implies that deficient children would show better improvement because nutrient absorption is higher in deficient states. The improvements observed in this study may be attributed to deworming because intestinal worms are known to interfere with nutrient absorption and intestinal helminths are problems of school children.

Conclusion

Cowpea (*Vigna sinensi, apama*) fortified cookies is a good vehicle for improving micronutrient status of school children and can be implemented in schools as snacks, especially where school feeding is difficult or impossible.

Limitation of the study

The study was conducted on only 17 pupils whose parents granted consent.

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Conflicts of interest

There are no conflicts of interest.

References

1. Morris Preface. In: Kraemer K, Zimmermann MB, editors. Nutritional anaemia. Switzerland: Sight and Life Press; 2007.
2. de Benoist B, McLean E, Egli I, Cogswell M. Worldwide prevalence of anaemia 1993-2005: WHO global database on anaemia. Geneva: World Health Organization; 2008.
3. Ramakrishnan U. Prevalence of micronutrient malnutrition worldwide. Nutr Rev 2002;60:46-52.
4. Wessells KR, Brown KH. Estimating the global prevalence of zinc deficiency: Results based on zinc availability in national food supplies and the prevalence of stunting. PLoS One 2012;7:e50568.
5. Onabanjo OO, Balogun OL. Anthropometric and iron status of adolescents from selected secondary schools in Ogun state, Nigeria. Childhood Obesity Nutr 2014;6:109-18.
6. Akeredolu IA, Oguntona BE, Okafor C, Osisanya OJ. Iron, zinc and copper malnutrition among primary school children in Lagos, Nigeria. Food Nutr Sci 2011;2:1063-70.
7. Atimati AO, Abiodun PO, Ofovwe GE. High prevalence of vitamin A deficiency in school age children in Benin City. Ann Biomed Sci 2012;11:106-16.
8. Ayogu RNB, Nnam NM, Ibemesi O, Okechukwu F. Prevalence and factors associated with anthropometric failure, vitamin A and iron deficiency among adolescents in a Nigerian urban community. Afr Health Sci 2016;16:389-98.
9. Bailey RL, West Jr KP, Black RE. The epidemiology of global micronutrient deficiencies. Ann Nutr Metab 2015;66(Suppl 2):22-33.
10. Mudryj AN, Yu N, Aukema HM. Nutritional and health benefits of pulses. Appl Physiol Nutr Metab 2014;39:11197-204.
11. Agu HO, Ezeh GC, Jideani AI. Quality assessment of Acha-based biscuit improved with Bambara nut and unripe plantain. Afr J Food Sci 2014;8:278-85.
12. Centers for Disease Control and Prevention. International micronutrient malnutrition prevention and control. Micronutrient facts. 2018 Available from: https://www.cdc.gov/immpact/micronutrients. [Last accessed on 2017 Nov 17].
13. Ayogu RNB, Nnam NM, Mbah M. Evaluation of two local cowpea species for nutrient, anti-nutrient, and phytochemical compositions and organoleptic attributes of their wheat-based cookies. Food Nutr Res 2016;60:29600.
14. Stadlmayr B, Charrondiere R, Victor N, Enujiugha VN, Bayili RG, Fagbohoun EG, *et al*. West African food composition table. Rome: Food and Agriculture Organization of the United Nations; 2012. Available from: http://www.fao.org/docrep/015/i2698b/i2698b00.pdf. [Last accessed on 2015 Nov 12].
15. Ayogu RNB, Abraham GO, Nnam NM. Evaluation of nutrient, anti-nutrient and phytochemicals in wheat based cookies incorporated with two cowpea species. Niger J Nutr Sci 2017;38:90-9.
16. FAO/WHO/UNU. Energy and protein requirements. WHO Technical Report series No. 724. Geneva: WHO; 1985
17. Dabone C, Delisle H, Receveur O. Poor nutritional status of school children in urban and peri-urban areas of Ouagadougou (Burkina Faso). Nutr J 2011;10:34.
18. WHO. WHO growth standards for children 5 – 19 years. 2007 Available from: http:/www.who.int/growthref/en /. [Last accessed on 2008 Jul 30]
19. Oguntona T, Omojekun SO, Aminu FT, Demehin KO, Falana AO, editors. Federal Ministry of Health national guidelines on micronutrient deficiencies control in Nigeria. Abuja, Nigeria: Department of Community Development and Population Activities (Nutrition division); 2005, p. 15-29.
20. Neeld JB, Pearson, WN. Macro and micro method for the determination of serum vitamin A using trifluoroacetic acid. J Nutr 1963;79:454-62.
21. Tietz NW. Fundamentals of clinical chemistry Philadelphia: Saunders WB. 1976; p 923-9.

22. Hotz C, Brown KH. International Zinc Nutrition Consultative Group (IZINCG), Technical Document #1. Assessment of the risk of zinc deficiency in populations and options of its control. Food Nutr Bull 2004;25:S146.
23. Zimmermann MB, Hurrel R. Nutritional iron deficiency. Lancet 2007;370:511-20.
24. Hotz C, Peerson JM, Brown KH. Suggested lower cutoffs of serum zinc concentrations for assessing zinc status: Reanalysis of the second National Health and Nutrition Examination Survey data (1976–1980) 1–3. Am J Clin Nutr 2003;78:756-64.
25. Ibeanu V, Onuoha N, Ezeugwu E, Ayogu R. Food preservation and security at `household level in rural Nsukka, Enugu State, Nigeria. J Trop Agr Food Environ Ext 2010;9:125-30.
26. Olumakaiye MF, Atinmo T, Olubayo-Fatiregun MA. Food consumption patterns of Nigerian adolescents and effect on body weight. J Nutr Educ Behav 2010;42:144-51.
27. Nwamarah JU, Otitoju O, Otitoju GTO, Emewulu CUD. Iodine and nutritional status of primary school children in a Nigerian Community Okpuje, in Nsukka LGA, Enugu State, Nigeria. Scholars Res Lib 2015;7:271-80.
28. van Stuijvenberg ME, Kvalsvig JD, Faber M, Kruger M, Kenoyer DG, Benadé AJS. Effect of iron-, iodine-, and b-carotene–fortified biscuits on the micronutrient status of primary school children: A randomized controlled trial. Am J Clin Nutr 1999;69:497-503.
29. Das JK, Salam A, Kumar R, Bhutta ZA. Micronutrient fortification of food and its impact on woman and child health: A systematic review. J System Rev 2013;2.
30. Goyle A. Effect of micronutrient fortified biscuit supplementation on the weight, height and body mass index of adolescent girls. Coll Anthropol 2012;36:573-9.
31. Winichagoon P, McKenzie JE, Chavasit V, Pongcharoen T, Gowachirapant S, Boonpraderm A, *et al*. A multi micronutrient-fortified seasoning powder enhances the hemoglobin, zinc, and iodine status of primary school children in North East Thailand: A randomized controlled trial of efficacy. J Nutr 2006;31:1618-23.
32. Goyle A, Prakash S. Effect of supplementation of micronutrient fortified biscuits on serum total proteins and vitamin A levels of adolescent girls (10-16 years) of Jaipur city, India. Nepal Med Coll J 2011;13:233-7.
33. Jood S, Gupta M, Yadav SK, Khetarpaul N. Effect of supplementation on haemoglobin and serum retinol levels and nutritional status of school children of northern India. Nutr Health 2001;15:97-111.
34. Liu P, Bhatia R, Pachón H, Emory. Food Fortification in India: A Literature Review. Indian J Comm Health 2014;26(Suppl S1):59-74.
35. Ene–Obong HN. Eating right. Calabar: University of Calabar Press; 2001.