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Comparative Proximate and Mineral Nutrients Compositions of Friso Gold Wheat®, Cerelac® and 'Tom Bran' As Complementary Foods

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Abstract: *Children in developing countries within complementary feeding window are challenged with nutrition related health problems predicated in part upon poor nutritional knowledge of caregivers. This study therefore, compared the proximate and mineral nutrients, empirically determined, of a proposed complementary food ('Tom Bran') with those in two proprietary kinds (Cerelac and Friso Gold Wheat) for nutrient adequacy for the infant sub-population. The empirical data obtained (with the use of standard protocols) were statistical compared at p≥ 0.05. The result obtained demonstrated that Tom Bran is statistically richer in macro-nutrients (crude protein, crude fat and crude fibre) and energy than in either Cerelac or Friso Gold Wheat, save proximate ash content that was highest in Cerelac. Ca, K and Mg were significantly lower in Tom Bran compared to Friso Gold, which was similar to Cerelac. Compared with Tom Bran, Friso Gold wheat and Cerelac had significantly higher levels of Na, P, Zn, Cu, Fe and Mn; but significantly lower levels of Co. All three complementary foods studied are nutritionally adequate as complementary foods though, Tom Bran is richer in macro-nutrients than Cerelac and Friso, which are rather richer in mineral nutrients. Although optimum amount of nutrients in a particular food type does not always translate into healthy nutrition, good knowledge of local food stuffs could be explored to formulate and compound nutritionally adequate and healthy food that could provide the physiological supports required for optimum performance in growth and development in infants.*

Keywords*: 'Tom Bran', Cerelac, Friso, Gold Wheat, Mineral Nutrients, Proximate Composition, Complementary Food,*

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I. Introduction

Healthy infant nutrition involves exclusive breastfeeding for the first six months of age after which other foods should be introduced to the infant to complement breast milk. Complementary feeding therefore could be described as the processing of introducing other food to the infants to make up for the limitations in breast milk when breast milk alone is no longer sufficiently supportive in providing the nutrients required for optimum growth and development in the infant. To this end, it could be extrapolated that timing and content are essential to introducing other foods beside breast milk to the infant, if healthy infant nutrition is in view.

Several empirical observations concluded that for healthy term infants, after four to six months of age breast milk alone is no longer sufficient to provide for the requisite proteins, essential minerals and most vitamins to healthy performance of the infant in growth and development (World Health Organization, 2017). Therefore, complementary feeding should be introduced from six months of age while breast feeding could continue up to about twenty-four months of age (World Health Organization, 2017; United Nations Children's Fund, 2017). The predominant aspect of brain and cognitive development occur within the first and second year of the human life and require certain nutrients such as protein, zinc, cholesterol, essential fatty acids and certain vitamins. All of these nutrient requirements cannot be met by nutritional support offered by exclusive breastfeeding for more than six months of age (Mahan & Escott-Stump, 2008, United Nations Children's Fund,

2017). Usually stunting in infant growth during this period predicated upon inadequate nutrient intake is difficulty reversible at later stage in life and could present certain downstream physiological defects.

Experts have argued for the possibility of producing nutritionally adequate and acceptable complementary foods from readily available and easily affordable local food sources in Nigeria (Plahar& Annan, 1994;Nnam, 2002; Solomon, 2005a;Anigo *et al*., 2010 Akinola *et al*., 2014; Amah *et al*., 2016). Notwithstanding, the critical window of complementary nutrition still presents some public health nutrition challenge to the infant population group. Therefore, this study took on this note to compare the mineral and proximate nutrient profiles of certain proprietary complementary foods with those of a proposed kind in order to observe for the potential of such local food in providing healthy complementary nutrition for the infant population group.

II. Materials And Methods

Formulation and Compounding of 'Tom Bran'

The mixed legume-cereal based complementary food ('Tom Bran') was composed of a dry milled blend of soybeans, groundnut, yellow corn, guinea corn, and millet in ratio 2:1:1:1:1 (w/w). The soybeans and groundnut are to complement the nutrients deficient in the grains.

Determination of Nitrogen and Crude Protein

The samples were digested in sulphuric acid at temperature ranging between 360 to 410^{o}C. The rate of digestion was accelerated by using mixture of copper sulphate and sodium sulphate in the ratio of 1:9 respectively. On completion of digestion, the samples were cooled and distilled in the presence of NaOH. The distilled ammonia was collected in boric acid and titrated against standard acid in the presence of mixed indicator (Horneck and Miller, 1998). Then, crude protein was estimated as the nitrogen content multiplied by the protein factor (AOAC, 2005).

$$\%Nitrogen = \frac{(S-B)\times N \times 1.407}{Weight\ of\ sample\ (g)}$$

$$\%\,\mathrm{Pr}otein = \%Nitrogen \times 6.25$$

Where

S = Volume of acid used against the sample

B = Volume of acid used against the blank

N = Normality of the acid used in titration.

Determination of Crude Fat

Method 954.02 of Association of Analytical Chemists (AOAC, 1990) was slightly modified as described forthwith and applied to determine the crude fat content of the respective samples. Each sample was placed in the oven overnight at 105^{o}C and cool in desiccator to completely remove water from it. 5g of dehydrated sample was weighed into a completely dried thimble and uprightly positioned in Soxhlet apparatus whose flask was filled to a third of quarter with petroleum ether. Cooling water was set to run through the condensing compartment while heating the flask. The system was set to condense at 5-6 drops per second and left refluxing for four hours. The thimble was removed from the Soxhlet apparatus and kept at room temperature for ether to evaporate, and then kept overnight in the oven at 105^{o}C. The thimble was removed from the oven, cooled in desiccator and weighed. Amount of crude fat was estimated as percentage of the weight of sample taken:

$$\%Crude\ Fat = \frac{weight\ of\ fat}{Weight\ of\ sample\ (g)} \times 100$$

Determination of Crude Fibre

Four grams of each moisture-free sample was weighed into a 250ml beaker, and 50ml 4% H_2SO_4 added followed by distilled water to a volume of 200ml. This was then heated to boiling and kept boiling for exactly 30 minutes, with constant stirring using a rubber tipped glass rod to remove all particles from sides of beaker. The volume was kept constant by addition of hot distilled water. After 30 minutes of boiling, the content was poured into a buchner funnel fitted with an ashless Whatman filter paper No. 40 and connected to a vacuum pump. The beaker was washed several times with hot distilled water and then transferred quantitatively with a jet of hot water. Washing continued on the funnel until the filtrate was acid-free as indicated by litmus test. The acid-free residue was transferred quantitatively from the filter paper into the same beaker, removing the last

traces with 5% NaOH solution and hot water to a volume of 200ml. Again the mixture was brought to boil and kept boiling for 30 minutes with constant stirring as earlier described, keeping the volume constant with hot water. The mixture was then filtered and washed as earlier described until alkaline free. Finally, the resultant residue was washed with two portions of 2ml 95% alcohol. Residues on filter paper were transferred to a pre-weighed porcelain crucible. The content of the crucible was then dried in an oven maintained at 110^{o}C to a constant weight after cooling in a desiccator. Crucible content was then ignited in a muffle furnace at 550^{o}C for 8 hours, cooled and weighed. Each food sample was analyzed in triplicate. Crude fibre was calculated as loss in weight due to ignition

Calculation

$$\%\ Crude\ \ fibre = \frac{W_2 - W_3}{W_1} \times 100$$

Where:
W_1 = Weight of sample
W_2 = Weight of sample after extraction
W_3 = Weight of sample after ashing in muffle furnace

Determination of Moisture Content
The standard method of AOAC (1990) was used to determine the moisture contents of the experimental diets.

Procedure: For each sample, a set of three evaporating dishes was cleaned, labeled and dried in hot air Cabolite oven set to 105^{o}C for 40 minutes. They were then cooled in a dessicator containing dried silica gel as desiccant, and their weight was noted. 2g each of the milled samples was accurately weighed into the labeled evaporating dishes. The gross weight of each samples and its containing dish was read using a previously balanced Adams top loading balance. The sample was then dried in the oven at 105^{o}C for 5hours, cooled in the dessicator, and weighed. Drying and weighing of samples continued, at same temperature but at 1hour time interval, until constant weight was attained by each sample.

***Calculation*:** The moisture content of each sample was calculated as the difference in weights before and after drying to constant weights and expressed in percentage. The dried samples were separately stored in clean dry airtight container, labeled, and kept to serve further analytical needs.

$$\%\ Moisture\ content = \frac{W_2 - W_3}{W_2 - W_1} \times 100$$

Where:
W_1 = Weight of evaporating dish
W_2 = Weight of sample and evaporating dish before drying in the oven
W_3 = Weight of sample and evaporating dish after drying in the oven

Determination of Ash Content and Organic Matter Content
Ash content of the samples was determined as prescribed by standard procedure (AOAC, 1990).

***Procedure*:** 2g of each sample was accurately weighed into labeled lidded crucible and the gross weight of the crucible and sample read. Crucibles containing their respective samples were ignited in the muffle furnace at 550^{o}C for 6 hours to light gray coloured ash; then they were removed by means of tong and placed immediately in dessicator containing silica gel dessicant to cool. The weight of the crucible and ash was noted. Ash content determination was carried out in triplicate.

***Calculation*:** Weight loss by samples due to ignition in the furnace was calculated as organic matter content of each food sample. Whereas, the difference between the gross weight of crucibles and the sample on one hand, and that of the crucible containing the ash was read as the weight of ash of each sample. Ash content of each sample was calculated and expressed in percentage.

$$\%\ Organic\ matter\ content = \frac{W_1 - W_2}{W_1 - W_0} \times 100$$

$$\%\ Ash\ content = \frac{W_2 - W_0}{W_1 - W_0} \times 100$$

Where:
W_0 = Weight of empty crucible
W_1 = Weight of sample and crucible before igniting in furnace
W_2 = Weight of sample after igniting in furnace

Estimation of Total Carbohydrate
Carbohydrate content of each sample was estimated using the *Carbohydrate by Difference Theory* as prescribed by standard procedure (AOAC, 1980). The theory suggests that proximate carbohydrate composition of a food sample could be estimated by the difference between the sum of the samples' proximate protein, fat, fibre, ash, and moisture and the percentage value of 100 (Elinge *et. al.*, 2012)

$$\%\,\text{Carbohydrate} = 100 - (\%\,\text{protein} + \%\,\text{fat} + \%\,\text{moisture} + \%\,\text{ash} + \%\,\text{fiber})$$

Calculation of Caloric Value of the Food samples
The factors 4, 9 and 4 represent the approximate amount of energy available to the body per gram of carbohydrate, fat and protein respectively (physiological fuel value). These were used to compute the caloric values of the food samples analyzed as follows:
Total caloric value = Sum (gram of each nutrient in diet x factor) (Solomon, 2005b)Details of the mathematical relation is presented below as described by Elinge *et. al.* (2012):

Energy (kcal) =[(%CHO x 4) + (%CP x 4) + (CL x 9)]
Where CHO, CP and CL stand for carbohydrate, crude protein and crude lipid respectively.

Mineral Nutrient Analysis
Clean pulverized samples were prepared for mineral analyses following the method of the Association of Official Analytical Chemist (AOAC, 1990), with certain modifications as describe forthwith. However, wet tri-acid digestion was adopted to ensure insignificant loss (if any) of mineral nutrients from sample.

Tri-acid digestion and preparation of stock solution: 2g of each powdered sample was weighed in a 250ml pyrex conical flask into which 5ml of concentrated H_2SO_4 was added. The acid-sample mixture was heated at 100^oC for 30 minutes during which frothing ceased, and allowed to cool. 5ml of the tri-acid digestion mixture, a mixture of concentrated nitric, perchloric, and sulphuric acids in the ratio 9:2:1(Elinge *et. al.*, 2012), was then added to the flask content. The entire reaction system was heated at 200^oC until dense white fume evolved and transparent white residue is left behind in the flask. The reaction system was allowed to cool and 50ml of double distilled deionized water was added to dissolve the residual paste. The solution was filtered into a 100ml pyrex volumetric flask with 4 to 5 washing and made up to the volume. This filtrate was used as stock solution for the various mineral analyses. Further dilutions of the stock solution were made as needful to ensure accurate chemical analyses.

Determination of mineral Nutrients in Digest:The tri-acid digests were subjected to three different analytical procedures to determine their respective select mineral nutrient composition. Fe, Zn, Co, Mg, Ca and Mn were determined by Atomic Absorption Spectrophotometry (Alpha 4 model, Buck Scientific Ltd USA). Na and K were determined using atomic emission spectrometer (200-A model, Buck Scientific Ltd UK), while colorimetric method was adopted determining the amount of phosphorus in the different samples (Elinge *et al*., 2012).

III. Statistical Treatment Of Data

Descriptive and inferential tools of statistical analyses were adopted while analysing the data collated in course of the study. Measure of central tendency like mean and standard deviation of the mean, and other descriptive statistical tools like percentages, bars, and table were employed for the data analysis. Whereas comparison of mean among groups was carried out with the use of One Way Analysis of Variance (ANOVA), Post Hoc Duncan Waller Test was carried at Alpha values of less than 0.05 (95% confidence interval for the mean values) to separate the values in to their heterogenous subsets and to determine significance. Values of N less 1 and N were the adopted degrees of freedom between treatment groups and within treatment groups respectively. Type 1/Type 2 Error Seriousness Ratio was 100% considered meanwhile the statistics for each analysis were based on cases with no missing data for any variable through out the analysis. The statistical treatment was carried out using the Statistical Package for Social Sciences (SPSS).

IV. Result

Table 1: Comparative Proximate Composition of Friso Gold, Cerelac and Tom Bran

	Friso Gold	Cerelac	Tom Bran
Crude Protein (%)	13.31	15.92	22.71
Crude Fat (%)	1.12	1.93	14.52
Crude Fibre (%)	0.33	2.18	6.62
Moisture (%)	0.21	3.28	3.86
Ash (%)	2.37	3.17	2.36
Carbohydrate (%)	82.66	73.52	49.93
Energy (Cal/g)	3477.19	3320.11	3775.56

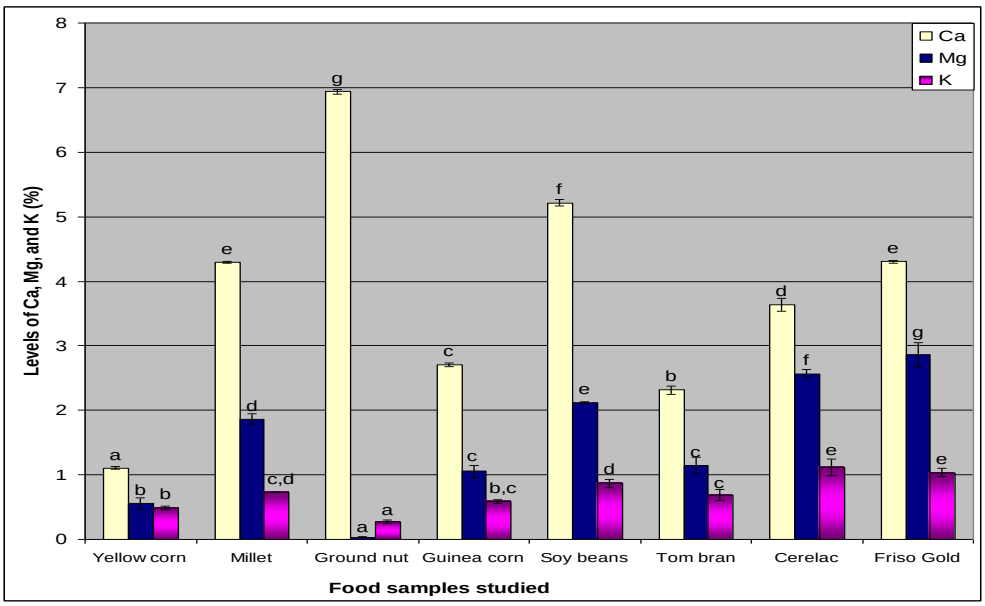

Figure 1: Comparative levels of calcium, magnesium, and potassium in the food samples studied. Each bar represents mean value while the 'mark' on each bar represents standard deviation around the mean. Bars with different alphabet labels are significantly different at $p<0.05$. The color legend on the chart indicates the variables represented by the various bar colors

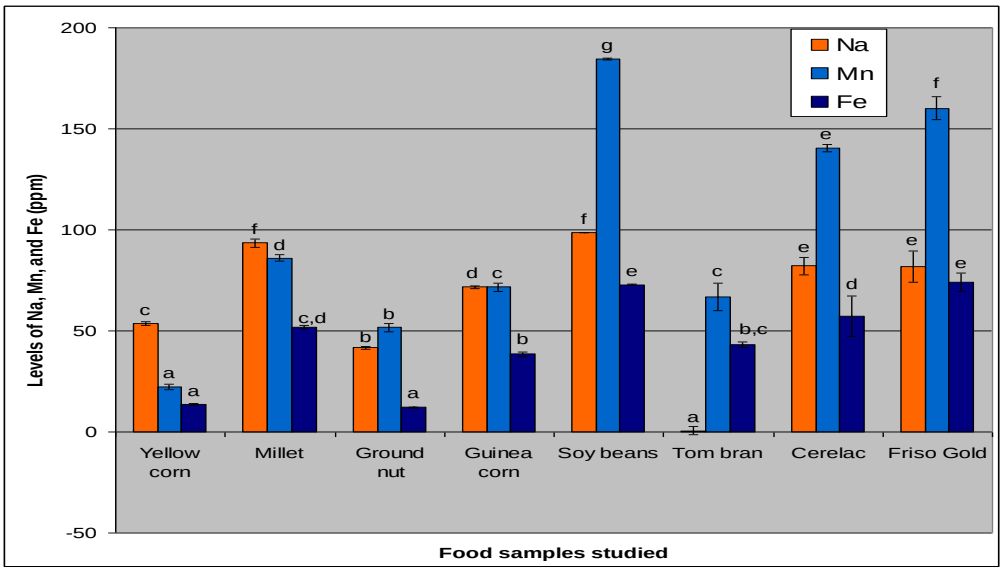

Figure 2: Comparative amounts of sodium, manganese, and iron in the food samples studied. Each bar represents mean value while the 'mark' on each bar represents standard deviation around the mean. Bars with different alphabet labels are significantly different at $p<0.05$. The color legend on the chart indicates the variables represented by the various bar colors.

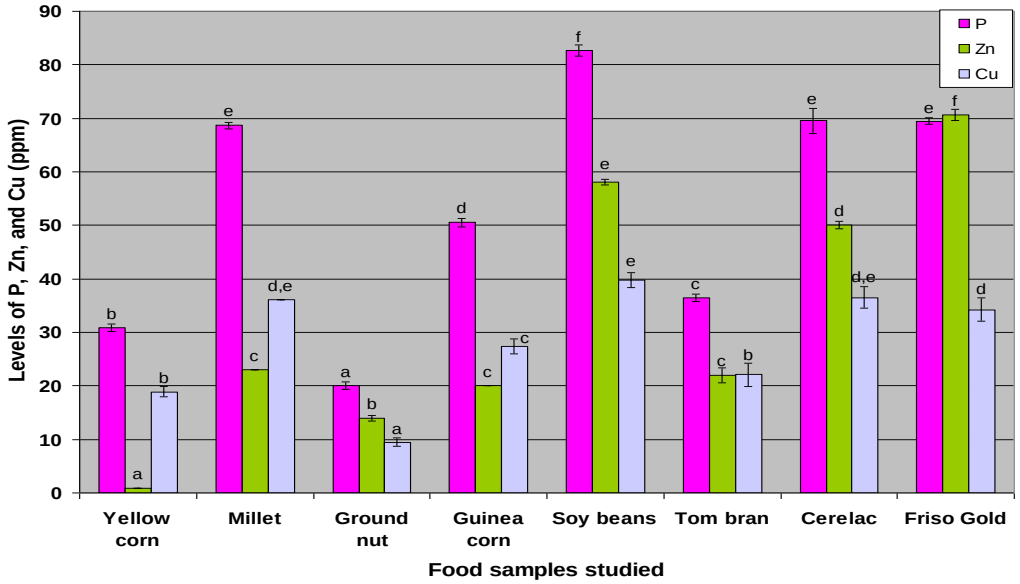

Figure 3: Comparative amounts of phosphorus, zinc, and copper in the food samples studied. Each bar represents mean value while the 'mark' on each bar represents standard deviation around the mean. Bars with different alphabet labels are significantly different at $p<0.05$. The color legend on the chart indicates the variables represented by the various bar colors.

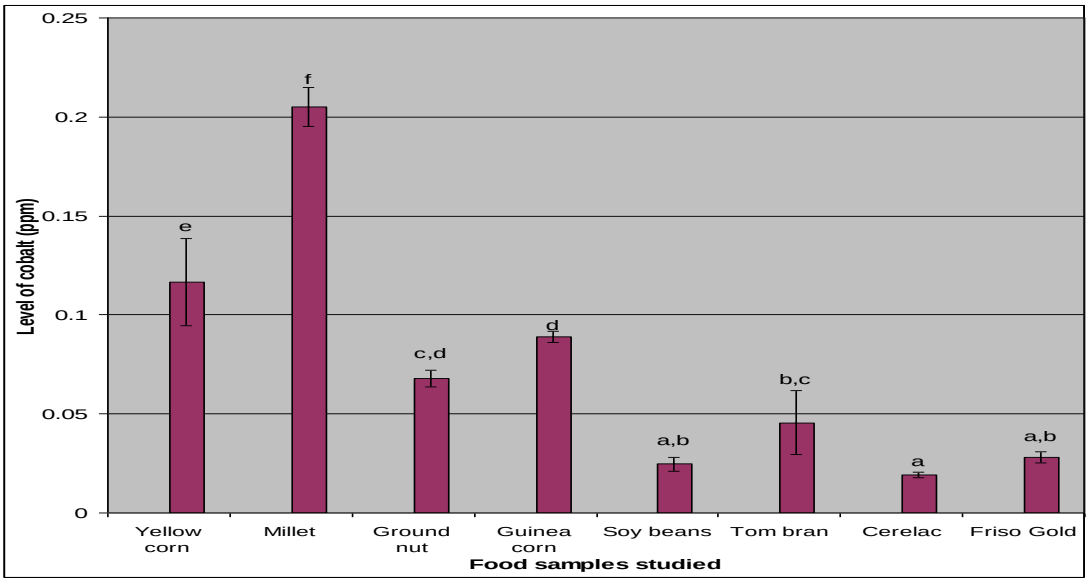

Figure 4: Comparative amount of cobalt present in the food samples studied. Each bar represents mean value while the 'mark' on each bar represents standard deviation around the mean. Bars with different alphabet labels are significantly different at $p<0.05$. The color legend on the chart indicates the variables represented by the various bar colors

V. Discussion

When the proximate composition of the foods investigated was compared (table 1), Tom Bran has the highest levels of both crude protein and crude fat (22.71% and 14.52%) compared with Cerelac (15.92% and 1.93%) and Friso Gold (13.31% and 1.12%) respectively. Cerelac had the highest amount of ash (3.17%) compared with Tom Bran Friso Gold has (2.37%) and Tom Bran (2.36%). Although very high in moisture, Tom is very rich in crude fibre and total (Artwater) energy compared with the other food types studied.

The composite legumes and cereals from which Tom Bran was made were studied for their levels of mineral nutrients and compared with those of 'Tom Bran' and the two branded complementary foods studied. The result (as shown of Figure1) revealed that (calcium) Ca in groundnut was statistically higher ($p \geq 0.05$) than observed in soy bean, millet, guinea corn or yellow corn. When comparing the complementary foods studied, Ca

and Mg (magnesium) were significantly lowest in Tom Bran but highest in Friso Gold Wheat. Although there was no significant difference between the levels of K (potassium) in Cerelac and Friso Gold Wheat, they were significantly higher than K observed in Tom Bran.

Figure 2 portrays the respective levels of iron (Fe), manganese (Mn) and sodium (Na) in all the foods studied. Amount of Na was significantly highest in soy bean and millet while groundnut recorded the lowest level of Na of all the composite foods studied; guinea corn and yellow corn come in (in that order) within the two extremes. Compared with Tom Bran, Friso Gold wheat and Cerelac had significantly higher levels of Na., Fe and Mn. Friso Gold had significantly higher levels of Fe and Mn (but not Na) than Cerelac.

The highest levels of Fe and Mn were observed in soy beans of all the foods studied. Whereas iron is important for both mental and physical development (Ford & Stein, 2016), iron deficiency anemia has been noted as a risk factor for poor child development (Walker *et al*., 2007; Walker *et al*., 2011). Again, stunted growth has been associated with poor nutrition during infancy (United Nations Children fund, 2013).In human, Mn has been demonstrated to play antioxidant role (Irshad & Chaudhuri, 2002), used as food supplement and in medicine and is essential for keeping in good health and well being (Clarke & Upson, 2016). International Manganese Institute (2014) asserted that Mn deficiency is linked with vitamin K deficiency in humans. Again, that impaired growth, skeletal abnormalities, disturbed or depressed reproductive functions, lack of muscular coordination among newborns and defect in both lipid and carbohydrate metabolism also do result from deficiency in Mn in all species. World Health Organization (2012) warns that excessive Na intake has been associated with a number of non-communicable diseases such as hypertension, cardiovascular disease and stroke while decreased intake reduces both blood pressure and risk of associated non-communicable diseases.

Comparative levels of copper (Cu), zinc (Zn) and phosphorus (P) in the composite grains and legumes from which Tom Bran was compounded and those in Cerelac and Friso Gold Wheat are shown in Figure 3 as observed in this study. Among the composite food studied, P was significantly highest in soy bean but least in groundnut. P in millet was statistically at per with that in both Cerelac and Friso Gold, which are significantly higher than P in Tom Bran; which was higher than that in yellow corn but lower than P in guinea corn. Higher level of Zn was observed in Friso Gold and Cerelac compared with Zn in Tom Bran. Soy Bean has High level of Zn, though, but not comparable with that in Friso Gold, although higher than Zn in either Cerelac or Tom Bran. Meanwhile the highest comparative level of Cu was observed in soy bean, Cu in Tom Bran was statistically lower than those in either Friso Gold or Cerelac. Groundnut seemed very poor in Cu content while yellow corn is poorest in Zn.

The United States National Institute of Health, NIH (2017) asserts that infants (7-24 months old) require 3mg Zn per day, needful for optimum immune function, healthy growth and division of cell, would healing, and breakdown of carbohydrates as well as for healthy growth and development during infancy and childhood beside being an antioxidant.Cu is a trace element with the primary roles of, beside being and antioxidant mineral nutrient, enhancing formation of haemoglobin and collagen and therefore, prevent against anaemia; and keeps the blood vessels, nerves, immune system, and bones healthy as well as aiding Fe absorption. Copper deficiency during developmental stage has been associated with poor mental and neuronal development. Copper slows down aging, and enhances ATP synthesis in the mitochondria (Pennington *et al*., 1995; Ma & Betts, 2000; National Institute of Health, 2017)

Comparing the the three complementary food studied, Tom Bran has significantly higher level Cobalt (Co) compared either Cerelac or Friso Gold. Notwithstanding, the highest level of Co was observed in millet, followed by yellow corn. Soy bean could be seen as a poor nutritional source Co (see Figure 4).

VI. Conclusion And Recommendation

Empirical laboratory investigation carried out on the composite cereal-legume based complementary food (Tom Bran) compounded and analyzed in course of this study, has nutrients obtainable in the conventional proprietary complementary formulae Friso Gold Wheat and Cerelac, although at varied proportions comparatively. The baseline emphasis is laid on whether or not any of the food studied contains the basic nutrient required for optimum growth and development in infants within the complementary feeding window than on mere nutrient content comparison. This is because suitability of a food kind for complementary feeding is predicated largely (if not completely) upon nutrient adequacy than content comparison, if healthy physiological support is the focal point.

From the result obtained as presented and discussed above, it could also be concluded that the three complementary food types studied have the potentials to singularly provide healthy amounts of different nutrients physiologically needful for infant growth and development, in good matrices respectively. Good

knowledge of local food stuffs could be explored to formulate and compound nutritionally adequate and healthy food that could provide the physiological supports required for optimum performance in growth and development of an infant.

Optimum amount of nutrients in a particular food type does not necessarily translate into healthy nutrition. The food must be acceptable and consumed in the right amount while the nutrients in the food matrix must be made available to the body system to drive healthy growth and development. Against this background, it is strongly recommended that biological studies be carried out, followed by clinical trials, to ascertain that the nutrients in these foods could be made available for body system to mobilized to bring about healthy nutrition and possibly correct certain reversible malnutrition-related aberrations.

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