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Full Length Research paper

Fortified Maize with Cowpea and Iron: A Strategy for Improving Children's Growth and Reducing Anaemia

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Iron and iron deficiency anaemia is of concern globally, and most vulnerable are children and women. In Ghana, after six months of age when breast milk is not enough, children are given cereal-based gruels which are poor in nutrients. Addition of cowpea to maize improved nutrient quality but not enough to meet iron needs. We investigated the effect of iron-fortified maize-cowpea blend in controlling iron deficiency anaemia in a high risk population. Fifty-six children aged 6 - 18 months in two peri-urban communities were randomly assigned (i) iron-fortified food or (ii) non-iron fortified food, fed daily for six months. Haemoglobin concentration (Hb), serum iron, total iron-binding capacity (TIBC), transferrin saturation, weight, length and mid upper arm circumference (MUAC) were measured at baseline and at the end of intervention. Generally, growth improved in the iron fortified group over the control group. Iron status was improved in the test group. Significant differences were observed in haemoglobin concentration (1.08±1.43 compared with -0.40±1.72 g/dL, p=0.0009), and the risk of developing anaemia was about 3 times less likely among this group compared to the non-fortified group. The children liked the diets, and preparation did not create an additional burden for mothers. Use of cowpeas and maize are within the socio-cultural context of the people, hence the right vehicle for fortification and has implications for intervention, policy and advocacy.

Key words: Iron status, anaemia, child growth, fortification, maize.

INTRODUCTION

At the close of the last decade, there was a global recognition of the massive problem of micronutrient (vitamin A, iodine and iron) deficiency (WHO/NHD, 2001). Iron deficiency (ID) was reported to be the most prevalent of the three micronutrient deficiencies. The standing committee on nutrition of the United Nations drew attention recently to the lack of progress on tackling iron deficiency anaemia (IDA). ID affects more people than any other non-communicable disease, constituting a public health condition of epidemic proportions (Foege, 2002). Furthermore, Foege (2002) reiterated that IDA is becoming more prevalent worldwide, affects mostly people of low socioeconomic status and those who do not consume iron-fortified food. Women of childbearing age, pregnant women and children are mostly affected, with the situation being worse in developing countries (Stoltzfus, 2004).

The causes of ID and IDA may be due to insufficient dietary intake of iron-rich foods and the presence of iron inhibitors in the diet. In developing countries, the situation is aggravated by intestinal worm infestation and malaria (Weinberg, 1977; Grantham-McGregor and Ani, 2001). The impact of ID on the health and development of millions of women and children, in spite of the availability of practical, low-cost interventions, cannot be over-emphasized (Asibey-Berko et al., 1999; WHO/NHD, 2001).

Over the years, comprehensive multi-pronged intervention programmes have been carried out to combat ID and anaemia through increased iron intake (that is, iron supplements, iron-rich diets, increasing iron fortified foods), infection control (that is, public health

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measures to control hookworm infection, malaria and schistosomiasis) and through the intake of nutrient dense foods (dietary diversification) (Yip and Ramakrishnan, 2002; Yip, 2002; Sanghvi, 2007). With all these available strategies, why is it that iron deficiency and iron deficiency anaemia remain public health issues to date?

This could be explained in terms of the approaches taken and problems of sustainability of such strategies and programmes. Most intervention programmes undertaken in developing countries are not sustainable due mainly to programme design, poverty, illiteracy, and also communication tools (Quarshie and Amoaful, 1998; Stoltzfus et al., 2004). For an intervention programme to be effective, it must have a well-defined goal, community involvement and sense of ownership, and an enabling policy and strategy. In other words, it must be within the socio-economic and socio-cultural frame work of the populace to ensure sustainability.

ID continues to be a problem in Ghana. Research by the ministry of health found anaemia prevalence of 83% in preschool children (6 - 59 months), 71% in school aged children, 65% in pregnant women and 58% in lactating women (Quarshie and Amoaful, 1998). Asibey-Berko et al. (1999) also reported prevalence of 70% among children, while the Micronutrient Initiative (Manson, 2001) puts the prevalence in children at 65%.

For a long time, it has been recognized that fortifying complementary food with iron when iron stores have significantly depleted, especially for children at 4 - 6 months, is a step in the right direction (INACG, 1986; Rush et al., 1988). It was against this background that the iron-fortified maize-cowpea flour was developed and its efficacy tested in a community intervention trial. The aim of this study was to quantify the effect of iron fortified maize-cowpea blend on iron deficiency anaemia.

RESEARCH DESIGN AND METHODOLOGY

Setting and study population

This was a randomized control (intervention) trial. The study took place in two peri-urban communities (Danfa and Otinibi) in the Greater Accra Region, Ghana. The sites were chosen because their ethnicity is fairly homogeneous, and demographic, ethnographic and other social characteristics are similar for the two communities.

Inclusion criteria were: Child must be between 6 and 18 months old, reside in the village for the next 7 months following the start of the study, be free from any illness, not show any signs of malnutrition and have haemoglobin levels ≥ 9 g/dl. Children who were on iron supplements, had received blood transfusion and were not available for baseline haematological screening were excluded.

The participants in the current study were 60 pre-school children; 26 boys and 34 girls. Participants were randomly assigned into two groups: the test group (31 children) who received the intervention diet and the control group (29 children) who received a placebo diet (non-fortified maize-cowpea blend). Recruitment was done over a period of 5 days and was achieved with the help of opinion leaders as well as community volunteers in the communities. Written informed consent was obtained from each participating mother after the study was explained to her. Ethical clearance was obtained from the University of Ghana Internal Review Board.

Study diets

Maize-cowpea blend was used in this study, and it consisted of 80% maize (*Zea mays*) and 20% cowpea (*Vigna unguiculata* Walp). The preparation of the dough and fermentation using traditional methods have been described elsewhere (Sanni et al., 2002). The fermented dough was dehydrated in an oven at 45°C for 9 - 12 h and milled into fine flour. The flour was divided into two parts and to one part (the test diet) ferrous fumarate added (Iron fortified blend). The control diet did not have ferrous fumarate. Dry rations were distributed weekly to mothers on take-home basis, and they were encouraged to use the ration at least 3 times daily to prepare complementary foods for feeding the children. The duration of the feeding programme was 6 months. To ensure compliance, mothers were visited randomly at home by a trained nutritionist to observe the preparation of ration and feeding to their children. The children liked the diets, and preparation did not create an additional burden for mothers. The iron content for the test diet and the control diet were 184 mg/kg dry weight and 75.7 mg/kg dry weight, respectively. Mean daily intake of iron by the children in the iron-fortified and non iron-fortified groups were 12.2 ± 0.4 mg and 5.2 ± 1.0 mg, respectively.

Data collection

Semi-structured interview type questionnaires were administered to mothers at baseline and at follow-up assessments. Data collected included socio-demographic information, infant feeding practices, as well as dietary intake of children using repeated 24 h recall method. Anthropometric measurements, including weight, length and mid upper arm circumference (MUEC) were collected. In addition, information on source of drinking water was obtained. Venous blood was collected for haematological assessment. All interviews and physical measurements were done by a trained nutritionist, and blood samples were drawn by a certified nurse practitioner.

Measures

Socio demographic

Demographic information collected included: (1) ethnicity, (2) age, (3) educational level, (4) number of people in household and (5) current employment status.

Anthropometry

Subjects were weighed naked to the nearest 10 g with a digital beam balance (perspective enterprises, portage, MI). Recumbent length was measured to the nearest 0.1 cm with a portable measuring board (an infantometer). MUAC was taken to nearest 0.1 cm using an insertion tape. Weight and length measurements were transformed into z-scores using the national centre for health statistics reference (NCHS, 1978). Participants were classified as moderately or severely malnourished if z-score is below -2 SD and severely malnourished if MUAC is below 11.0 cm.

Haematological tests

About 5 ml of venous blood was taken from each subject and

Table 1. Baseline anthropometric and haematological characteristics of children[1].

Indices	Iron-fortified diet n = 29	Non iron-fortified diet n = 27	p-value
Age (months)	11.10 ± 4.13	11.37 ± 4.26	0.8127
Weight (kg)	8.22 ± 1.41	7.72 ± 1.56	0.2132
Length (cm)	73.04 ± 5.61	72 .19 ± 6.39	0.5971
Weight-for-length	- 1.10 ± 1.15	- 1.45 ± 0.94	0.2161
Weight-for-age	- 1.01 ± 1.23	- 1.59 ± 1.11	0.0710
Length-for-age	- 0.17 ± 1.19	- 0.60 ± 1.22	0.1845
MUAC (cm)	14.27 ± 1.21	13.96 ± 1.47	0.3853
Hb (g/dL)	10.78 ± 1.23	10.99 ± 2.03	0.6825
Serum iron (µmol/ L)	17.18 ± 2.80	17.39 ± 2.91	0.7877
TIBC (µmol/ L)	63.05 ± 8.11	61.46 ± 7.52	0.6428
TS (%)	28.19 ± 5.89	28.34 ± 5.30	0.9203

[1]Mean ± SD.

centrifuged. Serum obtained was kept frozen at - 20°C until ready for analysis. Haemoglobin (Hb) concentration was done using a Hemocue Haemoglobinometer. Serum iron and Unsaturated Iron-Binding-Capacity (UIBC) were measured using colorimetric methods (Artiss et al., 1981; WHO/UNICEF/UNU, 1996). Total iron-binding-capacity (TIBC) was expressed as the sum of serum iron concentration and UIBC. Transferrin saturation (TS) was expressed as a percentage of serum iron and TIBC. TS below 16% was considered iron deficient and values above this cut-off point were thought consistent with adequate iron stores.

Data analysis

Statistical analyses were carried out using Epi Info Version 3.4.3 and Statgraphics. Descriptive statistics were run for the sample, and independent samples student t-test analyses were used to evaluate significant differences between baseline and post-intervention variables. Regression and correlation were used to establish relational associations. The relative risk (point estimate) was calculated to estimate the effect of iron fortification on the incidence of anaemia. A 95% confidence interval was determined to give a range of estimates that are also consistent with the data.

RESULTS

Background of mothers and environment

Background information about the children's mothers and the environment in which they live are important since these factors can impact on nutrient intake among children. Literacy rate was low among the mothers; about two-thirds have had no form of formal education. The average household size ranged between 3 and 6 persons, although a few (about 10%) had more than 7 members in the household. Source of drinking water for the majority of the participants (57%) is a pond at the outskirts of town. A few had access to treated water which is purchased from water tankers owned by private individuals. About a third of the respondents are involved in petty trading, while a few are professionals such as teachers, dressmakers, caterers and nurses.

Children's profile

The age distribution of the children ranged between 6 and 23 months, with boys making up 46% and girls 54%. Table 1 summarises the baseline anthropometric and haematological characteristics of the children. At baseline, no significant differences were observed for all anthropometric indices between the test and control groups. Z-scores of weight-for-age (WFA), and weight-for-length (WFL) were low. The MUAC for the test and control groups were 14.27 (1.21) cm and 13.96 (1.47) cm, respectively.

Relatively smaller percentages of children were wasted, about 4 and 7%; stunting 10.3 and 11.1%; and underweight 20.8 and 18.5% in test and control groups respectively. MUAC identified a higher proportion of malnourished children. 24.1% and 29.6% of participants in test and control groups were malnourished (mild to moderate). Severe malnutrition was recorded in 3.6% of participants.

Post-intervention data showed a decreasing trend of malnutrition in both test and control groups. Underweight decreased to 17.2 and 14.8% in test and control groups. Percentage of stunting decreased to 6.9% in the test but no change in the controls. However, the differences observed in both groups were not statistically significant. Severe malnutrition as assessed by MUAC was totally eliminated in both groups.

The dietary profiles of the children were consistent throughout the study, with very little variety in consumption behaviour. About 57% of children were given meat at least once in a week whenever available. Fish was the preferred choice by mothers and as such, fed frequently to children. Slightly over half (52%) of children were given fish at least two times in a week. Eggs and milk were seldom fed. Beans, the black-eye

Table 2. Haematological profile of children.

Indicator	Iron-fortified (n=29)		Non iron-fortified (n=27)	
	Baseline	**Post intervention**	**Baseline**	**Post intervention**
Hb (g/dl)[1]	10.78 ± 1.23	11.86 ± 1.49	10.99 ± 2.03	10.60 ± 1.37
Serum iron (μmol/ L)	17.18 ± 2.80	16.87 ± 3.32	17.39 ± 2.91	16.18 ± 2.69
TIBC (μmol/ L)	63.05 ± 8.11	57.06 ± 13.03	61.46 ± 7.52	59.39 ± 11.53
% TS	28.19 ± 5.89	30.12 ± 10.18	28.34 ± 5.30	29.41 ± 6.96
% Fe deficient	10.3	6.9	7.2	3.7

[1]p = 0.0009.

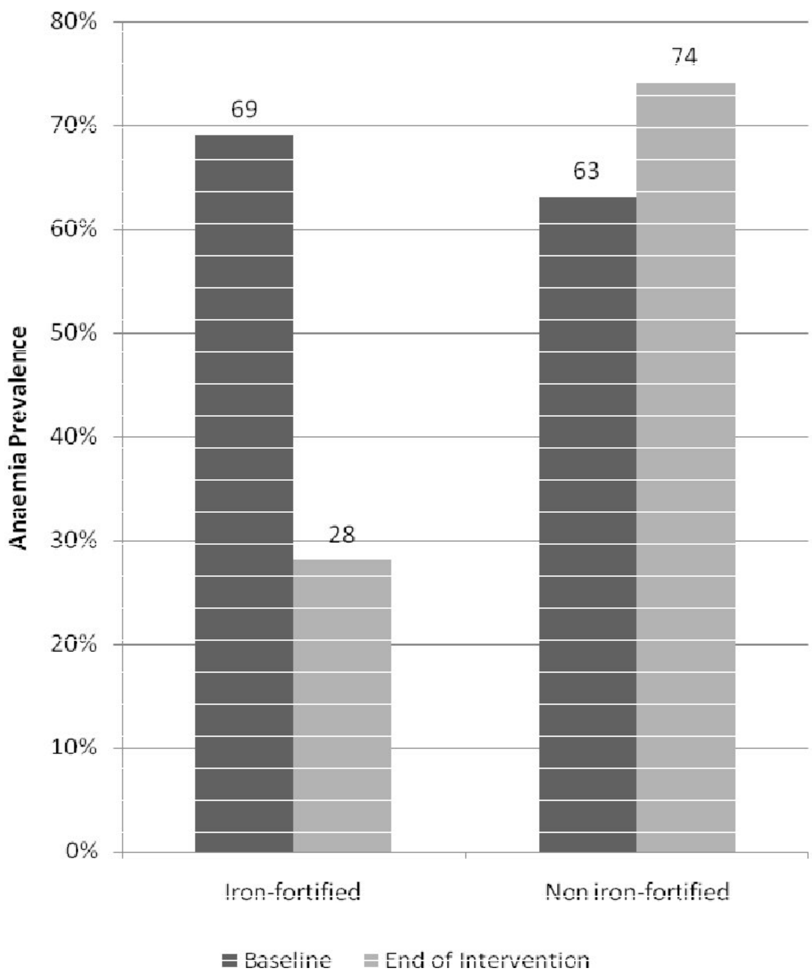

Figure 1. Prevalence of anaemia among children in the study.

peas, rank second after fish as the major source of protein in the diets of the children. Maize, rice and millet are fed to the children regularly. Oranges were given to the children on a regular basis. In general, diets of all subjects were similar and consistent.

The baseline and follow-up haematological characteristics are presented in Table 2 and Figure 1. There were no significant differences between test and control groups at baseline. At the end of the intervention, a statistically significant difference was observed between the mean haemoglobin of test and control groups, (0.0009). The number of children with low transferrin saturation declined in both groups but this was not statistically significant.

Hb levels of the majority of the children in both groups were low at the start of the study. About 38% of the total sample had mild anaemia (Hb between 9 g/dl and 11 g/dl), and 32% of participants were moderately anaemic

(Hb below 9 g/dl). Overall, the prevalence of anaemia was high (70%). The serum transferrin saturation values observed were within the normal range. There was an increase in mean Hb level with corresponding decline in the prevalence of moderate anaemia in the iron fortified group (from about 24-7%). The relative risk of developing anaemia was 3.10 (p = 0.003, CI 1.47 - 6.5) times less likely for children who consumed the iron-fortified maize-cowpea diet.

DISCUSSION

Anthropometry

Growth of preschool children is commonly used as an indicator of their nutritional status. MUAC has also been shown to correlate well with clinical and other anthropometric indicators of nutritional status (Chen, 1980; Gayle, 1988), making it an excellent indicator in assessing nutritional status. In the present study, using MUAC, we identified a higher percentage of malnutrition among the children than weight-for-height, and this is in concordance with what has been reported in the literature (Velzeboer et al., 1983; Zeitlin, 1986; Sefa-Dedeh et al., 1996). Stunting, which is an index of past chronic malnutrition, was relatively low and this could be due to the fact that the age bracket of the children was below the cut-off point of 18 and 23 months where stunting peaks.

Impact of diet on iron nutrition

Maize-cowpea flour is an improved weaning food over the traditional porridge (koko). Its use in intervention studies has been well-documented (Dallman et al., 1980). Iron fortification of weaning foods is a targeted strategy aimed at reducing iron deficiency and anaemia in infants and young children. The high prevalence of anaemia (70%) observed in the current study is consistent with findings of other studies (Quarshie and Amoaful, 1998; Asibey-Berko et al., 1999, WHO/NHD, 2001). Nonetheless, the prevalence of iron deficiency was relatively low (transferrin saturation below 16%). This phenomenon has been observed in physiological studies where iron stores are more likely to be depleted by 6 months after birth and to 2 - 3 years of age (Cook and Bothwell, 1984; Oski, 1993; Lutter et al., 2008).

Data shows that the highest rate of anaemia among pre-school children is found among 12 - 24 months of age, which could be explained by a rapid growth during this period (Hallberg et al., 1992). At this stage there is an increase in the total number of red blood cells and in muscle mass, which occurs with normal development. The high prevalence of anaemia reported in the present study could have been contributed by dietary factors.

Although mean iron intake at baseline was high, this was mainly from plant sources. Plant foods may contain high levels of iron but are not highly bioavailable. Consumption of cereal, particularly maize, was high. This is consistent with a study in Nigeria where the high rate of anaemia in children was attributed to cereal-based diets (WHO/NHD, 2001). Of particular importance is the presence of phytates and fibre in the cereal-based products which tend to bind iron thereby making it unavailable; and secondly, maize is also low in iron.

The effect of iron-fortified food on iron status was significant in which the 6 months of feeding. This period is within the time frame of one year that 80% of adjustment in iron stores occurs when changes in dietary intake of bioavailable iron is instituted (Ballot et al., 1989). The statistically higher Hb concentration observed in the fortified children confirms findings from other related studies (Bradley et al., 1993; Walter et al., 1993; Lartey et al., 1999).

Other studies have reported significant changes in serum ferritin but not in transferrin saturation, (Kruger et al., 1996; Soemantri et al., 1985). In addition, Soemantri et al. (1985) did not find significant differences in TIBC and transferrin between fortified and control groups. They speculated that possible decrease in the rate of viral and bacterial infection had a greater effect on transferrin saturation than the additional iron intake. Infection and iron deficiency are both associated with decreased transferrin saturation but they have the opposite effect on TIBC.

IMPLICATION FOR NUTRITION AND HEALTH

The findings in this study show that fortification of the cowpea-maize blend with iron had a significant positive effect on iron status and iron deficiency anaemia (IDA) in children. These results were achieved with little interference in dietary behaviour and care givers time, food preparation techniques and other resources. The control diet is an improved diet over the traditional maize-only porridge (koko), and its efficacy in preventing protein energy malnutrition (PEM) has been recognized. Nonetheless, it is limited in iron, which is critically needed at the early years of development in a child's life. The addition of iron to this diet makes it complete and will help alleviate the double burden of PEM and IDA in infants and young children in developing countries.

Additionally, adequate iron intake is necessary for brain development, and its deficiency is implicated in impaired cognitive development (Lozoff et al., 2006; Pollitt, 1993).

Therefore, if the problem of iron intake and hence anaemia is not addressed properly, then children are likely to experience problems with learning at school age. According to Sanghvi et al. (2007), the learning capability may occur regardless of brain damage: the controlling factor here is the presence of anaemia. Children with moderate IDA have scored lower in tests compared with their peers of normal standing (Pollitt, 1993; Lozoff, 1988; Pollitt et al., 1989). However, early nutritional supplementation eliminated the decline in test scores (Pollitt et al., 1989; Soewondo et al., 1989).

LIMITATIONS

Infections such as malaria and other infestations are important in the aetiology of ID and IDA. Aside from dietary inadequacy, malaria is a major contributor to anaemia prevalence. Only a few of the subjects reported malaria one month prior to the commencement of the intervention. Moreover, worm infestation did not contribute significantly to iron deficiency and anaemia in infants and young children (Quarshie and Amoaful, 1998). The number of children in the study was also too small to generalise our findings but the data is promising and forms the basis for larger intervention studies.

Conclusion

Iron status and IDA during infancy and childhood are affected by both external (diet, socioeconomic and educational) and internal factors (bioavailability of iron, infections and infestations). The implications on health and development cannot be overemphasised and need to be considered in totality in intervention programmes. Furthermore, the use of cowpeas and maize flour as a vehicle for the fortification is a step in the right direction. This is because the food agent for fortification is culturally tailored and relevant, hence making acceptability and usage very effective.

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