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RESEARCH ARTICLE

Assessment of the dietary pattern and serum zinc concentrations of adults in Umuahia North Local Government Area, Abia State

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Abstract: Dietary pattern is a parameter that assesses the general profile of food and nutrient consumption which is characterized on the basis of the usual eating habits. This study was conducted to assess the dietary pattern and serum zinc concentrations of adults in Umuahia North Local Government Area, Abia State. To achieve this, a cross-sectional analytical study design was conducted on a designed questionnaire distributed amongst 252 respondents to collate data on their socio-demographic characteristics on age, sex, marital status, religion, occupation, and educational levels. Food Frequency Questionnaire (FFQ) was also carried out to assess adults' dietary patterns daily, weekly, sometimes and none, on some foods such as cereals, vegetables, legumes, milk & dairy, meat, fish & seafood, eggs, roots, and tubers. Serum zinc was conducted on 50 volunteered adults from the study area. Serum zinc levels present in the collected blood samples were analyzed with the aid of an Atomic Adsorption Spectrophotometer (AAS). Data obtained was analyzed with the aid of SPSS software on mean, standard deviation, t-test, and ANOVA for the hypothesis. Serum zinc deficiency was defined as a zinc level of less than 46 ug/dl from a reference book. The mean concentrations of serum zinc of healthy adults conducted were recorded as male 49.566±19.384, female 24.017±6.999, 38.025±24.862 (18-25years), 37.305±18.263 (26-40years) and 39.294±19.446 (41-55years) respectively. The results revealed that serum zinc concentrations in the participating healthy adults were within the reference level of 46 ug/dl, and also statistically significant at a p-value of 0.01 for the alternate hypothesis. Also, the relationship test of association between dietary pattern and serum zinc concentration is statistically significant as their p-value was less than 0.05 (0.027). Also, the tests confer with the alternate hypothesis that the association between dietary pattern and serum zinc concentration of adults in Umuahia North LGA is statistically significant. This study, therefore, recommends that studies should be carried out in other areas where symptoms of zinc deficiency are evident.

Keywords: dietary pattern, zinc deficiency, serum zinc concentration, micronutrient

1 Introduction

A healthy diet is a pillar of well-being throughout the lifespan. It promotes the achievement of healthy pregnancy outcomes; supports normal growth, development, and aging; helps maintain healthy body weight; reduces chronic disease risks; and promotes overall health and well-being. It is often not possible to separate the effects of individual nutrients and foods, and the totality of diet-the combinations and quantities in which foods and nutrients are consumed-may have synergistic and cumulative effects on health and disease [1,2]. Dietary patterns are defined as the quantities, proportions, variety, or combinations of different foods and beverages in diets, and the frequency with which they are habitually consumed [2]. Traditional approaches to nutritional epidemiology have focused on the associations of diseases with one or a small number of specific nutrients or foods [3,4]. Given that people eat a variety of foods with a complex combination of nutrients, the single-nutrient approach may fail to take into consideration the complicated interaction among nutrients, the potential confounding by an individual's eating pattern, and the statistically significant associations by chance [5]. In order to overcome these limitations, an increasing number of researchers have begun to use food consumption patterns to characterize a population's dietary intake and to examine the potential relationships between these patterns with health [6]. The two major dietary patterns that are not only associated with health outcomes, but have also been shown to be related to age, gender, living area, educational attainment, and other baseline demographic characteristics are the "Western" dietary pattern, characterized by high intake of meat, highly processed foods, and sweets [5,7] and in contrast, a healthier pattern referred to as "Healthy or Prudent", is characterized by higher intake of fruits, vegetables, legumes, whole grains, poultry, and fish [8].

Zinc is a micronutrient that is integrated with several enzyme systems [9]. It falls into the category of minerals that are needed in quantities of < 100 mg/day, depending on the stage of life and sex of the individual [10]. Important biological functions of zinc include gene expression, cell division, immunity, insulin secretion, and reproduction [9, 11]. Zinc deficiency is an important public health issue, particularly in resource-poor countries [9, 11]. In the human body, zinc is found in muscles (60%), bones (30%), and skin (5%) [12]. Zinc (Zn) is an essential trace mineral element vital for many physiological functions and plays an important role in growth, reproduction, and the immune system [11]. It is found in all body tissues and secretions in relatively high concentrations, with 85% of the whole body zinc in muscle and bones, 11% in the skin and the liver, and the remaining in all the other tissues, with the highest concentrations in the prostate and parts of the eye [13]. The average amount of Zn in the adult body is about 1.4–2.3 g [13]. Moreso, the optimal level of zinc is important for the growth and development of human health [10]. In developing countries, zinc deficiency is one of the significant factors contributing to the burden of disease [14]. The World Health Organization (WHO) estimates that zinc deficiency affects 31 % of the prevalence rates ranging from 4 to 73 % in various regions of the world's population [15]. Furthermore, even a small deficiency of zinc is a disaster to human health, so as such, the number of biological functions, health implications, and pharmacological targets that are emerging for zinc has evoked further interest regarding its status in human health and nutrition [16]. In addition, the lack of generally accepted biomarkers of zinc status has impeded the estimation of the global prevalence of zinc deficiency. Although measurement of zinc consumption and/or plasma zinc concentration can be used to assess population zinc status, few countries have collected adequate data to permit estimation of the prevalence of zinc deficiency. Studies have shown that zinc deficiency in humans may lead to adverse health consequences such as growth retardation, prostatic hyperplasia, delayed sexual and bone maturation, skin lesions, diarrhea, impaired appetite, increased susceptibility to infections mediated via defects in the immune system, and the appearance of behavioral change, especially in infants, toddlers and children and pregnant women [13, 17]. Despite the importance of zinc in the human body, there is a paucity of data on the zinc levels of humans especially adults in developing countries such as Nigeria. In light of the aforementioned realities, this research aims to assess the dietary pattern and serum zinc concentrations of adults in Umuahia North Local Government Area, Abia State. This study will add to the existing body of knowledge to improve public awareness of the dietary pattern and serum zinc concentrations of adults as well as the importance and deficiency of zinc.

2 Methodology

2.1 Study area

This study was conducted at Umuahia North Local Government Area (LGA) of Abia State. Umuahia North is bounded on the East by Bende Local Government Area, on the West by Obowo Local Government Area and Ihitte-Uboma Local Government Area, on the South by Umuahia South Local Government Area, and North by Isikwuato Local Government Area. Its headquarters are in the city of Umuahia, the capital city of Abia State. Umuahia North Local Government Area is made up of eight (8) communities which comprise Umuahia, Umukabia, UmuawaAlaocha, Umuagu, Umuekwule, IhiteUde, UmudaIsingwu, and Ohuhu. Umuahia North Local Government Area was created from the then Umuahia Local Government Area in 1996 by the Abacha–led government [18]. Their traditional language is Igbo though English is also widely spoken, and serves as the official language in governance and business while the religion of Christianity is extensively practiced in the area. The current metro area population of Umuahia in 2022 is 861,000. Agriculture is the major occupation of the people of Umuahia North LGA; the main food crops grown are yam, cassava, rice, cocoyam, and maize while the cash crops include oil palm, rubber, cocoa, banana, and various types of fruits. Umuahia North LGA has a viable trade sector and the area hosts several markets such as the Ubani main market and the Industrial market in Azueke Ndume Ibeku which attract a multitude of buyers and sellers of different commodities. The LGA also hosts some banks, hotels, industries, as well as government-owned establishments.

2.2 Study design

A descriptive cross-sectional study design was used for this study.

2.3 Study population

The study population consisted of male and female adults in Umuahia North Local Government Area of Abia State.

2.3.1 Inclusion criteria

Healthy adults aged 18 years to 55 years [19].

2.3.2 Exclusion criteria

Adults who have a history of jaundice were excluded. This is because research has shown that serum zinc levels have significantly decreased in the presence of liver diseases such as non-alcoholic fatty liver [20]. Adults receiving zinc supplements at the time of recruitment or within the preceding four weeks as this is likely to influence their zinc levels will be excluded [21].

2.4 Sample size determination

2.4.1 Sample size for survey

The sample size was determined using the Cochran formula for simple proportion [22].
$n = z^2p(1-p)/d^2$
Where,
n = sample size
p = 82%, using an estimated prevalence of zinc deficiency [23, 24]
z = critical value and in a two-tailed test it is equal to 1.96
q = complementary prevalence = (1-p)
d = degree of precision/accuracy = 0.05
$n = \frac{1.96^2 \times 0.82 \times (1-0.82)}{0.05^2} = \frac{0.56702016}{0.0025} = 226.808064 \approx 227$
To minimize errors arising from the likelihood of non-response, (10%) ten percent of the sample size was added to the sample size:
$n_a = \frac{n}{1-f}$
Where,
n_a = adjusted sample size
n = unadjusted sample size
f = non-response rate
$n_a = \frac{227}{1-0.1} = \frac{227}{0.9} = 252.2 \approx 252$ (the sample size that was used)

2.4.2 Sample size for serum zinc assessment

A sub-sample of fifty (50) individuals was assessed for serum zinc concentration. Six (6) to seven (7) individuals per village will be sampled.
Sampling interval: $\frac{\text{sample size}}{\text{proportion allocated per village}} = \frac{252}{50} \approx 5$
Therefore, in every fifth (5^{th}) household, a blood sample will be collected from the respondent.

2.5 Sampling techniques

A multistage sampling technique was used for the study.

Stage one: a sampling frame of eight (8) communities in Umuahia North Local Government Area was listed and four (4) communities were selected by simple random sampling using the balloting method.

Stage two: a sampling frame consisting of all the villages in the four (4) selected communities was drawn up. Two (2) villages per community were selected by simple random sampling making a total of eight (8) villages.

Stage three: based on an equal allocation of the sample size approximately a total of thirty-two (32) households will be selected per village. Households were selected using a modified World Health Organization (WHO) [25, 26] cluster sampling technique; before the commencement of the data collection, an empty beer bottle was spun at the center of the community to determine the starting point; a central location will be identified in each village such example; village square and households were selected in a clockwise manner. Wherever the tip of the bottle points after spinning for at least three (3) times was the starting point for the data collection.

Stage four: only one (1) adult was selected per household. If there is more than one (1) eligible adult, one was selected by simple random sampling method using the balloting method.

A subset of 50 respondents was selected for serum zinc analysis using a systematic sampling technique with a sampling interval of every 5^{th} household.

2.6 Data collection

Collection of data was preceded by advocacy visits to Mira-mercy Hospital Laboratory, Umuahia, Abia State which is licensed and has a spectrometer as well as trained biochemists, where serum zinc test results were analyzed. As well as advocacy visits to the Local Government Department of Health for approval of data collection.

2.7 Data collection instrument

The tool for data collection was an interviewer-administered pre-tested structured questionnaire [27], It consists of three (3) sections. Section A comprises of questions on the demographic data of the respondents. Section B contains questions on the knowledge of the existence and the importance of zinc. Section C contains questions on the dietary pattern – food frequency questionnaire.

2.8 Training of research assistants

The copies of the questionnaire were administered to the eligible respondents in the communities with the help of 4 research assistants. The research assistants who comprised village volunteers were trained on the meaning, pattern, and administration of the questionnaire for effective data collection. The distribution of the questionnaire and collection of the responses lasted for four weeks.

2.9 Laboratory procedures

2.9.1 Sample collection for serum zinc level

Non-fasting blood samples were collected from the subjects in the morning (i.e., before noon). The sample collection was done by the researcher fully assisted by the laboratory technicians. The cubital fossa and the dorsum of the wrist were inspected for superficial veins. When visualized, a tourniquet was applied to the wrist or above the cubital fossa as applicable. The area over and around the visualized vein was cleaned with a 76% alcohol swab circularly, from the center (the area to be punctured) outward [28]. This was then allowed to air dry for about 5–10 s [28]. Subsequently, a 23G veroject was inserted into the vein in the cephal direction at an angle of 30 degrees with the bevel of the needle facing superiorly [28]. When adequately situated inside the vein, 5 ml of blood was collected, and dispensed into one 5 ml trace element-free plain tube, for zinc analyses. The sample bottles were then labeled accordingly. The samples were allowed to stand for about 90 min, (to allow for clotting and retraction), after which it was spinned with a centrifuge at 3000 revolutions per min for 10 min. Subsequently, the serum, (usually about 2.0 ml), was separated with a bulb pipette into trace element-free plain tubes. These were clearly labeled and placed in sealed plastic bags in a cardboard canister with absorbent cotton wool and immediately transported in an ice-packed cooler dedicated for this study to Mira-mercy Hospital Laboratory, Umuahia, Abia State for zinc analysis. These samples were placed in sample racks clearly labeled for the study and stored in a refrigerator at -20°C. The key to this refrigerator was in the sole custody of the laboratory technician.

2.9.2 Zinc analysis

The analysis was done at Mira-mercy Hospital Laboratory, Umuahia, Abia State, using Atomic Absorption Spectrophotometer (Model 210, manufactured by Buck Scientific Cooperation, Connecticut, USA [29]. The machine operates at a wavelength range of 190–900 nm with typical sensitivity in the parts per million range [30]. The analysis was done using the principle of absorption spectrophotometry which assesses the concentration of an analyte in a sample [31]. The samples for serum zinc analysis were batched into groups of 20 and stored in a refrigerator (at -20°C) for later analysis of serum zinc. The analysis was done within 3h of submission by the chief laboratory scientist assisted by the researcher. The instrument was zeroed using deionized water as blank. One milliliter of serum (obtained by allowing blood to coagulate) [30] was aspirated into an air-acetylene flame. This causes the evaporation of the solution and vaporization of the free zinc atoms (atomization). A line source (hollow cathode lamp) operating in the ultraviolet (UV)-visible spectral region was then used to cause electronic excitation of the metal atoms, and the absorbance was measured with a UV-visible dispersive spectrometer with a photomultiplier detector. The concentration of each sample in parts per million (ppm) was then extrapolated from the calibration curve.

The obtained values were finally entered into the pro forma. The Nigerian food consumption survey of 2003 used 80μg/dl as the lowest limit of normal for zinc. In this study, serum zinc deficiency was defined as a zinc level $<$80 μg/dl.

2.10 Data analysis

Data were analyzed using Statistical Package for Social Science SPSS for Windows, Version 26.0. Descriptive statistics which includes frequency, percentage, mean, standard deviation, and median will be used to summarize categorical and continuous variables. The test of association was done using Chi-square, and the relationship between serum zinc levels and age, sex will be done using regression analysis. The level of significance is set at $P < 0.05$. Results will be presented in tables and charts. A data analysis matrix was carried out to cover areas like objectives, dependent variables, nature of variables, method of data collection, and statistical tests. These tests were carried out with the following steps;

Step 1: To determine the social demographic characteristics influencing serum zinc levels in adults, blood analysis was collected as data in form of continuous categorical data. Linear regression was used as a statistical test. Serum zinc levels were the dependent variables while the independent variables are age, marital status, educational status, and occupation.

Step 2: To access the dietary pattern of adults in Umuahia North Local Government Area, FFQ was collected in form of a continuous variable. The statistical tests used are mean, standard deviation, and regression. The independent variables are dietary zinc intake, diversity, and food consumption.

Step 3: To access serum zinc levels in apparently healthy adults in Umuahia Local Government Area, continuous data was collected as blood analysis. Mean, standard deviation, and ANOVA was used for a statistical test, with serum zinc as an independent variable.

Step 4: To determine the influencing serum level in apparently healthy adults in Umuahia North Local Government Area, FFQ was collected as data in form of a continuous variable. The statistical test used was linear regression and serum zinc as the independent variable.

Step 5: To determine the association between dietary patterns and serum zinc concentration of adults in Umuahia North Local Government Area, data was collected as blood analysis, with the continuous variable as the nature of the variable, serum zinc as the dependent variable while independent variables are age, marital status, educational status, dietary zinc intake, diversity, and food consumption while linear regression as a statistical test.

2.11 Study duration

This study is stipulated to last for a period of seven months.

2.12 Ethical considerations

Ethics committee clearance and approval for this study were sought and obtained from the Nnamdi Azikiwe University Teaching Hospital Institutional Research Ethics Review Committee (NAUTHEC) (see Appendix three), before the commencement of the study. Permission was also obtained from the village heads and community leaders of the villages during fieldwork. In addition, written informed consent was obtained from the participants. The participants will be properly enlightened on the aims, objectives, benefits, and protocols of the study and the need for voluntary participation and withdrawal at any given time. All data obtained were treated with the utmost confidentiality and only for this research.

2.13 Study limitation

Some of the information obtained from the subjects may be subject to bias from recall and self-reporting.

3 Results and discussion

In this study, blood samples were collected from fifty (50) healthy adults aged 18-55 years, and their serum zinc concentration was assessed from it; twenty-two (22) women and twenty-eight (28) men. A total of 252 questionnaires were distributed among families in Umuahia North Local Government Area in Abia State and data on their dietary patterns were collected. Table 1 shows data on socio-demographic characteristics of the study participants ranging from age, sex, religion, education, marital status, and occupation respectively. Age is an important factor that affects serum zinc levels from dietary food patterns. Age also facilitates zinc adsorption from dietary food patterns as studies have shown that individuals in some age-disadvantage groups may not adequately consume food that could boost serum zinc in their system. Data obtained from Table 1 shows that 40.0±14.142 were within the age 18-25years, 43.50±4.949 were within the age 26-40 whereas 42.50±17.677 were within the age 41-55 years respectively indicating that most participated participants fall within the age 26-40 years (Table 1). Data obtained for gender shows that the majority of the respondents are male with a mean value of 67.50±17.68 while female are 58.50±16.26 respectively. Data obtained from Table 1 shows that the majority of the respondents are protestant (42.50±10.607), catholic (32.50±10.606%) while Islam and traditionalist are (25.0±7.071%) respectively. Level of education varied from none to post-secondary education with participants having most (46.0±19.798) secondary, primary (32.50±17.677), none (27.50±9.192), and tertiary (20.0±7.071) (Table 1). The level of education contributes immensely to the dietary pattern in families. This is because an increase in knowledge facilitates healthy dietary patterns capable of providing basic nutrients needed for the body. The marital status of individuals contributes immensely to their healthy dietary patterns as individuals in their singlehood care, not to the quality of their dietary consumption. From

Table 1, the majority of the participants are married with (52.50±45.961), 40.0±7.071% are divorced, and 20.0±2.828 are singles while a little proportion are widowed (13.50±4.949). The occupation of participants plays a vital role in purchasing power of daily dietary patterns. Good income determines the quality dietary patterns. Majority of the occupation among participants are traders (40.0±16.970), civil servants (30.0±7.071), professionals (10.0±7.071), artisans (40.0±16.970), and farmers (25.0±4.243) (Table 1). The study has revealed that traders are on the advantage part of a good dietary pattern as they are categorized as daily earners.

Table 1 Socio-demographic characteristics of the study participants

Variables	n = 252	(%)	Mean+SD
Age (years)			
18-25	80	31.75	40.00±14.142
26-40	87	34.52	43.50±4.949
41-55	85	33.73	42.50±17.677
Sex			
Male	135	53.57	67.50±17.677
Female	117	46.43	58.50±16.263
Religion			
Catholic	65	25.8	32.50±10.606
Protestant	87	34.52	42.50±10.607
Islam	50	19.84	25.00±7.071
Traditionalist	50	19.84	25.00±4.242
Education			
None	55	21.83	27.50±9.192
Primary	65	25.79	32.50±17.677
Secondary	92	36.51	46.00±19.798
Tertiary	40	15.87	20.00±7.071
Marital status			
Single	40	15.87	20.00±2.828
Divorced	80	31.75	40.00±7.071
Married	105	41.67	52.50±45.961
Widowed	27	10.71	13.50±4.949
Occupation			
Civil servants	60	23.81	30.00±7.071
Professional	20	7.93	10.00±7.071
Farmers	50	19.84	25.00±4.243
Traders	80	31.75	40.00±16.970
Artisans	42	16.67	21.00±5.399

Table 2 shows the mean concentration of serum zinc of 50 adults comprises of both males and females ranging from age 18 – 55 years. Serum zinc levels were not normally distributed but rather were skewed to the right, with a majority of the subjects having serum zinc levels between 14.5 μg/dl and 93.5 μg/dl. The reference value of the analyzed serum zinc from the reference book is 46ug/dl. Mean concentration of serum zinc in female participants is recorded as 49.566±19.384 and 24.017±6.999 for males. The result shows that serum zinc concentrations for female participants were above the reference standard of 46 ug/dl. Serum zinc concentrations in participating age groups were recorded as 38.025±24.862 (18-25 years), 37.305±18.263 (26-40 years), and 39.294±19.446 (41-55 years) (Figure 1). Results of the present study on serum zinc show that serum zinc levels within the reference value (46 ug/dl) are normal while the ones above the reference value are abnormal. Also, the mean of the conducted serum zinc concentration falls within the normal concentration of the general population, therefore, we fail to reject the null hypothesis and accept the alternate hypothesis that there is a difference in the mean serum zinc level of apparently healthy adult in Umuahia North LGA from mean zinc level of the general population as p-value is less than 0.05 using student t-test statistical tool.

The results of this study are comparable to the study carried out in Austria which determined the reference value of zinc in sera of adults. The mean value for zinc in people of Austria with a mean age of 25 years was 24.9 μmol/L. This value of serum zinc was comparable to the population in Lahore where the mean serum zinc concentration was 24.02 μmol/L. This high level of zinc was mainly attributed to the geographical region as Austria is rich in lead & zinc ores. Excessive amount of zinc present in the environment of Austria might result in raised level of zinc in people living in that particular region [32]. A study conducted in Italy showed a mean concentration of 12.39 μmol/L for zinc which is lower in the population under study. It was expected that many factors including age, sex, habits, living standards, working environments & patterns of diseases result in different levels of zinc in this population [33].

Parizadeh et al. (2011) [34] demonstrated that a low zinc status was a common feature in the Persian population. The mean value for zinc was 11.7 μmol/L which was lower than our population. This difference might be explained by the difference in dietary intake & age of the population under study. The mean concentration of zinc in this present study was higher than the different studies carried out in China (24.20), Canada (24.90), Italy (13.39), Bangladesh (13.39), Japan (11.70) & Spain (24.8) ug/dl. Statistical model on regression was conducted with the aid of SPSS software at 95% confidence level, df =1 and p-value =0.002 is significant.

Table 2 Mean concentration of serum zinc in apparently healthy Adults in Umuahia North

Total sample	Mean±SD	statistic Test	P-value
Sex			
Male	49.566±19.384	T-test	0.000
Female	24.017±6.999	T-test	0.000
Age (years)			
18-25	38.025±24.862	T-test	0.001
26-40	37.305±18.263	T-test	0.000
41-55	39.294±19.446	T-test	0.000

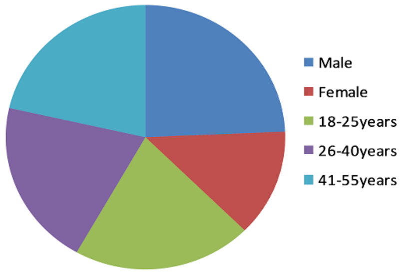

Figure 1 Graphical representation of mean concentration of serum zinc in apparently healthy of adults in Umuahia North L.G.A

Table 3 shows the food frequency of dietary pattern of adults in Umuahia North L.G.A The table shows the food frequency dietary pattern of the study participants ranging from cereals, vegetables, roots & tubers, legumes, milk & dairy products, fish & seafood, meat and eggs (Table 3). The majority of the participants 45±2.04 consumes cereals weekly 90 (35.71%), 50±17.11 consumes vegetables sometimes 100 (39.68%), 50±13.13 ate roots & tubers sometimes 100 (39.68%), 42.50±6.19 ate legumes 85(33.73), 47.50±8.99 consumes milk & dietary products, 52.50±9.34 ate fish & seafood 105(41.66%), 49±13.87 ate meats 98(38.88) whereas 40±17.22 consumes eggs 80 (31.75%). Healthy food pattern promotes good metabolic activities in healthy adults while irregular and inconsistent dietary food pattern promotes a negative imbalance in adult system. Statistical analyses conducted with regressional analysis show that the dietary patterns of the adults in Umuahia North LGA are statistically significant with p-value <0.05, Chi-square (X^2) = 0.537, df = 2 at 95 confidence level, and p-value 0.027, we, therefore, accept the alternate hypothesis and states that there is a statistically significant association between dietary pattern and serum zinc concentration of adults in Umuahia North LGA.

Studies have shown that insufficient dietary zinc intake is one of the main contributing factors in the development of zinc deficiency [35–37]. Zinc deficiency is documented to be significant in developing countries and this has been attributed to low dietary zinc intake. Most of the diets consumed are mostly plant diets (cereals and legumes) which have low zinc bioavailability, as compared to animal diets which have high zinc bioavailability [38, 39]. Serum zinc reflects the usual zinc intake of an individual over a few weeks or months [40]. Dietary intake has remained a useful indicator in the assessment of zinc deficiency among populations levels was expected. However, the findings did not reveal an association between dietary zinc and [38, 39]. A positive association between dietary zinc intake and serum zinc levels among the study population was observed. A recent study done among the Kenyan population attributed ZD to a high level of cereals and legumes which have a high level of zinc inhibitors [41]. Findings from other studies have documented low zinc status with low dietary zinc intake [27]. In this study, zinc deficiency was possibly due to the high consumption of cereals, roots & tubers, and legumes which are high in zinc inhibitors. These food sources have been documented to be of low zinc bioavailability than animal sources such as meat, fish & seafood, and eggs which are of high zinc bioavailability [42]. Similar findings have been reported in other studies among pregnant women in the developing world [10, 36, 43].

The study finding revealed a high dependency on the consumption of cereals, roots & tubers, and legumes which provide considerable amounts of energy and dietary zinc to the participants. This relatively high intra-person variability in the consumption of a combination of zinc-dense foods with a very high level of phytate intake could result in a weaker association of serum zinc. Experimental studies have shown that utilization of dietary zinc could be markedly different depending upon the source of the dietary protein [44]. Zinc in diets containing proteins from animal sources (meat, fish, milk, and eggs), has been found generally to be of high availability and well absorbed. Whereas those from plant products notably those from cereals and legumes are poorly absorbed. One factor that is of major importance in giving rise to low zinc availability from cereals and legumes based diets is phytic acid (inositol hexaphosphate) and its salts, known as phytates. They attach it irreversibly in the intestines. The highest amounts are found in wheat, beans, and nuts, less in fruits and vegetables, and a few tubers. This is what makes them non-reliant sources of zinc even though dietary zinc concentration is relatively high in these foods [44].

The findings of this study indicate a high prevalence of zinc deficiency in the study area. This signals a public health concern in the area which needs to be addressed. The results are fairly consistent with the findings from other studies in developing countries [43, 45].

Table 3 Dietary food patterns of the study participants

Variables	n = 252	(%)	Mean±SD
Cereals			
Daily	60	23.81	30.0 ±4.06
Weekly	90	35.71	45.0±2.04
Sometimes	70	27.77	35.0±4.01
None	32	12.7	16.0±1.03
Vegetables			
Daily	40	15.87	20.0±5.03
Weekly	80	31.75	40.0±8.02
Sometimes	100	39.68	50.0±17.11
None	32	12.69	16.0±3.81
Roots and tubers			
Daily	95	37.69	47.5±7.08
Weekly	45	17.86	22.5±3.34
Sometimes	100	39.68	50.0±13.13
None	12	4.76	6.0±0.04
Legumes			
Daily	85	33.73	42.5±6.19
Weekly	65	25.8	32.5±8.11
Sometimes	75	29.76	37.5±12.02
None	27	10.71	3.5±3.42
Milk & diary products			
Daily	45	17.86	22.5±4.98
Weekly	95	37.69	47.5±8.99
Sometimes	80	31.75	40.0±5.04
None	32	12.7	16.0±1.18
Fish & seafood			
Daily	105	41.66	52.5±9.34
Weekly	75	29.76	37.5±6.49
Sometimes	20	7.9	10.0±2.05
None	52	20.63	26.0±3.88
Meat			
Daily	98	38.88	49.0±13.87
Weekly	72	28.57	36.0±9.08
Sometimes	52	20.63	26.0±5.11
None	30	11.9	15.0±3.29
Eggs			
Daily	45	17.86	22.5±4.30
Weekly	75	29.76	37.5±14.23
Sometimes	80	31.75	40.0±17.22
None	52	20.63	26.0±10.01

4 Conclusion

This study has shown that the dietary pattern and serum zinc concentration are dependent, but age and sex have no effect on serum zinc levels in apparently healthy adults in Umuahia North Local Government Area. Also, the present study has revealed that there is a positive relationship between dietary pattern serum zinc levels in apparently healthy adults in Umuahia North Local Government Area with a p-value less than 0.05 for the alternate hypothesis. This study, therefore, concludes that the prevalence of zinc in dietary food patterns is of a public health concern as analysis of dietary patterns gives a more comprehensive impression of the food consumption habits within a population. Also, adequate awareness of the adverse effects of zinc deficiency in food patterns should be created by Public Health officers within the study area.

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