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Research Article
Alleviating Micronutrient Malnutrition within 1000 Days' Window Period Using Rabbit (*Oryctolagus cuniculus*) Meat

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Abstract
Background and Objective: The study was conducted to evaluate the micronutrients composition of rabbit meat raised in the humid tropics in order to alleviate hidden hunger within the first 2 years of life. Micronutrient malnutrition (MNM) is a global challenge to the health and consequently to the social and economic growth of a nation. MNM is a "hidden hunger" and as such may not be noticed over the years. However, long period effects are associated with a vast impact on the health of vulnerable populations like children under year 2 and women of reproductive age. Unchecked situations have jeopardized the national economy and prosperity of developing countries. **Materials and Methods:** A total of eighty four (84) samples were analyzed to determine the micronutrient content of 7 meat species (beef, pork, chevon, chicken, rabbit, fish and cattle's skin). Spectrometer absorbance records with references to the standard curves were used to determine Iron (Fe) and Zinc (Zn) content. The iodine (I) content was determined by titration method while that of Vitamin A and B_{12} were carried out by colorimeter method with little modification. **Results:** Present investigation indicated that rabbit meat contained an appreciable amount of micronutrient content (Fe = 3.31±0.48 mg, Zn = 5.92±0.38 mg, I = 11.07±0.15 µg, Vitamin A = 0.05±0.01 Iµ and Vitamin B_{12} = 15.75 µg) making it to be a good source of supplementary diet for women of reproductive age and as an additive to children's food formulation. **Conclusion:** Micronutrients analysis of rabbit meat provided an insight into the nutritional composition of such animal food, facilitating its maximal efficacy and utilization in control of malnutrition such as hidden hunger.

Key words: Malnutrition, micronutrients, window period, animal food, hidden hunger

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Micronutrient malnutrition (MNM) is a form of under-nutrition associated with a low intake or poor absorption of vitamins (especially vitamin A and B_{12}) and minerals (such as zinc, iodine and iron) to sustain good health and development[1]. FAO[2] affirmed that insufficient dietary consumption of micronutrients results in hidden hunger. MNM affects global health and it is linked to reduced access to micronutrient-rich foods such as fruits, vegetables, foods of animal origin and fortified foods[1]. Research shows that some of the key causes of MNM are poverty, high cost and unavailability of micronutrient-rich foods[3]. Other factors as reported by Save the Children[4] include gender inequality, poor infant and young child feeding practices, limited access to healthcare, safe drinking water and adequate sanitation.

Although, the deficiency affects every age group of both sexes, the most vulnerable groups are children within 1000 days of their life and women of reproductive age including pregnant women and lactating mothers[5]. The World Health Organization (WHO) estimates that more than 2 billion people are deficient in key vitamins and minerals, including one third (1/3rd) of the world's children[6]. Most of these people live in developing countries and the situation may even be much doleful in low-income countries.

According to UNICEF[7] in State of the World's Children Report 2015 (Table 1), 37% of children, or 6 million Nigerian children, are stunted (chronically malnourished) while 18% of children suffer from wasting (acutely malnourished). It was also observed that 29% of these children are underweight (both acutely and chronically malnourished).

Micronutrient malnutrition is the world's most prevalent and most devastating nutritional problem. There have always been grave consequences of MNMs especially among children and pregnant mothers. In a study, Rush[8] reported higher rate of maternal mortality due to under nutrition in developing countries. When people suffer from multiple MNMs, they are at higher risk of multiple impairments. A study showed that iodine, iron and zinc deficiencies are associated with cognitive deficits among children, primarily due to iodine deficiency[9]. The negative impacts of physical and mental impairment in national economy cannot be overemphasized[10]. Kuku-Shittu[11] documented that hidden hunger impairs physical growth and learning, limits productivity and ultimately perpetuate poverty in a continuous cycle. Countries where a large share of the population is affected by vitamin and mineral deficiencies cannot realize their economicpotential[12,13].

Studies[6,11,14,15] have demonstrated that the silent crisis of malnutrition (hidden hunger) can be alleviated through dietary strategies such as micronutrient supplementation, food fortification, dietary diversification, nutrition education, bio-fortification etc. Unfortunately, most of these international nutrition programmes do not consider usage in food of animal origin (e.g. rabbit) as a primary weapon in their arsenal of solution against this public health crisis.

Animal foods play an important role in the diet of man. Nutritionally they are important sources of protein of good quality and excellent sources of vitamins and minerals. The major contribution in foods of animal origin to human health is through the alleviation of malnutrition caused by deficiencies in micronutrients that contribute to poor growth, impaired mental development and ill health, which, in aggregate terms can, contribute to poor economic growth of nations. Iron, zinc and vitamin A are the main micronutrients available in meat while vitamin B_{12}, riboflavin, calcium and conjugated linoleic acid are available in milk. The bioavailability of these nutrients is high, compared to those in plants, because of the presence of the heme protein and the absence of fibre and phytates in foods of animal origin[16].

Meat from rabbit is an all-white meat product that is high in protein and low in fat, sodium and cholesterol as compared to other common meats, such as beef, lamb, pork and poultry which continuous consumption can lead to cardiovascular diseases, diabetes and obesity[17]. On the contrary, rabbit meat has for years been recommended by some physicians to their patients with coronary heart conditions[17]. In addition, rabbit has immense potentials and good attributes, which include early sexual maturity, high prolificacy, relatively shorter gestation period, short generation interval, high productive potential, rapid growth, good ability to utilize forages and agricultural by-products instead of cereal/grain, efficient feed conversion, low cost per breeding female and profitability for small-scale system of production. Despite all these attributes, we observed a dearth of information available to consumers of meat as it concerns the nutritional value of rabbit meat. Hence, the present study was designed to assess micronutrients' value of rabbit meat in order to alleviate the problem of hidden hunger among children within 1000 days of their life and women of reproductive age.

MATERIALS AND METHODS

Experimental site/location: The study was conducted in the Rabbitry Unit of the Teaching and Research Farm of the Ebonyi State University, Abakaliki. The area lies within latitudes 06°4'N and longitude 08°65'E in the derived Savanna Zone of Southern Eastern Nigeria. The area within the zone is characterized by an annual rainfall of about 2710 mm. Mean

Table 1: Prevalent of malnutrition on Nigerian children of under-five between 1990 and 2015

	Surveying method/organization							
	NDHS	NDHS	NFCNS	NDHS	MICS	NDHS	UNICEF	UNICEF
Indicators	1990	2003	2004	2008	2011	2013	2014	2015
Stunting (%)	43	42	42	41	34	37	32	37
Wasting (%)	09	11	09	14	16	18	09	18
Underweight (%)	36	24	25	23	31	29	21	29
Total	88	77	76	78	81	84	62	84

Source: IFPRI[9]. NDHS: Nigeria demographic and health survey, NFCNS: Nigeria food consumption and nutrition survey, MICS: Multiple indicator cluster survey, UNICEF: United nations children fund report IFPRI: International food policy research institute

daily temperature of Abakaliki within the experimental period was 27.5°C. Mean monthly relative humidity at 12.00 GMT ranged from 75-90% in the rainy season and 62-67% in the dry season with a mean annual value of 81.75%. The meteorological data were collected from the Meteorological Station of the Ebonyi State University, Abakaliki, Ebonyi State.

Materials and research tools: The materials used within the duration of this experiment included meat samples (beef, pork, chevon, chicken, fish, cattle skin and rabbit meat), petri-dish, volumetric flasks, sensitive scale, desiccator, water bath, oven, colorimeter, 55B atomic absorption spectrophotometer (AAS).

Experimental procedures: Apart from rabbit meat, other meat samples (beef, pork, goat, chicken, fish and skin) were purchased from a local meat market outlet within the Abakaliki metropolis. Twelve live rabbits were selected from the existing rabbit population at the Rabbitry Unit of the Teaching and Research Farm of the Ebonyi State University, Abakaliki on 15th July, 2019. These were processed and samples obtained thereafter in line with the method described by Simonova *et al.*[18]. Four samples of each of the seven meat types and three from different retail sources were collected for the experiment.

Experimental design: Four samples from each of the three retail source for each of the seven meat types were distributed in a Completely Randomized Design (CRD) with four samples from each meat type representing four replicates.

Micronutrients/chemical analysis: In all, 84 samples collected were transported in a cold-chain to the Biochemistry Laboratory, National Root Crops Research Institute, Umudike, Abia State for nutrients analysis. Micronutrients and vitamins analyzed were Iron, Zinc, Iodine, Vitamin A and Vitamin B_{12} respectively.

Determination of iron and zinc: The filtrate used for the analysis was obtained through the method described by Onwuka[19] and subsequently analyzed using a spectrometer (Thermo Scientific, USA). The appropriate hollow cathode lamp (for Iron and Zinc) was put in place and the monochromator was set at the appropriate wavelength of 248 and 212 nm respectively. The instrument was flushed by aspirating distilled deionized water into the system followed serially by the dilution of standard solutions of the test elements and their respective absorbance were recorded and plotted into a curve in the system. The sample test extracts were aspirated in turns into the system and their absorbance were recorded with reference to the standard curve earlier plotted.

Determination of Iodine: The iodine content was determined by titration method as described by Sami *et al.*[20] with a slight modification.

Determination of vitamin A and B_{12}: High Performance Liquid Chromatography (HPLC) method was also employed to determine Vitamin A and Vitamin B_{12} content of the meat samples as described by Sami *et al.*[20].

Data collection and statistical analysis: Data obtained for micronutrients content (Fe, Zn, I, Vitamin A and Vitamin B_{12}) from each of the meat types were subjected to Analysis of Variance (ANOVA) using the General Linear Model (GLM) procedure followed by Duncan Multiple Range Test (DMRT) using the SPSS[21] Statistics version 22.0. Differences of $p<0.05$ were considered statistically significant.

RESULTS

Table 2 shows the results of micronutrients analysis of different meat samples studied. The results indicated that rabbit meat contained an appreciable amount of micronutrients content (Fe = 3.31±0.48 mg,

Table 2: Results of micronutrient content of meat samples/100 g

Meat types	Iron (mg)	Zinc (mg)	Iodine (μg)	Vitamin A (RE)*	Vitamin B_{12} (μg)
Beef	4.73±0.45[b]	11.42±0.12[b]	42.67±0.99[c]	0.17±0.01[d]	3.75±0.13[c]
Pork	1.13±0.08[d]	2.79±0.60[d]	16.80±0.30[d]	0.10±0.09[d]	0.69±0.03[d]
Chevon	4.31±0.13[b]	5.21±0.02[c]	13.83±0.25[e]	0.84±0.03[c]	0.41±0.01[d]
Chicken	1.41±0.02[d]	2.51±0.05[d]	62.53±1.33[b]	23.10±15.80[b]	2.13±0.02[b]
Rabbit	3.31±0.48[c]	5.92±0.38[c]	11.07±0.15[e]	0.05±0.01[e]	15.75±0.79[a]
Fish	1.35±0.02[d]	1.29±0.03[e]	276.30±3.55[a]	44.70±37.63[a]	13.05±0.80[a]
Cattle skin	27.80±0.08[a]	13.25±0.25[a]	0.00±0.00[f]	0.00±0.00[e]	0.00±0.00[e]

*RE: Retinol equivalent, Each value represents the mean±SD of four determination on dry weight of 100 g. [a,b-f]Means along columns with different superscripts are significantly (p<0.05) different. Source: Biochemistry Laboratory, National Root Crops Research Institute (NRCRI), Umudike, Abia state. Nigeria

Table 3: Results of previous studies for nutrient composition of some animal source food per 100 g

Food	Calcium (mg)	Iron (mg)	Zinc (μg)	Vitamin A (RE)*	Vitamin B_{12} (μg)
Beef	07	3.20	6.00	0.00	2.40
Chicken	13	1.30	1.80	42.00	0.20
Goat	17	3.70	0.00	0.00	1.20
Rabbit	20	2.40	2.40	0.00	6.50
Fish	37	8.40	0.60	14.00	0.60

*RE: Retinol equivalent. Adapted from Neumann *et al.*[16]

Zn = 5.92±0.38 mg, I = 11.07±0.15 μg, Vit. A = 0.05±0.01 Iμ and Vit. B_{12} = 15.75 μg). Other micronutrients results for beef, pork, chevon, chicken and fish are also depicted in Table 2.

Generally, except for the value of vitamin B_{12} (15.75±0.79), micronutrients in rabbit meat were significantly (p<0.05) lower than that of the beef. However, Fe, Zn and vitamin B_{12} in rabbit meat were significantly (p<0.05) higher than those obtained for white meat like chicken and pork.

Table 3 shows that micronutrients values obtained in the present study were generally higher in beef, chevon, chicken, rabbit and fish (except for Fe in fish, vitamin A in chicken and vitamin B_{12} in chevon). Negligible vitamin A (0.05±0.01) obtained for rabbit meat is similar (p>0.05) to those obtained for beef, pork and cattle skin but significantly (p<0.05) different from values obtained for fish, chicken and chevon.

DISCUSSION

There may be a dearth of information on the value of Zn content in rabbit meat, therefore, this study was designed to assess micronutrients' value of rabbit meat in order to alleviate the problem of hidden hunger among children. The iron content (3.31±0.48 mg/100 g) in rabbit meat was found to be higher than those in the white meats (pork, chicken and fish) and those reared in temperate regions[16,22]. The higher value may be attributed to the feeding of grasses with little or no supplementation of commercial diets. Barbato *et al.*[23] reported higher iron content (2.15 mg/100 g) in the meat of local breeds of rabbit reared extensively. Therefore, rabbit meat will contribute to the alleviation of hidden hunger.

The presence of Zinc (Zn) in high amounts is of special interest based on its importance in the human diet. Results of the present investigation showed higher levels of Zn (5.92±0.38 mg/100 g) when compared to the results of a previous study conducted by Stein[13]. However, Swanepoel *et al.*[24] noted the importance of Zn in DNA, RNA, insulin and enzymes synthesis. Zn is also required for cell reproduction and growth, especially the sperm cells[25].

The results showed that rabbit meat contained low iodine (I). Iodine content found in rabbit meat and other meat species (Table 1 and 2) suggested the fortification of food/salt with iodine in order to get required daily intake (RDI) for pregnant women (250 μg day^{-1}), lactating women (250 μg day^{-1}) and infant <2 years (90 μg day^{-1})[26]. Iodine contents in food of animal origin have not been evaluated in previous studies but it has been considered for having strong effects on the production of thyroid hormones, which are necessary for normal brain development in children[7].

In the present study a negligible value (0.05±0.01) obtained for vitamin A is similar to the non-detected result (0.00) of a previous study[20]. These results are in agreement with the findings of WHO[6], Givens and Shingfield[27] and UNICEF[28] which stated that fortification of rabbit meat and other human food with vitamin A is highly recommended. Levels of vitamin A in any meat type are generally low and difficult to measure and often have not been previously included in food composition data[29].

The value of vitamin B_{12} (15.75±0.79 μg/100 g) (Table 2) obtained in this study is higher than those reported by Neumann *et al.*[16] and Dalle Zotte and Szendrő[22]. The variation observed in the present study may be due to breed type, age, feeding, ante and post mortem factors. Lombardi-Boccia *et al*.[30] observed a significant variation, not only among meats of different species but also among cuts of the same species.

CONCLUSION

Micronutrients analysis of rabbit meat provided an awareness of nutritional composition of such animal food, facilitating its maximal utilization in the control of malnutrition (e.g. hidden hunger). Since, vitamin B_{12} is found only in foods of animal origin and in order to meet up with the required daily intake (RDI), we recommend the consumption of rabbit meat for women of reproductive age and its inclusion in infant diets' formulation. This will be a good measure of solving the problem of hidden hunger in an area where facilities to raise such animals abound. Other micronutrients in rabbit meat not covered in this investigation and their possible roles in food safety call for future research.

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