Agro-Science
Journal of Agriculture, Food, Environment and Extension
Volume 3, Number 2

ISSN 1119-7455 URL: http://www.agrosciencejournal.com/

# ADEQUACY OF MICRONUTRIENT CONTENT OF SOUTH EASTERN NIGERIAN MEALS IN MEETING THE NUTRITIONAL NEEDS OF VULNERABLE GROUPS.

**Madukwe, E. U. and Ene-Obong, H. N.**
Department of Home Science and Nutrition University of Nigeria Nsukka

All correspondence should be addressed to Mrs. E. U. Madukwe, Department of Home Science and Nutrition, University of Nigeria, Nsukka, Enugu State Nigeria.

## ABSTRACT

*The Zinc (Zn), iron Fe) and copper (Cu) contents and their bioavailability in south-eastern Nigerian meals were evaluated. Their adequacy in meeting the nutritional requirements of pregnant and lactating women and preschool children were determined. Mineral content was determined using atomic absorption spectrophotometer after dry ashing. Phytate was determined by the ion exchange method. The bioavailability of Zn was evaluated using the phytate: Zn molar ratio (PZMR). Bioavailability of iron was determined by the in vitro procedure involving a simulated gastrointestinal digestion followed by dialysis. Portion sizes of meals consumed by these vulnerable groups were obtained during an interview and validated using data obtained from food consumption surveys. The amount of Zn and Fe in such portions were calculated and compared with the recommended intakes. Zn content of the meals ranged from 1.18mg to 4.99mg/100g, Fe from 1.10mg to 3.31mg/100g and Cu from 0.03mg to 0.21mg/100g edible portion or as consumed. Phytate levels varied from 4.11mg to 53.05mg/100g. The PZMR of the meals and serving portions were <10. Bioavailability of iron from the meals varied from 6-26%, while that of Cu varied from 1-59%. The diets were found to contain enough micronutrients to meet nutritional requirement of the vulnerable groups. However, the amount of bio-available Fe and Cu were grossly inadequate for all the groups. The results showed that Zn deficiency in Southern Nigerian may not be due to inadequate intake or phytic acid content of foods but probably due to interaction with other dietary components. This study highlights the need for dietary modification and other nutrition intervention for the Nigerian population and particularly the vulnerable groups.*

Keywords: Micronutrients, diets, vulnerable groups, Nigeria

## INTRODUCTION

Micronutrient deficiencies are a major public health problem in both developed and developing nation of the world, due to their enormous health, social and economic impact. Long- term answers to preventing micronutrient deficiencies lie in nutrition education, modifying diets and eating habits, food fortification and the sustainable production of micronutrient - rich foods.

Several attempts have been made by individuals and groups to determine the nutrient composition of Nigeria foods/diets. Some include the works of Eka and Edijala (1972); Ubani *et al.,* (1980); Akinyele and Osibanjo (1982) Nnanyelugo *et al.* (1985). Ene-Obong (1993). Okeke and Ene-Obong (1995) and Akpanabiatu *et al.* (1998). More recently is the published food composition table by Oguntona and Akinyele (1995). Since the nutritional quality of foods/ diets depend not just on the nutrient content but also on the availability and utilisation of the nutrients, there is need to evaluate Nigerian foods/diets in term of what is biologically available.

Nigeria foods/diets are essentially of plant/vegetable origin. According to Sayer *et al.* (1974) foods/diets of vegetable origin are consumed in developing countries in quantities which contain most of the essential elements in excess of individual requirements when total intakes are compared.. Earlier attempts to evaluate the micronutrient contents of some Nigerian foods/diets using the Metallocalorie ratio (MCR) (Mhafing et al., 1984) and the index of Nutritional Quality (INQ) (Ene-Obong., 1993) showed that these food/diets are able to provide more than enough of these nutrients when consumed at recommended energy levels. Despite the apparent adequacy of these micronutrients in varied food items, their deficiency disorders are still prevalent. Etiologically factors contributing to micronutrient deficiencies include inadequate dietary intake, excessive losses, increased requirement, reduced store, genetic factors, decreased availability and decreased absorption. In this study we have attempted to evaluate the adequacy of Nigerian foods/diets in meeting the nutritional needs of vulnerable groups based on both the contents and relative bio- availability of iron, zinc and copper. It is hoped that this will help to justify the implementation of some short-, medium-, and long-term intervention that will alleviate micronutrient deficiencies among vulnerable groups in Nigeria.

## MATERIALS AND METHODS

**Materials**: All ingredients for the preparation of the foods/diets were purchased from the urban main market, Nsukka, Enugu State, Nigeria

**Preparation of Samples**: Sixteen dishes were selected based on the list of dishes commonly consumed in Southeastern Nigeria as identified by Anele (1980), Asake (1988), Egbuna (1986), Nnanyelugo *et al*. (1985), Okeke and Ene-obong (1995). The recipes used were as outlined by Anele (1980), Asake (1988) and Egbuna (1986).

Below are the ingredients that made up the dishes:

CF - Cassava foofoo (*Manihot spp*): fermented, cooked cassava paste

YF - Yam foofoo (*Dioscorea spp*): Boiled yam, pounded into paste

YP - Yam pottage (*Dioscorea spp*): Yam cubes, boiled with salt, palm oil, crayfish, pepper, water; cooked into a pottage.

GA _ Gari (*Manihot spp*): Grated, fermented cassava, sieved and toasted and soaked in boiled water

UO - Ukpo-Ogede (*Musa paradisiaca*): Mixture of mashed ripe plantain with plantain flour or yam flour, salt, pepper, crayfish, palm oil and steamed into a pudding.

MM _ Moi-moi (*Vigna unguiculata*): Wet milled dehulled cowpea paste mixed with vegetable oil, pepper, crayfish, onion, salt and steamed into a pudding

BP - Bean pottage (*Vigna unguiculata*): Cooked cowpea mixed with palm oil, pepper, salt, onion, Crayfish.

OK - Okpa (*Vigna subteranea*): Mechanically dehulled, dry milled bambara nuts flour mixed with palm oil, salt, water and steamed into a pudding.

AY - Ayaraya (*Cajanus cajan and Xanthosoma spp*): Mixture of boiled pigeon pea; cracked, soaked, and steamed cocoyam[a], onion, pepper, salt, fermented and sliced oil bean seed (*Pentaclethra macrophylla*), and crayfish (optional).

AK-Akara (*Vigna unguiculata*): Wet milled dehulled cowpea whipped and mixed with pepper, onions, salt and deep fried in balls in vegetable oil

PA - Pap (*Zea mays*): Fermented, wet milled, sieved maize paste, slurried and gelatinized with boiled water

IO - Igbangwu - Oka ( *Zea mays*): wet - milled parboiled maize mixed with palm oil, pepper, onions, crayfish, fermented slices oil bean seed, egg plant leaf (*Solanum spp*) and steamed into a pudding

JR - Jollof rice (*Oryza sativa*): Rice cooked in tomatoes sauce ( containing pepper, oil, and water, salt, vegetable oil, curry powder, maggi cubes). Meat/fish maybe used.

ES - Egusi Soup or sauce (*Citrullus vulgaris*): Cooked with ground melon seeds, crayfish, pepper, palm oil, water, salt fluted pumpkin or bitterleaf or any preferred vegetable, dry fish, meat, fermented locust bean

BS - Bitterleaf Soup or sauce (*Vernonia amydalina*): Cooked with dry fish, meat, pepper,

palm oil, water, crayfish, fermented locust bean *(Parkia spp.)*, cocoyam paste, bitter leaf.
OS - Okro Soup or sauce (*Hibiscus esculentus*): Sauce cooked with okro, meat, crayfish, dry fish, pepper, palm oil, salt, water, fluted pumpkin , fermented locust bean *(Parkia spp.)*
a = previously cooked, slice and dried cocoyam traditionally called "achicha"

**Determination of Portion Sizes:** Thirty (30) randomly selected pregnant and lactating mothers/women attending ante-natal and Immunization Clinics at Bishop Shanahan Hospital, Nsukka were interviewed. They were asked to indicate for each of the prepared meals their normal portion and the quantity they served their preschool aged children. The weights of each of the meals contained in the displayed bowls/plates of different sizes were determined. These were also validated with portion sizes obtained from food consumption surveys in the area.

**Chemical Analysis:** All utensils were washed thoroughly with acetone, 2M nitricacid and distilled/deionised water before use. Each meal was homogenized separately. Portions were taken from each for moisture determination. The remaining portions were dried at about 55°C - 60°C in an air oven. The dried samples were milled and stored in the freezer until further analysis. Moisture was determined by the oven drying method at 105°C (14). Zinc (Zn), copper (Cu) and iron (Fe), were determined after dry ashing using Atomic Absorption Spectrophotometer (AAS).

**Bioavailability Assay:** Iron and copper bioavailability were determined by a modification of the methods of Miller *et al.* (1981) and modification of Nolan *et al.* (1987), respectively. The former is an *in vitro* simulated gastrointestinal digestion followed by dialysis. Meals were homogenized and exposed to pepsin at pH 2. Dialysis was used to adjust the pH to intestinal levels and digestion was continued after the addition of pancreatic and bile salts. Iron from the digestion mixture which diffused across a 6 to 8000 molecular weight cut-off semi permeable membrane was used as an indicator of available iron. Dialyzable iron was determined using the bathophenthroline sulphate reagent. Copper was determined by the use of AAS. Zinc bioavailability was determined using phytate: zinc molar ratio (PZMR) as proposed by Oberleas and Prasad (1976).

**Analysis of data**: Mean ± SD of analysed valued were computed for each of the diets. The percentage contributions of the available micronutrient were calculated based on the FAO/WHO (1988) requirements for iron and the WHO (1996) requirement for copper and zinc. Although the PZMRs of the diets were adequate, the normative requirements on diet of moderate Zn bioavailability were used. For preschool children a mean of 3.6mg/d was used while for pregnant and lactating women a mean of 10.3mg/d and 12.2mg/d, respectively were used. For iron, the requirement to prevent anaemia (RPA) (ie adequate to prevent overt anaemia) was used for low bioavailability diets FAO/WHO (1988). The adequacy of Cu was also determined using the normative requirements of 0.57mg/d for preschool children, 1.15mg/d for pregnant women and 1.25mg/d for lactating women. A phytate: zinc molar ratio of <10 was regarded as adequate. A diet that satisfied 30% or more of requirement was also considered adequate.

## RESULTS

Table 1 shows the total micronutrients in the foods analysed. Total iron in the diets ranged from 1.10 - 3.31mg/100g edible portion with the fermented maize gruel (PA) having the lowest values. Total copper content of the dishes varied from 0.03 - 0.21mg/100g edible portion. Total zinc content ranged from 1.18 - 4.99mg/100g edible portion. The PZMR were all <10 (0.20-1.28).

**Table 1: Iron, copper zinc, phytate content and phytate: zinc molar ratios (PZMR) of South-eastern Nigerian[a] dishes (per 100g as consumed)**

| Dishes | Total iron mg | Total copper mg | Total Zinc mg | Phytate mg | PZMR mg |
|---|---|---|---|---|---|
| **a) Starchy based diets** | | | | | |
| Cassava foofoo (CF) | 1.70 ± 0.32 | 0.14 ±0.05 | 3.32 ± 0.11 | 4.17± 0.02 | 0.12 |
| Yam foofoo (YF) | 1.50 ± 0.16 | 0.10 ± 0.01 | 2.74 ± 0.17 | 15.42± 0.04 | 0.57 |
| Yam Pottage (YP) | 2.48 + 0.18 | 0.20 ± 0.02 | 3.09 ± 0.03 | 15.47 ± 0.01 | 0.50 |
| Garri (GA) | 2.11 ± 0.18 | 0.06 ± 0.03 | 2.72 ± 0.16 | 5.44 ± 0.01 | 0.20 |
| Ukpo- Ogede (UO) | 1.74 ± 0.14 | 0.09 ± 0.02 | 3.15 ± 0.06 | 12.73 ± 0.04 | 0.40 |
| **b) Legume - based dishes** | | | | | |
| Moi-moi (MM) | 2.70 ± 0.18 | 0.18 ± 0.02 | 2.83 ± 0.14 | 31.58 ± 0.04 | 0.20 |
| Bean Pottage (BP) | 2.27 ± 0.17 | 0.17 ± 0.01 | 3.98 ± 0.25 | 27.16 ± 0.02 | 0.90 |
| Okpa (OK) | 2.27 ± 0.14 | 0.15 ± 0.02 | 3.33 ± 0.12 | 32.88 ± 0.02 | 0.98 |
| Ayaraya (AY) | 3.31 ± 0.18 | 0.20 ± 0.01 | 4.99 ± 0.02 | 53.05 ± 0.02 | 1.05 |
| Akara (AK) | 2.85 ± 0.30 | 0.17 ± 0.02 | 3.77 ± 0.26 | 48.46 ± 0.01 | 1.28 |
| **c) Cereal based dishes** | | | | | |
| Pap (PA) | 1.10 ± 0.26 | 0.03 ± 0.01 | 1.18 ± 0.03 | 3.13 ± 0.02 | 0.27 |
| Igbagwu- Oka (IO) | 2.48 ± 0.01 | 0.21 ± 0.01 | 3.60 ± 0.05 | 10.85 ± 0.01 | 0.30 |
| Jollof rice (JR) | 1.54 ± 0.13 | 0.11 ± 0.01 | 2.82 ± 0.05 | 9.20 ± 0.01 | 0.32 |
| **d) Soups** | | | | | |
| Egusi Soup | 2.72 ± 0.14 | 0.09 ± 0.01 | 1.69 ± 0.14 | 5.25 ± 0.01 | 0.31 |
| Bitterleaf soups(BS) | 2.25 ± 0.19 | 0.09 ± 0.01 | 1.98 ± 0.19 | 7.29 ± 0.01 | 0.36 |
| Okoro soup (OS) | 1.66 ± 0.15 | 0.06 ± 0.02 | 1.59 ± 0.00 | 4.43 ± 0.01 | 0.28 |

A: Values in parentheses represent percentage of absorbed mineral

YP = Yam pottage; UO = Ukpo-Ogede; BP = Bean pottage; AY = Ayaraya;
IO = Igbagwu-Oka; JR = Jollof Rice; CF = Cassava foofoo; YF = Yam foofoo;
ES = Egusi soup; BS = Bitter leaf soup; OS = Okro soup; GA = garri;
PA = Pap; MM = Moi-moi; OK = Okpa; AK = akara

**Table 2: *In vivo* bioavailability of iron and copper of South –eastern Nigerian dishes (per 100g as consumed)**

| Dish (mg) | Absorbed iron(mg) | Absorbed copper |
|---|---|---|
| a) **Starch-based dishes** | | |
| Cassava foofoo (CF) | 0.10 (6) | 0.002(1) |
| Yam foofoo (YF) | 0.11 (7) | 0.040(36) |
| Yam pottage (YP) | 0.32 (13) | 0.020(11) |
| Gari (GA) | 0.17 (8) | 0.020(36) |
| Ukpo- Ogede (UO) | 0.20 (11) | 0.020(27) |
| b) **Legume-based dishes** | | |
| Moi-moi (MM) | 0.41 (15) | 0.030(17) |
| Bean pottage (BP) | 0.41(18) | 0.030(17) |
| Okpa (OK) | 0.36 (16) | 0.030(18) |
| Ayaraya (AY) | 0.20 (6) | 0.040(20) |
| Akara (AK) | 0.48 (17) | 0.030(18) |
| **c) Cereal-based dishes** | | |
| Pap (PA) | 0.13 (12) | 0.020(59) |
| Igbangwu oka (IO) | 0.29 (12) | 0.020(11) |
| Jollof rice (JR) | 0.29 (19) | 0.020(22) |
| **Soups** | | |
| Egusi soup (ES) | 0.37 (14) | 0.030(33) |
| Bitterleaf soup (BS) | 0.56 (25) | 0.003(3) |
| Okro soup (OS) | 0.43 (26) | 0.001(2) |

a: Values in parenthesis represent percentage of absorbed minerals

**Table 3: Bioavailable micronutrients in serving portions of Southeastern Nigeria dishes and their contribution to the requirements of pregnant women.**

| Dishes | Serving Protion (g) | Total iron (mg) | Available iron (mg) | Total copper (mg) | Available copper (mg) | Total zinc (mg) | PZMR (mg) |
|---|---|---|---|---|---|---|---|
| YP | 400 | 9.90 (34) | 1.29(9.4) | 0.78 (68) | 0.09(8) | 12.48(121) | 0.50 |
| UO | 395 | 6.88(24) | 0.78(2.7) | 0.35(30) | 0.10(9) | 12.44(121) | 0.40 |
| BP | 600 | 13.59(47) | 2.45(8.4) | 1.17(102) | 0.18(16) | 17.87(113) | 0.90 |
| AY | 600 | 19.88(69) | 1.19(4.1) | 1.19(104) | 0.24(21) | 29.93(290) | 1.05 |
| IO | 375 | 9.29 (32) | 1.10(3.8) | 0.77(67) | 0.09(8) | 13.51(130) | 0.30 |
| JR | 390 | 6.02(21) | 1.13(3.9) | 0.43(37) | 0.09(8) | 10.99(107) | 0.32 |
| CF:ES | 400:200 | 12.24(42) | 1.15(4.0) | 0.74(64) | 0.06(5) | 16.67(162) | 0.4 |
| CF:BS | 400:225 | 11.85(41) | 1.67(5.8) | 0.78(68) | 0.02(2) | 17.75(172) | 0.49 |
| CF:OS | 400:250 | 10.95(38) | 1.49(5.1) | 0.72(63) | 0.10(9) | 17.28(168) | 0.40 |
| YF:ES | 400:200 | 11.44(39) | 1.16(4.0) | 0.59(51) | 0.20(17) | 14.32(139) | 0.88 |
| YF:BS | 400:225 | 11.05(38) | 1.68(5.8) | 0.62(54) | 0.16(14) | 15.41(149) | 0.93 |
| YF:OS | 400:250 | 10.15(35) | 1.50(5.2) | 0.56(49) | 0.15(13) | 14.93(145) | 0.84 |
| GA:ES | 400:200 | 13:89(48) | 1.42(4.9) | 0.41(36) | 0.14(12) | 14.25(138) | 0.51 |
| GA:BS | 400:225 | 13:51(47) | 1.92(6.7) | 0.45(39) | 0.10(9) | 15.34(149) | 0.56 |
| GA:OS | 400:250 | 12:61(43) | 1.76(6.1) | 0.29(25) | 0.09(8) | 14.87(144) | 0.47 |
| PA:MM | 300:350 | 12.75(44) | 1.80(6.2) | 0.71(62) | 0.16(14) | 13.40(130) | 1.37 |
| PA:OK | 300:450 | 13.4(47) | 2.30(7.0) | 0.74(64) | 0.17(15) | 18.48(179) | 1.25 |
| PA:AK | 300:150 | 7.55(26) | 1.02(3.5) | 0.34(30) | 0.10(9) | 9.16(89) | 1.54 |

a: Values in parentheses represent percentage contribution to requirement.

YP = Yam pottage; UO = Ukpo-Ogede; BP = Bean pottage; AY = Ayaraya; IO = Igbagwu-oka; JR = Jollof rice; CF = Cassava foofoo; YF = Yam foofoo; ES = Egusi soup; BS = Bitter leaf soup; OS Okro soup; GA = garri; PA = Pap; MM = Moi-moi; OK = Okpa; AK = akara

**Table 4: Adequacy of serving portions of Southeastern Nigerian dishes in meeting the micronutrient needs of lactating women**

| Dishes | Serving Portions (g) | Total iron (mg) | Available iron (mg) | Total copper (mg) | Available copper (mg) | Total Zinc (mg) | PZMR (mg) |
|---|---|---|---|---|---|---|---|
| YP | 400 | 9.90(58) | 1.29(8) | 0.78(62) | 0.09(7) | 12.38(102) | 0.50 |
| UO | 425 | 7.40(44) | 0.84(5) | 0.38(30) | 0.10(8) | 13.39(110) | 0.40 |
| BP | 635 | 14.4(84) | 2.59(15) | 1.10(88) | 0.19(15) | 18.91(155) | 0.90 |
| AY | 625 | 20.71(122) | 1.24(7) | 1.24(99) | 0.24(19) | 31.18(226) | 1.05 |
| IO | 375 | 9.29(55) | 1.10(6) | 0.41(33) | 0.09(7) | 13.51(111) | 0.03 |
| JR | 425 | 6.56(39) | 1.23(7) | 0.47(38) | 0.10(8) | 11.97(98) | 0.32 |
| CF:ES | 400:250 | 13.60(80) | 1.34(8) | 0.79(63) | 0.08(6) | 17.51(144) | 0.43 |
| CF:BS | 400:225 | 11.85(70) | 1.67(10) | 0.78(62) | 0.02(2) | 17.75(146) | 0.49 |
| CF:OS | 400:25 | 10.95(64) | 1.49(9) | 0.72(58) | 0.01(1) | 17.28(142) | 0.40 |
| YF:ES | 400:250 | 12.80(75) | 1.35(8) | 0.63(50) | 0.22(18) | 15.16(124) | 0.88 |
| YF:BS | 400:225 | 1.05(65) | 1.68(10) | 0.62(50) | 0.16(13) | 15.41(126) | 0.93 |
| YF:OS | 400:250 | 10.15(60) | 1.50(9) | 0.56(49) | 0.15(12) | 14.93(122) | 0.84 |
| GA:ES | 400:250 | 15.25(90) | 1.61(10) | 0.46(37) | 0.16(13) | 15.10(124) | 0.51 |
| GA:BS | 400:225 | 13.51(79) | 1.94(11) | 0.45(36) | 0.95(8) | 12.91(106) | 0.56 |
| GA:OS | 400:250 | 12.61(74) | 1.76(10) | 0.39(31) | 0.09(7) | 12.43(102) | 0.47 |
| PA: MM | 300:500 | 16.80(99) | 2.42(14) | 0.98(78) | 0.20(16) | 17.64(145) | 1.37 |
| PA: OK | 300:450 | 13.49(79) | 2.03(12) | 0.98(78) | 0.17(14) | 18.68(153) | 1.25 |
| PA: AK | 300:150 | 7.55(44) | 1.12(7) | 0.34(27) | 0.10(8) | 9.16(75) | 1.54 |

a: values in parentheses represent percent percentage contribution to requirement.

YP = Yam pottage; UO = Ukpo-Ogede; BP = Bean pottage; AY = Ayaraya; IO = Igbagwu-oka; JR = Jollof rice; CF = Cassava foofoo; YF = Yam foofoo; ES = Egusi soup; BS = Bitter leaf soup; OS Okro soup; GA = garri; PA = Pap; MM = Moi-moi; OK = Okpa; AK = akara

**Table 5:** Adequacy of Adults in meeting the Micronutrient needs of Pre-School Children[a]

| Dishes | Serving Portions (g) | Total iron (mg) | Available iron (mg) | Total copper (mg) | Available copper (mg) | Total zinc (mg) | PZMR (mg) |
|---|---|---|---|---|---|---|---|
| YP | 200 | 4.95(58) | 0.64(8) | 0.39(68) | 0.04(7) | 6.19(173) | 0.05 |
| UO | 200 | 3.48(41) | 0.37(5) | 0.18(32) | 0.05(9) | 6.30(176) | 0.40 |
| BP | 275 | 6.23(73) | 1.12(13) | 0.48(84) | 0.08(14) | 8.19(229) | 0.90 |
| AY | 175 | 5.80(68) | 0.35(4) | 0.35(61) | 0.07(12) | 8.73(244) | 1.05 |
| IO | 250 | 6.20(73) | 0.74(9) | 0.51(89) | 0.06(11) | 9.01(252) | 0.30 |
| JR | 150 | 2.32(27) | 0.43(5) | 0.17(30) | 0.04(7) | 4.23(118) | 0.32 |
| CF:ES | 200:100 | 6.12(72) | 0.58(7) | 0.11(19) | 0.03(5) | 8.33(233) | 0.43 |
| CF:BS | 200:125 | 6.21(73) | 0.90(11) | 0.14(25) | 0.01(2) | 9.12(255) | 0.49 |
| CF:OS | 200:125 | 5.48(64) | 0.74(8) | 0.01(19) | 0.01(2) | 8.54(239) | 0.40 |
| YF:ES | 125:100 | 4.60(54) | 0.50(6) | 0.22(39) | 0.07(12) | 5.11(143) | 0.88 |
| YF:BS | 125:125 | 4.68(55) | 0.83(10) | 0.25(44) | 0.05(9) | 5.90(165) | 0.93 |
| YF:OS | 125:125 | 3.95(46) | 0.67(8) | 0.20(35) | 0.05(9) | 5.41(151) | 0.84 |
| GA:ES | 200:200 | 6.95(82) | 0.71(8) | 0.21(37) | 0.07(12) | 7.13(200) | 0.51 |
| GA:BS | 200:125 | 7.03(83) | 1.04(12) | 0.24(42) | 0.05(9) | 7.82(219) | 0.56 |
| GA:OS | 200:125 | 6.30(74) | 0.88(10) | 0.20(35) | 0.05(9) | 7.34(206) | 0.47 |
| PA: MM | 200:200 | 7.60(89) | 1.07(13) | 0.92(161) | 0.09(16) | 7.99(224) | 1.37 |
| PA: OK | 200:225 | 7.29(86) | 1.08(13) | 0.39(68) | 0.09(16) | 9.82(275) | 1.25 |
| PA: AK | 200:100 | 5.04(59) | 0.75(9) | 0.22(39) | 0.06(11) | 6.11(171) | 1.54 |

a: values in parentheses represent percentage contribution to nutrient requirement.
YP = Yam pottage; UO = Ukpo-Ogede; BP = Bean pottage; AY = Ayaraya; IO = Igbagwu-oka; JR = Jollof rice; CF = Cassava foofoo; YF = Yam foofoo; ES = Egusi soup; BS = Bitter leaf soup; OS Okro soup; GA = garri; PA = Pap; MM = Moi-moi; OK = Okpa; AK = akara

Table 2 shows the available iron and copper. Available iron was generally <1mg/100g edible portion. The soups and legume-based dishes had higher bio available iron (0.20-0.48mg and 0.37-0.56mg/100g edible portion, respectively) than the diets based on roots, tubers, starchy fruits and cereals. The available copper varied from 0.002- 0.04mg/100mg edible portion. Legume-based meals had higher bio available copper (0.03-0.04mg/100g edible portion) than all the other food groups. The bio available micronutrients in portion sizes consumed by pregnant women are shown on Table 3. With the exception of Ukpo-Ogede (UO), Jollof rice (JR), and Pap (PA): Akara (AK) for iron, Gari (GA): Okro soup (OS) for Cu, the total micronutrient content of the meals appeared adequate. However, bio available Fe and Cu were very inadequate with Fe contributing from 2.7% - 8.4% and Cu 2 - 21% of requirement. Phytate: Zn molar ratio was <2. For lactating mothers (Table 4), all the meals contained more than enough nutrients to meet requirements. Available Fe and Cu contents were also grossly inadequate contributing less than 20% of requirements. Zn intake was adequate for lactating women. For preschool children, bioavailable Fe and Cu were very inadequate (2-16% of requirement) (Table 5). Zn was also adequate (> 100% of requirement).

## DISCUSSION AND CONCLUSION

The results of this study are in line with earlier observation that foodstuffs of vegetable origin are consumed in developing countries in quantities which contain most of the essential elements in excess of individual requirements (Ene-Obong, 1993, (Sayers et al 1974). However, when the bioavailability of these elements was considered a grave picture emerged. For all the vulnerable groups bioavailable iron was grossly low and inadequate. This explains the high incidence of iron deficiency anaemia in Nigeria. The National mioronutrient Survey (OMNI/USAID, 1993) showed that 67% of pregnant women and 75% of children surveyed were iron deficient. The low bioavailability is obvious since the foods were mostly plant based with non-heme iron content. Although the "meat factor" was not considered, we assumed that this would not have made a significant change since meat is very expensive and beyond the reach of many in the rural areas and was not a major component of the soups/sauces.

It needs to be stated that in very deprived environments, the portion sizes given in this paper may not be attained, making the situation worse. In a study of pregnant women in Izzi Local Government Area of Ebonyi State, Nigeria, portion sizes were lower for fear of having big babies (mozie 2000). One of the major problems of Nigerian foods/diets is their high bulk, containing 50-88% moisture per 100% edible portion. This makes it impossible particularly for the preschool child with a small stomach capacity to consume much at a given time. Furthermore, fruits which are very good sources of ascorbic acid (an effective non-heam iron absorption enhancer) are not usually consumed together with these meals. These call for modification of diets and eating habits.

Available Cu from these food/diets appeared to be inadequate for all the vulnerable groups. Although Mbofung and Atinmo (1987) reported that pronounced Cu deficiency related to diet was uncommon, the data presented here, does not support this view. Copper is an essential element for a wide range of animal species (Davis and Mer 1987). It is a component of ceruloplasmin responsible for oxidation of iron to its trivalent ($Fe^{+3}$) state. Only as $Fe^{+3}$ can iron be coupled to its transport protein, transferrin. It is possible that the iron deficiency found in the Nigerian population is a combination of Fe and Cu deficiency. The low bioavailability of Cu could be due to the fact that Cu absorption is influenced by other dietary components e.g Zn and Fe which were reasonably high in these foods/diets. There is need for further investigation on the interaction of these micronutrients for the Nigerian population.

Foods of plant origin, including cereals and legumes, generally contain Zn with low bioavailability (O'Dell, 1969). Both endogenous and exogenous factors have been implicated as causative in reducing the absorption of Zn from foods of plant origin. It is generally thought that phytic acid is the major inhibitor of Zn utilization from foods of plant origin, especially in the presence of calcium. Fibre is also another factor. However, the PZMR of these foods/diets were low, showing that phytate exerted little effect on Zn bioavailability. This could be as a result of various foods processing methods adopted by Nigerian households e.g. fermentation (for cassava and pap). Even for legume-based dishes, PZMRs were low. This study also confirmed earlier study (Ene-Obong 1995). that these legumes pose no serious health problems to populations consuming them especially when appropriate processing has been applied. Based on the results above, we conclude that Zn deficiency in Nigeria may not be attributed to phytic acid or tannin but may occur as a result of it interaction with other dietary components. Calcium and dietary non-haem iron interfere with Zn uptake by direct competition.

There is need to revisit the issue of iron deficiency to find out whether it is due to inadequate intake, inadequate absorption, or excessive demand. This study points to low bio availability as the major cause of iron deficiency anaemia and other micronutrient deficiencies among the Nigerian population.

There is an urgent need for nutrition education to promote dietary change towards the consumption of micro-nutrient - rich foods together with bioavailability enhancers e.g. ascorbic acid which can be obtained from fruits. While food fortification with bio available micronutrients is supported there is also the need for genetic manipulation of our traditional plant foods in order to make their micronutrient contents available to the body when consumed. Micronutrient supplementation and improved food processing to increase bioavailability should also continue to be exploited.

## REFERENCES

Akpanabiatu, M. I, Bassey, N. B, Udosen, E.O AND Eyong, E. U. (1998) Evaluation of some minerals and toxicants in some Nigerian soup meals J. Fd Composition and Analysis. 11, 292-297

Akinyele I.O. and Osibanjo (1982) Levels of some trace elements in hospital diets.. Fd Chem. 8, 247-257

Anele, N.I. (1980) Identification of Nigerian recipe. Starchy roots and tubers and soups. Home Economics Education. Thesis Department of Vocational Teacher Education, University of Nigeria Nsukka.

Asake, O. S (1988) Chemical analysis and biological evaluation of common dishes and fermented foods in Anambra State, Nigeria. Thesis Department of Home Science and Nutrition, University of Nigeria, Nsukka

Aoac (1990) Official Method of Analysis of the Association of Official Analytical Chemists, 14th Edition, Washington, D.C Association of Official Analytical Chemistry. MILLER, D, D. SCHRICKER, R.R, RASMUSSEN, R.R AND VAN CAMPEN, D. (19810 An *in vitro* method for estimation of iron availability from meals Am. J. Clin. Nutr 34, 2248-2254.

Davis, G.K. and Mertz, W (1987) Copper. In: Trace Elements in Human and Animal Nutrition W, Mertz (ed.) 5th Edn. Academic Press, San Diego; California , 1 301-364

EgbunA, H. I (1986). The identification of pulses in the various ways of consumption in Nsukka LGA. Unpublished B. Sc Home Economics Education Thesis, Department of Vocational Teacher Education, University of Nigeria, Nsukka

Eka, UO and Edijala J. K (1972) Chemical composition of some traditionally prepared Nigerian foods, Nig J. Nutr. Sci. 6,157-160

Ene-Obong, H. N. (1993) Adolescents living in boarding houses in Nsukka, Enugu State, Nigeria 11: Quality of school meals and snacks and their contribution to nutrient intake. Ecol. Fd Nutr. 30, 195-205

Ene-Obong, H.N (1995) Content of antinutrients and in vitro protein digestibility of African yambean, pigeon pea and cowpea. Pl. Fd. Hum. Nutr. 48, 225-233

FAO/WHO (Food and Agricultural Organisation of the United Nations/ World Health Organisation) (1988) Requirements of vitamin A, iron, folate and vitamin $B_{12}$. Food and Agricultural Organisation, Rome

Mbofung, C.M.F, Atinmo, T. Omololu, A. (1984) Mineral content of Colostrum and mature milk of lactating Nigerian women as influenced by stage of lactating. Nutri Rept. Int. 30, 1137-1146

.Mbofung, C.M.F. and Atinmo. T (1987) Trace element nutrition of Nigerians International nutrition in health and diseases GH Bourns (ed) World Review of Nutrition and Dietetics. Switzerland: S. Kergar Baseh.

Mozie A. (2000) Food habits and nutrient intakes of pregnant women and their effects on birth weight of infants in Izzi L.G.A, Ebonyi State, Nigeria. M.Sc Project Report

Miller, D.D., Schricker, RR, Rasmussen, and Nan camped, D. (1981) An in into method for estimation of iron availability from meals Am. J. ctin. Nutr. 34: 2248-2254

Nolan, K.B. Duffin, P.A, and Mc Weany, D.J. (1987) Effects of phytate on mineral bioavailability In vitro studies on $Mg^{2+}$ , $Ca^{2+}$, $Fe^{3+}$ , $Cu^{2+}$ and $Zn^{2+}$ (also $Cd^{2+}$ ) solutions in the presence of phytate J. Sci. fd. Agric. 40, 79-85

Nnanyel Ugo, D. O, King, J, Ene-Obong, H. N. and Ngoddy, P. O (1985)Seasonal variation and the contribution of cowpea (*Vigna unguiculata*) and other legumes to nutrient intakes in Anambra State, Nigeria, Ecol. Fd Nutr 17, 271 - 274

Oberleas, D. and Prasad, A.S. (1976) Factors affecting zinc homeostasis. In .Trace Elements in Human Diseases Vol.1 A. S PRASAD (Ed) Liss, New York.

Omni/ Usaid (1993) National Micronutrient Suvey. P. 7

O'dell, B.L (1969) Effect of dietary components upon zinc availability. Am J. Clin Nutri. 22, 1315-1322

Oguntona, E. B. and Akinyele, I.O (1995) Nutrient Composition of Commonly Eaten foods in Nigeria - Raw, Processed and Prepared. Food Basket Foundation. Publication Series, 151, Pp 131

Okeke, E. C and Ene-Obong H, N (1995) Nutrient composition of conventional foods as eaten in northern Anambra, Nigeria. J. NUTR. Recipe and Menu Development I, 27-34

Sayer, M. H, Lynch, S.R, Charlton, R.W, Bothwell, T.H, Walker, R.B and Mayer, F (1974) Iron absorption from rice meals cooked with fortified salt containing ferrous sulphate and ascorbic acid. Brit. J. Nutr. 31, 367-375

Ubani, U. G. I;. Williams C. S and Church R, A (1980) Essential aminoacid content of some selected Nigerian meals. J. Fd Sci. 45, 1363 - 1368

WHO (World Health Organisation) (1996) Trace elements in human nutrition and health WHO, Geneva