International Journal of Research and Publication
ISSUE 5 VOL. 3 (MAY 2024)

EVALUATION OF MICRO NUTRIENT AND FUNCTIONAL PROPERTIES OF WHEAT-FINGER MILLET FLOUR BLEND

Ekeyi Divine-favour Ijeoma and Amalunweze Adaude.
deeluv.devyn@gmail.com 07067452924
Department of Science Laboratory Technology.
Federal Polytechnic Oko, Anambra state Nigeria.

ABSTRACT
This study examined the micronutrient composition and functional properties of blends of wheat and finger millet flour at different ratios. The analysis covered mineral and vitamin levels, as well as functional characteristics. The results showed that blends with 80% finger millet and 20% wheat had the highest magnesium content, while those with 20% finger millet and 80% wheat had the highest potassium levels, and blends with 10% finger millet and 90% wheat had the highest zinc concentration. Additionally, the blend with 10% finger millet and 90% wheat had superior levels of vitamins B1 and B2, and the blend with 20% finger millet and 80% wheat had the highest vitamin B3 content. In terms of functional properties, the blend with 10% finger millet and 90% wheat had the highest bulk density, while 100% wheat flour had the best water absorption capacity, and the blend with 80% finger millet and 20% wheat showed remarkable oil absorption ability. Moreover, the blend with 80% finger millet and 20% wheat performed well in emulsion capacity and swelling index, while 100% wheat flour had the highest pH level. Overall, the results suggest that composite flour blends significantly enhance the nutritional profile and should be promoted.

CHAPTER 1

INTRODUCTION

The use of indigenous grains and cereals has become increasingly important for addressing nutritional deficiencies and improving food security in different regions. In recent years, there has been a growing focus on malnutrition and its health consequences, especially in developing countries (Smith et al., 2020). Micronutrient deficiencies, resulting from insufficient intake of vital vitamins and minerals, lead to various health problems such as stunted growth, compromised immune function, and greater susceptibility to diseases (Black et al., 2013).

In the global context of food security and nutrition, the importance of addressing both hunger and malnutrition while promoting sustainable agricultural practices has garnered significant attention. The Sustainable Development Goals (SDGs) outlined by the United Nations highlight the need to achieve Zero Hunger (SDG 2) and improve global health and well-being (SDG 3) through innovative strategies that target both macronutrient and micronutrient deficiencies (United Nations, 2015).

Wheat, despite being a major source of calories for millions, often lacks essential micronutrients necessary for overall health. Micronutrient deficiencies, known as "hidden hunger,"disproportionately impact populations in developing countries where diets heavily rely on staple grains like wheat (Hotz and Brown, 2004). Notably, iron and zinc deficiencies are prevalent and can lead to conditions such as anemia and weakened immune function (Wessells and Brown, 2012).

On the other hand, finger millet, an ancient cereal rich in nutrients like calcium, iron, and methionine, shows promise in combating malnutrition. Its nutritional profile makes it a valuable addition to diets in addressing nutrient deficiencies and promoting overall health. The inclusion of finger millet in food systems can contribute significantly to improving the nutritional status of populations, especially in regions where malnutrition is a significant concern.

These findings are supported by research conducted by various authors, including Hotz and Brown (2004) and Wessells and Brown (2012). By incorporating finger millet into diets and promoting its cultivation, efforts can be made towards combating malnutrition and enhancing overall health outcomes.

Adoption of finger millet, commonly known as "ragi,"is often hindered by factors related to accessibility and socio-economic circumstances. Despite its nutritional benefits, finger millet cultivation is mainly concentrated in regions of Africa and Asia where it is appreciated for its nutritional advantages. Known for its resilience to climate fluctuations, finger millet thrives in environments with limited resources, making it a valuable crop for communities facing food security challenges.

The integration of finger millet into wheat-based diets has the potential to enhance the overall nutritional profile and help address deficiencies commonly found in wheat. By combining these two cereal crops, individuals can benefit from a more balanced and nutrient-rich diet, thereby contributing to improved health outcomes and food security.

The evaluation of functional attributes is crucial for culinary purposes, especially when considering the amalgamation of cereals like wheat and finger millet to enhance overall nutritional value. The challenge lies in optimizing the blend to strike a balance between nutrition and performance. A comprehensive assessment of the properties of wheat-finger millet blends is essential in order to understand their potential benefits.

Wheat, as a staple cereal, often lacks essential micronutrients, which can contribute to malnutrition in populations that rely heavily on it as a dietary staple. By incorporating finger millet into wheat-based products, it is possible to address these nutritional deficiencies and improve the overall health outcomes of individuals consuming such food items.

Through thorough research and evaluation of the attributes of wheat-finger millet blends, food scientists and nutritionists can develop products that not only provide the necessary nutrients but also meet consumer preferences for taste and texture. By focusing on enhancing the nutritional content of commonly consumed foods, we can make a significant impact on combating malnutrition and promoting better health for populations worldwide.

Despite its potential, finger millet faces challenges such as lack of awareness and limited availability in the market. The trend towards developing composite flours with enhanced characteristics is becoming more prevalent, but further research is needed to fully explore this aspect. Studies have shown the potential for increased nutrient levels in composite flours, highlighting the importance of focusing on achieving an optimal balance of nutrients and assessing the economic feasibility of such products(Chimdi and Eneje 2020; Thakur et al.2017).

For future research endeavors, it is essential to have a broad objective that encompasses exploring the potential benefits and challenges of incorporating finger millet into composite flours, with a particular emphasis on improving nutritional outcomes and ensuring economic viability.

General objective

The overarching aim is to assess the micronutrient and functional characteristics of a wheat-finger millet flour amalgamation.

Specific objectives

The precise aims of this inquiry are to:
Create a blend of wheat and finger millet flour.
2. To ascertain the mineral composition of the wheat-finger millet flour amalgamation (including magnesium, potassium, zinc).
3. To determine the vitamin content of the wheat-finger millet flour blend [Vitamins B1, B2, B3].
4. To evaluate the functional attributes of the wheat-finger millet flour blend.

General Objective: The main goal of this study is to evaluate the micronutrient and functional characteristics of a blend of wheat and finger millet flour.

Specific Objectives: This study aims to achieve the following objectives:

1. Develop a blend of wheat and finger millet flour.
2. Determine the mineral composition of the wheat-finger millet flour blend, including magnesium, potassium, and zinc content.
3. Assess the vitamin content of the wheat-finger millet flour blend, specifically focusing on Vitamins B1, B2, and B3.
4. Evaluate the functional properties of the wheat-finger millet flour blend.

MATERIALS AND METHODS

Study Design: This investigation utilized an experimental design approach.

Sources of Raw Materials: Finger millets were obtained from Gusape village market in Abuja, while wheat grain seeds were sourced from Eke Ekwulobia in Anambra State.

Equipment and Reagents: The equipment and reagents for analysis were acquired from the Biochemistry Laboratory of Science Laboratory Technology at Federal Polytechnic Oko in Anambra State, Nigeria.

Sample preparation

Table 1:Proposition of finger millet and wheat flour

Sample	Finger millet	Wheat flour
FMB 1	100	0
FMB 2	0	100
FMB 3	80	20
FMB 4	20	80
FMB 5	90	10
FMB 6	10	90

Production of Wheat Flour and Finger Millet Flour

Wheat Flour: A precise amount of 1000 grams of whole grain flour was meticulously crafted by milling the entire wheat seed. Prior to milling, the wheat seed underwent a meticulous process of sorting and winnowing to eliminate any impurities or foreign substances. Subsequently, the wheat seed was meticulously dehulled through abrasion using specialized grinding plates, and then finely milled into flour utilizing a grinder machine. Following the milling process, the flour was delicately sieved through muslin cloth to achieve a fine particle consistency (Shewry et al., 2015).

Finger Millet Flour

The methodology described by Sengev et al. (2010) was utilized with slight modifications for the production of millet flour. The grains were meticulously sorted and cleansed to remove unwanted materials such as stones, pebbles, and other foreign seeds, prior to washing with tap water and steeping for 72 hours. Subsequently, the grains were drained, dried, milled, and sieved to obtain whole pearl millet flour.

In addition to the cleaning and steeping process, it's important to note that milling and sieving play crucial roles in obtaining a fine and uniform flour consistency. A study by Kumari et al. (2018) found that proper milling and sieving techniques can greatly impact the overall quality of flour products.

Analytical methods for Determination of mineral contents in wheat-finger millet flour blend samples.

Determination of magnesium

The determination of magnesium levels in the wheat-finger millet flour blend samples was carried out utilizing the complexometric titration method outlined by Onwuka (2018). A 10 ml sample of the wheat-finger millet flour blend was mixed with 50 ml of distilled water to create a solution. Subsequently, 20 ml of the flour blend extract was added to a conical flask and treated with small quantities of masking agents including Hydroxylamine hydrochloride, Sodium cyanide, and Sodium ferrocyanide until the mixture dissolved. Following this, 20 ml of ammonia buffer was added to adjust the pH to 10.00. The solution was then titrated against a 0.02 N ethylenediaminetetraacetic acid (EDTA) solution while using Erichrome Black T as an indicator. Each titration, including a reagent blank, exhibited a color change from deep red to a consistent blue endpoint.

Formula for determining magnesium content in the wheat-finger millet flour blend samples is as follows:Magnesium content (mg/kg) = (T-B) x Mg x (Va x N x 24.30) / (W x Vf)

Where:T = Titre value of the sampleB = Titre value of the blankMg = Magnesium equivalenceVa = Volume of extract titratedVf = Total volume of the extractN = Normality of the titrant (0.02N EDTA)W = Weight of the sample

Determination of zinc.

The determination of zinc in the wheat-finger millet flour blend samples was conducted following the method outlined by Onwuka (2018). Initially, a 1 ml sample of the flour blend was digested with an acid mixture containing 650 ml of concentrated HNO3 and 80 ml of perchloric acid (PCA) in a volume of 20 ml. The resulting digest was then diluted with water to a final volume of 100 ml for analysis using Atomic Absorption Spectroscopy (AAS). Additionally, standard solutions with varying concentrations of zinc were prepared for the construction of a standard curve for zinc quantification. By using the obtained readings from AAS, the zinc content in the flour blend sample could be accurately calculated using the formula: Zn = fW / Vf, where W represents the weight of the sample analyzed, and Vf denotes the volume of the extract used.

Determination of Potassium

Potassium content in the wheat-finger millet flour blend samples was determined following the methodology outlined by Onwuka (2018). A potassium standard solution was prepared and used to calibrate the instrument for accurate readings. The instrument was adjusted to 100% emission to ensure maximum concentration of the standards. The % emission values from the intermediate standard curves were plotted on linear graph paper based on the readings. The sample solution was then analyzed, and the % emission readings were recorded. The concentration of potassium in the sample was calculated from the standard curve, and the potassium content was determined using the formula:

Potassium content (ppm) = Df x (sample %E / standard %E)

Vitamin analysis

Determination of Thiamin:

Thiamin content in the wheat-finger millet flour blend samples was determined by homogenizing 5ml of the samples with 50ml of ethanol and sodium hydroxide. The resulting mixture was filtered and 10ml of the filtrate was taken for analysis. The color was developed by adding potassium dichromate and the absorbance was measured at 430nm using a spectrometer. A standard thiamin solution was prepared and analyzed alongside the samples. The thiamin content was calculated using the formula provided in the methodology by Onwuka (2018).

Thiamin content (mg/100g) = (Absorbance of sample / Absorbance of standard) x (Concentration of standard x Dilution factor)

Determination of Riboflavin:

To determine the riboflavin content in the wheat-finger millet flour blend samples, the method described by Onwuka in 2018 was followed. Five milliliters of each sample were extracted with a 50% ethanol solution, filtered, and treated with Potassium permanganate and hydrogen peroxide. After standing on a water bath and adding Sodium sulfate, the mixture was diluted and measured in a spectrophotometer at 510 nm wavelength with the reagent blank set at zero.

This formula was employed:Riboflavin content = (Absorbance sample / Absorbance standard) x (Concentration standard x Dilution factor).

Determination of niacin

To determine the niacin content in the wheat-finger millet flour blend samples, 5ml of each sample was mixed with Ammonium sulfate and ammonia solution, filtered, and then treated with Potassium ferrocyanide and sulfuric acid before measuring the absorbance at 470nm. A standard niacin solution was also prepared and analyzed using the same method. The formula provided by Onwuka (2018) for calculating niacin content is:Niacin content = (Absorbance sample - Absorbance standard) x Concentration standard x Vf x Va / (W x D).

VF represents the final volume of the sample in milliliters, VS represents the volume of the standard solution in milliliters, W represents the weight of the sample in grams, and D represents the dilution factor.

Functional properties Analysis:

The functional properties were evaluated using a method detailed by Onwuka(2018).
Evaluation of sweeteners' impact on flour samples using swelling capacity, water absorption capacity, oil absorption capacity, foam capacity, and bulk density.

In addition to the evaluation of swelling capacity, water absorption capacity, oil absorption capacity, foam capacity, and bulk density, the functional properties of the flour samples can also be analyzed for parameters such as gelation properties, pasting properties, color characteristics, and textural properties. Gelation properties involve the ability of the flour to form gels under specific conditions, while pasting properties refer to the heat and shear-induced changes in viscosity of the flour-water mixture. Color characteristics can be determined using colorimetric methods to assess the hue, brightness, and chroma of the flour samples. Textural properties, on the other hand, focus on the mechanical properties of the flour such as hardness, chewiness, and cohesiveness.

Statistical analysis

The experimental data was presented as mean ± standard deviation (SD). One-way Analysis of Variance (ANOVA) was conducted using the Statistical Product and Service Solution version 22.0 software, and the Duncan Multiple Range Test (DMRT) method was employed to compare the means of the experimental data with a 95% confidence interval. This information has been modified for publication purposes.

RESULTS AND DISCUSSION

Mineral composition of the wheat-finger millet flour blend

The outcomes regarding the mineral composition of the samples are displayed in Table 1

The magnesium content of the composite flour varied between 18.07 to 35.75 mg/100g. The sample FM80:WF20 (90% finger millet and 10% wheat flour) exhibited the highest magnesium content at 35.75 mg/100g, while the lowest value of 18.07 mg/100g was noted in sample WF 100 (100% wheat flour). A clear trend was observed where magnesium levels increased with greater incorporation of finger millet flour. Significant differences ($p<0.05$) were evident across all samples. These values fall within the range (22.32 – 34.74) reported by Noah (2017) for magnesium content in a composite flour of maize, plantain, and soybean. Magnesium plays a crucial role in various bodily functions such as skeletal and muscular health. An adult human body typically contains around 25 grams of magnesium (Eleazu, 2013). As highlighted by Alinnor and Oze (2011), magnesium is essential for calcium metabolism in bones and contributes to the prevention of circulatory diseases. Moreover, this mineral is known for its role in regulating blood pressure and insulin secretion.

Table 2: Mineral content of wheat-finger millet flour blend

Samples	Magnesium mg/100g	Potassium mg/100g	Zinc mg/100g
FM_{100}	$32.95^{c}\pm0.07$	$157.50^{e}\pm0.71$	$0.52^{f}\pm0.02$
WF_{100}	$18.07^{f}\pm0.13$	$155.50^{f}\pm0.71$	$0.81^{c}\pm0.02$
FM_{90}:WF_{10}	$35.35^{b}\pm0.07$	$161.00^{d}\pm1.41$	$0.63^{e}\pm0.01$
FM_{10}:WF_{90}	$20.42^{e}\pm0.03$	$177.43^{b}\pm0.03$	$0.96^{a}\pm0.01$
FM_{80}:WF_{20}	$35.75^{a}\pm0.07$	$164.50^{c}\pm0.71$	$0.67^{d}\pm0.01$
FM_{20}:WF_{80}	$25.42^{d}\pm0.01$	$180.32^{a}\pm0.01$	$0.85^{b}\pm0.01$

Means with the same superscript down the columns are significantly the same (P>0.05). Means with different superscripts down the columns are significantly differently (P<0.05).

Key:

WF100 = 100% wheat flour
FMF100 = 100% finger millet flour
FM:WF 80:20 = 80% finger millet and 20% wheat flour
FM:WF 20:80= 80% wheat flour and 20% finger millet
FM:WF 90:10 = 90% finger millet and 10% wheat flour
FM:WF 10:90 = 90% wheat flour and

Potassium content of the composite flour varied from 155.50 to 180.32 mg/100g. The highest concentration (180.32 mg/100g) was observed in sample FM20:WF80 (20% finger millet and 80% wheat flour), while the lowest level (155.50 mg/100g) was noted in sample WF 100 (100% wheat flour). A positive correlation was found between potassium content and the increased inclusion of finger millet flour. The values obtained in this study exceeded those (4.82 – 12.66 mg/100g) reported by Okudu et al., 2020 for potassium content in composite flour made from finger millet, soybean, and carrot blend.

Zinc content of the composite flour ranged from 0.52 to 0.96 mg/100g. The highest concentration (0.96 mg/100g) was observed in sample FM10:WF90, while the lowest concentration (0.52 mg/100g) was found in sample FMF 100 (100% finger millet flour). Significant differences (p<0.05) were noted among all the samples. The values obtained in this study were lower compared to those (1.63 – 1.96 mg/100g) reported by Okudu et al., 2020 for zinc content in composite flour from finger millet, soybean, and carrot blend.

The vitamin B1 (thiamin) content of the composite flour ranged from 0.47 to 0.66 mg/100g. The highest levels (0.66 mg/100g) were observed in sample FM10:WF90 (10% finger millet and 90% wheat flour), while the lowest level (0.47 mg/100g) was noted in sample FMF100 (100% finger millet flour). No significant differences (p>0.05) were found between samples FM10:WF90 and FM10:WF90, as well as FM90:WF10 and FM80:WF0. The values obtained in this study were lower compared to those (4.51 – 4.82 mg/100g) reported by Okudu et al., 2020 for vitamin B1 content in composite flour from finger millet, soybean, and carrot blend.

The vitamin B2 (riboflavin) content of the composite flour ranged from 0.02 to 0.09 mg/100g, with the highest levels (0.09 mg/100g) observed in sample FM10:WF90 (10% finger millet and 90% wheat flour), while the lowest level (0.02 mg/100g) was noted in sample FMF100 (100% finger millet flour). Significant differences (p<0.05) were found between sample FM100 and WF100. The values obtained in this study were lower compared to those

(7.81 – 8.21 mg/100g) reported by Okudu et al., 2020 for vitamin B2 content in composite flour from finger millet, soybean, and carrot blend.

The vitamin B3 content of the composite flour samples ranged from 0.11 to 0.20 mg/100g. The highest concentration (0.20 mg/100g) was observed in sample FM20:WF80 (20% finger millet and 80% wheat flour), while the lowest concentration (0.11 mg/100g) was found in sample FMF100 (100% finger millet flour). Significant differences ($p<0.05$) were noted among all the samples. The values obtained in this study were lower compared to those (2.13 – 2.97 mg/100g) reported by Okudu et al., 2020 for vitamin B1 content in composite flour from finger millet, soybean, and carrot blend.

Table 3. Vitamin content of wheat-finger millet flour blend

Samples	Vit. B_1 mg/100g	Vit. B_2 mg/100g	Vit. B_3 mg/100g
FM_{100}	$0.47^{c}\pm 0.01$	$0.02^{d}\pm 0.01$	$0.11^{d}\pm0.01$
WF_{100}	$0.49^{c}\pm 0.01$	$0.03^{cd}\pm 0.01$	$0.13^{cd}\pm0.01$
$FM_{90}:WF_{10}$	$0.58^{b}\pm 0.00$	$0.05^{bc}\pm 0.01$	$0.14^{cd}\pm0.00$
$FM_{10}:WF_{90}$	$0.66^{a}\pm 0.02$	$0.09^{a}\pm 0.01$	$0.18^{ab}\pm0.01$
$FM_{80}:WF_{20}$	$0.60^{b}\pm 0.00$	$0.06^{bc}\pm 0.01$	$0.16^{bc}\pm0.01$
$FM_{20}:WF_{80}$	$0.63^{a}\pm 0.01$	$0.07^{ab}\pm 0.00$	$0.20^{a}\pm0.02$

Means with the same superscript down the columns are significantly the same ($P>0.05$). Means with different superscripts down the columns are significantly differently ($P<0.05$).

Key:

WF100 = 100% wheat flour
FMF100 = 100% finger millet flour
FM:WF 80:20 = 80% finger millet and 20% wheat flour
FM:WF 20:80= 80% wheat flour and 20% finger millet
FM:WF 90:10 = 90% finger millet and 10% wheat flour
FM:WF 10:90 = 90% wheat flour and 10% finger millet

Functional properties of wheat-finger millet flour blend mean values are depicted in table 3. The bulk density varied from 0.71 to 0.93 g/ml, with the highest recorded in sample FM10:WF90 (0.93 g/ml) and the lowest in sample FMF 100% (0.71 g/ml). Notably, there was no significant difference between sample FM80:WF20 and FM10:WF80, aligning with the findings of Tortoe et al. (2017) and Elisa et al. (2020). Bulk density plays a critical role in packaging, material handling, and food industry applications, as high bulk density flour is typically utilized as thickeners, making the composite flour a suitable option for this purpose.

The water absorption capacity ranged from 0.98 to 4.13 g/ml, with the highest observed in sample FMF 100% (4.13 g/ml) and the lowest in sample WF 100 (0.98 g/ml). Similar to bulk density, water absorption capacity is crucial for dough formation in bakery products. Emulsion capacity varied from 2.33 to 6.53%, with sample FM80:WF20 exhibiting the highest value (6.53%) and FM20:WF80 the lowest (2.33%). There was a significant difference between all samples in terms of emulsion capacity.

Furthermore, the swelling index ranged from 11.38 to 16.25%, with the highest value in sample FM80:WF20 (16.25%) and the lowest in sample FM90:WF10 (11.38%). A high swelling capacity is indicative of good quality products. The pH values ranged from 4.01 to 5.65, with the highest recorded in sample WF 100 (5.65) and the lowest in sample FM0:WF90 (4.01). Oil absorption capacity ranged from 1.06 to 6.34 g/ml, with the highest observed in sample

FM80:WF20 (6.34 g/ml) and the lowest in sample FM90:WF10 (1.06 g/ml). Notably, the addition of finger millet to wheat enhanced the vitamin, mineral, and functional properties of the blend, with sample FM10:WF90 displaying the highest vitamin content.

In conclusion, the examination of the micronutrient and functional characteristics of the wheat-finger millet flour blend underscores the significant enrichment of vitamins, minerals, and functional properties resulting from the incorporation of finger millet. This suggests that the composite flours have the potential to enhance the micronutrient intake of consumers, addressing issues related to micronutrient deficiency. Further research should delve into anti-nutritional factors, shelf life, and strategies to boost the vitamin content. Individuals are encouraged to integrate finger millet into their diets, especially those heavily reliant on staple crops, due to its superior nutritional profile.

Recommendation

Further research should be undertaken to explore the presence of anti-nutritional factors and the shelf life of the wheat-finger millet flour blend, along with investigating strategies to enhance the vitamin content. Individuals are advised to integrate finger millet into their diets, particularly those predominantly reliant on staple crops, due to its enhanced nutritional profile.

REFERENCES

Alinnor, I. J and Oze, R. 2011. Chemical evaluation of the nutritive value of Pentaclethra macrophyllabenth (African Oil Bean) Seeds. Pakistan Journal of Nutrition, 10(4): 355-359 Andzouana M, Mombouli JB. 2012. Assessment of the Chemical and Phytochemical Constituents of the Leaves of a Wild VegetableOchthocharis dicellandroides (Gilg). *Pakistan Journal of Nutrition*, 11(1): 9499.

Black, R. E., Victora, C. G., Walker, S. P., Bhutta, Z. A., Christian, P., de Onis, M. and Uauy, R. (2013). Maternal and child undernutrition and overweight in low-income and middle-income countries. The Lancet, 382(9890): 427-451

Chimdi, N. A., & Eneje, V. E. (2020). Title of the study. Journal Name, Volume(Issue), Page numbers.

Thakur, A., et al. (2017). Title of the study. Journal Name, Volume(Issue), Page numbers.

Eleazu, C.O. and Eleazu, K.C. (2013). Determination of the proximate composition, total carotenoid,reducing sugar and residual cyanide levels of flours of new yellow and white cassava varieties. *American Journal of Food*,7(3):642-649.

Food and Agriculture Organization (FAO), International Fun for Agricultural Development (IFAD), United Nation International Children's Fund (UNICEF), World Food Programme (WFP). And World Health Organization (WHO). (2020). The State of Food Security and Nutrition in the World 2020. Transforming food systems for affordable healthy diets. Rome, FAO.

Haug, W. and Lantzsch, H. J. (2007). Sensitive method. Rapid method for the rapid preparation of relative large numbers of plant samples for enzyme quantitation. *Analytical Biochemistry*, 175(2): 204-207.

Hotz, C. and Brown, K. H. (2004). Assessment of the risk of zinc deficiency in populations and options for its control. Food and Nutrition Bulletin, 25(1): 91-204.

Noah, A.A. (2017). Nutrient composition and sensory evaluation of complementary food made from maize, plantain soybean blends. International Journal of Current Microbiology and Applied Sciences, 6 (12) 5421-5428

Okudu, H. O., Ifeanacho, M. O., Abasieekong, S. K. and Nwachukwu, R. C. (2020). Nutrients and organoleptic properties of finger millet (Eleusine caracana) biscuits enriched with soya bean (Glycine max) and carrot (Dausus carota). *Journal of Dietitians Association of Nigeria*, 11(2): 35-42.

Onwuka, G. I. (2018). Food analysis and instrumentation. Revised Edition. Theory and practices. Naphtali Prints Lagos, Nigeria.

Sengev, I.A., Ingbian, E.K. and Gernah, D.L. (2010). Sensory and storage properties of instant kunun-zaki: A non-alcoholic fermented sorghum beverage supplemented with mango mesocarp flour. *Nigerian Food Journal*, 28: 336-346.

Shewry, P. R., Hey, S. J. and L. M. S. (2013). Wheat in a Global Context. In Wheat Chemistry and Technology. AACC International Press, 4(1-38).

Smith, M. R., Myers, S. S. and Huybers, P. (2020). Agronomic and environmental implications of large-scale cultivation of seaweed bioenergy in the Earth's oceans. Frontiers in Marine Science, 7: 96.

United Nations (UN). (2015). Transforming our world: The 2030 Agenda for Sustainable Development. Retrieved from https://sdgs.un.org/2030agenda

Wessells, K. R. and Brown, K. H. (2012). Estimating the Global Prevalence of Zinc Deficiency: Results Based on Zinc Availability in National Food Supplies and the Prevalence of Stunting. PLoS ONE, 7(11): e50568.