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Comparable Vitamin and Mineral Contents of Co-Fermented Maize/Carrot/ Pigeon Pea and Co-Fermented Millet/ Sweet Potato/Pigeon Pea as Infant Complementary Food

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ABSTRACT

Utilization of nutrients from plant foods is of importance in achieving adequate infant nutrition. This study investigated the vitamin content, mineral composition, and functional properties of co-fermented maize/carrot/pigeon pea (MACP) and co-fermented millet/sweet potato/pigeon pea (MISP) as infant complementary foods using standard methods. The vitamin content and mineral composition as well as functional properties were determined using standard procedures. From the results, vitamin contents of MACP are: Vitamin A (52.63-6.08μg) vitamin (B_1,(0.23-0.10), B_2, (0.12-0.09), B_3, (1.45-1.25μg) B_5,(0.41-0.12) B_6,(0.19-0.25) B_9 (0.00-0.00 μg), C(2.026-14.99), E (0.12-0.12), and total vitamin content (77.50 - 25.09). For MISP, the vitamin contents are: Vitamin A (0.07-1.86), B1 (34.65-24.43), B2 (63.76-85.75), B3 (9.79-11.29), B4 (88.39-141.42), B5 (20.69-67.05), B6 (54.67-2.78), B9 (141.42-141.42), Vitamin C (0.42-0.23), E (69.55-63.55), K (5.11-5.60). All vitamin composition values were below the recommended daily allowance expected from complementary foods. Mineral value ranges were: sodium (172.60-185.85), potassium (575.08-635.28), calcium (193.45-232.88), magnesium (95.51-128.39), zinc (7.79-12.86), and iron (5.51-13.76). β-carotene value was higher in MISP than in MACP. The results of this study suggest that MACP might be more desirable as an infant's complementary food than MISP.

***Keywords**:* Undernourished, Amino acids, Carotenoids, Deficiency, Legume, Tuber.

Introduction

Infant malnutrition is one of the major causes of cognitive developmental delay that may lead to lifelong adverse effects on health.[1] Undernourished infants have lower resistance to infection, a less resilient immune system, and are more likely to die from common childhood ailments.[2] Excessive amounts of certain vitamins can be toxic or even fatal to infants. Carotenoid contains about 40% *Vitamin A.*[3] Vitamin A contributes to the formation of healthy skin, growth and development. Children are easily susceptible to vitamin A deficiency (VAD) due to higher requirement needed during critical growth periods. Symptoms of lack of vitamin A include night blindness, poor bone growth, reduced resistance to infection and retarded growth. Thus, consumption of vitamin A-rich foods is encouraged to support sustainable livelihoods.[4] The B vitamins are water soluble. The B vitamins are involved in the metabolism of protein, fat and carbohydrate conversion to adenosine triphosphate (ATP). Symptoms from lack of the B vitamins are poor growth, megaloblastic anemia, and impaired cellular immunity. Vitamin B1 (thiamine) deficiency symptoms include beriberi, neuritis and edema. Vitamin B2 (riboflavin) assist in metabolism of the mucous membranes in the digestive system, and in the absorption of iron and folic acid,[5] reported that in children with autism, supplements of vitamins B2 and B6 plus magnesium reduced the levels of abnormal organic acids in the urine. Vitamin B9 (Foliate) is an important factor in the production of red blood cells. It is essential in the production of nucleic acid and preserving the brain health of infants. Parts of the symptoms of vitamin B deficiency are fatigue, nausea; loss of antibody production, diarrhea, and reduced bone growth long-term risk of lower bone density[5] reported that folic acid supplementation might reduce the risk of cleft palate.

Vitamin C, also known as ascorbic acid, is a common constituents of vegetables and fruits; adequate vitamin C in the body can prevent scurvy especially in infants, assist the repair of tissue and the production of certain neurotransmitters. Studies have shown that consuming more vitamin C can increase blood antioxidant levels by up to 30%.[6] Unlike vitamin K2, vitamin K1also called phylloquinone, is obtained from the diet, Deficiency symptoms include possible hemolytic anemia and hyperbilirubinemia (jaundice) in infants.[7]

The minerals that are important for complementary infant foods are: magnesium calcium, iron, zinc and manganese.

Magnesium is essential in the regulation of Ca, K, and Na to maintain optimal functioning conditions. Deficiency symptoms include diarrheoa, central nervous system dysfunction, and spastic symptoms [7]. Over 99% of the total calcium in the body is located in the bones, where it accounts for 39% of the total body bone mineral content.[5] According to[8], excessive calcium intake (2 g/day) can inhibit the absorption of magnesium in the small intestine. Iron is a key player in the formation of red blood cells deficiencies in iron symptoms include anemia, impaired psychomotor development and cognitive performance, and reduced immune function.[9] Sodium is involved in fluid and electrolyte balance and is required for normal cellular function.[10] According to WHO, [11] excess sodium consumption in infants can result in high blood pressure which may persist to

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adulthood, Manganese is essential for infant's healthy growth and it is considered and not toxic when orally consumed.[12] Zinc participates in protein synthesis and in the acid: base ratio in the body system. Zinc deficiency symptoms are nausea, vomiting, loss of appetite, abdominal cramps, diarrhea, and headache and can interfere with copper uptake.[13] Pigeon pea (*Cajanus cajan* (L) Millsp), belongs to the family leguminoseae. It contains 20 to 22% protein, 1.2% fat, 65% carbohydrate, and 3.8% ash.[14] Its utilization is generally low because of its tough testa which makes its cooking time long and increase fuel, and processing time. All products obtained from soya beans can be produced from pigeon pea.[15]

Pearl Millet (*Penninsetum americanum*) is not toxic at any stage, and it contains higher protein content (8-19%) than most cereals. Millet is rich in minerals, vitamins, and methionine.

Carrots (*Daucus carota)* of Apiaceae family have high levels of beta-carotene, which is converted to vitamin A within the body.

The root (tuber) of sweet potato *(Ipomean batatas),* has been shown to contain Vitamins A and C, tannins, phytin, oxalate, raffinose, copper, dietary fiber, and β-carotene (Neela and Fanta 2019).

Nigerian infants aged 6 to 24 months are faced with acute malnutrition among low-socio-economic mothers because the fermented cereal gruels used as infant complimentary foods are of poor nutritional quality while many other legumes and vegetables are underutilized as infant complimentary foods. This study aimed to compare the vitamin and mineral contents of co-fermented maize/carrot/ pigeon pea and co-fermented millet/ sweet potato/pigeon pea. This study explored the nutritional quality of cereals, legumes and vegetables and tubers as possible infant complimentary food.

Materials and Methods

Sample collection:

Mature grains of pigeon pea and pearl millet were bought from Oja-oba a rural market popular for marketing grains in Ikole-Ekiti Local Government area of Ekiti State, Nigeria Sweet potato and carrot were bought at Atikankan market in the Hausa community of Ado-Ekiti in Ado Local Government Area of Ekiti-State. Samples were collected on 12th September 2019. Two kilograms of each material was collected. Grains were winnowed and sorted; while fresh tubers of sweet potato and fresh roots of carrots were washed in clean water, peeled, and cut into slices of about 2.0 mm thickness.

Sample preparation:

Mixtures of maize/carrot/pigeon pea (MACP) and millet/sweet potato/ pigeon pea (MISP), each in the ratio 60:20:20 were weighed and soaked in tepid water for 72 h at every 24 h of the fermentation and pH was measured. After 72 h, each mixture was wet milled and wet sieved using a cheese cloth, the shafts were discarded, and Sediment from each mixture was left in the water for 24 h for further fermentation. The slurry was dewatered and dried at 60°C. Dried mixture was milled and sieved (300mm sieve). The final flour was stored at 4°C for analyses.

Vitamin analysis

The vitamin content profile of the samples was analyzed following the methods of [16].

Carotenoid analysis

This was carried using the method of Rodriguez-Amaya and Kimura,[17] absorbance was read at 450 nm. Total carotenoid content (μg/100)/6 was expressed as μg RE/100g.

Minerals analysis

Minerals were analyzed from the solution obtained by first dry ashing the samples at 550°C. Na, K, Ca, Mg, Zn, Fe, Mn, were determined using atomic absorption spectrophotometer (Buck Scientific Model-200 A/210, Norwalk, Connecticut 06855) and all chemicals used were of British Drug House (BDH, London, UK) analytical grade. The detection limits for the metals in aqueous solution had been determined previously using the method of Varian Techtron. [9]

This was analyzed from the solution obtained by first dry ashing the samples at 550°C. Na, K, Ca, Mg, Zn, Fe, Mn, were determined using atomic absorption spectrophotometer (Buck Scientific Model- 200 A/210, Norwalk, Connecticut 06855)

Mineral safety index (MSI)

The mineral safety index (MSI) of Na, Mg, Ca, Fe, and Zn were also calculated [18]

$$MSI = \frac{\text{Tabulated mineral safety index x Value of mineral in sample}}{\text{Recommended infant intake}}$$

Statistical analysis

Data were analyzed by one-way ANOVA with Dunnett's multiple comparison post hoc tests to compare between the groups. Data were analyzed using Graphpad Prism 5.0 version. All data were presented as mean ± SEM. The level of significance was set at $p < 0.05$.

Results and Discussion

During the first month, breast milk provides build-up stores of vitamin A. After six months**,** 19, complementary foods are needed to provide enough vitamins A. MACP had a comparable value for 9-11 and 9-11 -months-old infants on average breast milk intake, but higher values than RDA of zero for 6-23 on high breast milk intake. AB had higher values than required for 6-23mos; while MISP and UMISP were significantly too low. Thus, the consumption of MACP by 9-11 month old infants might enhance in the formation and maintenance of healthy skin, immune system and effective bone metabolism. Consumption UMACP for 6-23 months might lead to toxicity which might also result in BF (BF Bulging frontanelle), a, decrease in bone density resulting in retarded growth and lipid metabolism. Higher doses have no effect on 6- 9 -months-old infants but on 6-17 -week-old infants, [19] contrary to the finding of, [20] vitamin A was not affected by fermentation in this study.

In vitamin B1, MACP and UMISP had comparable values for 6-8 months on low and average breast milk intake; UMACP had comparable value to RDA for 9-11mo on low and average breast milk intake while MISP was too low. This result showed that consumption of MACP, UMISP, and UMACP in terms of vitamin B_1 might have a desirable effect on the utilization of glucose, protein, and fat because vitamin B1combines with phosphorus to form TPP which is necessary for these metabolisms and it will also reduce the chances of having Beriberi and neuritis. In vitamin B2, all values of UMACP, MACP and MISP and UMISP were significantly too low when compared to RDA values. Therefore, the consumption of these might not favour hydrogen ion transportation, synthesis of FMN and FAD, and the absorption rate of riboflavin. [21]

The values of vitamin B3 in all samples were significantly (P0>0.5) higher than the recommended values. Vitamin B3 UMACP had comparable RDA values for 6-8 months with low, average, and high breast milk intake. Consumption of this product will enhance brain function, energy release, and avoidance of pellagra. Vitamin B5, MACP had RDA comparable value for 6-8 months on low breast milk intake, while the value of UMACP was comparable to RDA for 12-23 months on low breast milk intake thus consuming both products can boost energy production, healthy liver, eyes and skin. In Vitamin B6, all values of MACP, UMACP, MISP, and UMISP were significantly (P>0.05) too high when compared to RDA values for 6-23mos infants. Consumption of these products in terms of vitamin B6 can lead to hyperoxaluria because tryptophan conversion to niacin is dependent on vitamin B6. [6] In comparison with its unfermented analogue UMACP; MACP had lower values of B3, B4, B6, B1, E, K, and B, while AB had higher values in these vitamins.

Vitamin B9 was zero for 6-23 months at low, average, and high breast milk intake. Consuming these products might lead to vitamin B9 deficiency which can be connected with autism, anemia, defective brain function which might be connected to autism, and can result in reduced permanent bone growth The slight decrease in B vitamins is in agreement with Haque *et al*.[22]

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Vitamin C, MACP, and UMISP had comparable values to RDA for 12-23 months old infants on low breast milk intake, while MISP had comparable values for 9-11months on low breast milk intake.

Table 1: vitamin content per 100g of MACP and MISP

	MACP		UMACP		MISP		UMISP	
Vitamin	Mean	CV%	Mean	CV%	Mean	CV%	Mean	CV%
B3 mg	1.45 ± 0.14[a]	9.79	3.91 ± 0.08[a]	2.17	1.27 ± 0.17[a]	13.33	1.35 ± 0.07[a]	5.30
B4 mg	0.00 ± 0.00[b]	20.20	0.08 ± 0.11[b]	132.58	0.08 ± 0.11[b]	141.42	0.08 ± 0.11[b]	135.98
B6 mg	0.19 ± 0.11[b]	54.67	0.47 ± 0.17[b]	36.50	0.37 ± 0.17[b]	45.99	0.29 ± 0.15[b]	50.51
C mg	20.25 ± 0.07[c]	0.35	10.19 ± 0.07[c]	0.69	14.99 ± 0.04[c]	0.28	18.74 ± 0.07[c]	0.38
A µg	0.16 ± 0.15[b]	94.28	0.19 ± 0.16[b]	82.57	0.12 ± 0.16[b]	134.41	0.07 ± 0.07[b]	102.48
B1 mg	0.23 ± 0.08[b]	34.65	0.42 ± 0.16[b]	38.63	0.19 ± 0.16[b]	82.31	0.24 ± 0.08[b]	32.01
B2 mg	0.13 ± 0.09[b]	69.64	0.05 ± 0.06[b]	141.42	0.09 ± 0.07[b]	82.22	0.01 ± 0.01[b]	54.39
E mg	0.14 ± 0.11[b]	77.42	0.19 ± 0.11[b]	58.62	0.15 ± 0.11[b]	76.44	0.13 ± 0.09[b]	65.06
B9 µg	0.05 ± 0.07[b]	141.42	0.09 ± 0.13[b]	141.42	0.09 ± 0.13[b]	141.42	0.08 ± 0.11[b]	141.42
K µg	0.01 ± 0.01[b]	111.65	1.35 ± 0.11b	8.09	0.10 ± 0.13[b]	138.51	0.09 ± 0.13[b]	136.86
B5mg	0.41 ± 0.08[b]	19.06	0.76 ± 0.17[b]	22.30	0.12 ± 0.08[b]	70.13	0.44 ± 0.08[b]	19.11
Total	23.02 ± 0.90	633.14	17.69 ± 1.33	665.00	17.56 ± 1.34	926.46	21.53 ± 0.96	743.50

Key: CA= Co- fermented maize/carrot/pigeon pea, AB= unfermented maize/ carrot/pigeon pea (control) ST= Co-fermented millet/sweet potato/pigeon pea FR= Unfermented millet/sweet potato/pigeon pea (control). Values with different superscripts are statistically significant at $p<0.05$

Table 2: Vitamin Profile per 100g of Co-fermented and unfermented samples

	MACP		UMACP		MISP		UMISP		RDA	
Vitamin	Mean	CV%	Mean	CV%	Mean	CV%	Mean	CV%	Mean	**CV%**
B3 mg	1.45 ± 0.14[a]	9.79	3.90± 0.07[a]	1.83	1.25 ± 0.14[a]	11.29	1.40 ± 0.14[a]	10.16	6.11 ± 0.15[a]	2.43
B4 mg	0.01 ± 0.01b	88.39	0.00± 0.00	60.61	0.00 ± 0.00	141.42	0.00 ± 0.00	35.36	0.58 ± 0.11[b]	18.45
B6 mg	0.19 ± 0.11[b]	54.67	0.41± 0.08[b]	20.95	0.25 ± 0.01[b]	2.78	0.24 ± 0.07[b]	29.59	330.08 ± 0.11[c]	0.03
C mg	20.26 ± 0.08[c]	0.42	10.20±0.08[c]	0.77	14.99 ± 0.03[c]	0.23	18.74 ± 0.08[c]	0.42	400.09 ± 0.13[d]	0.03
A µg	52.63 ± 0.04[d]	0.07	78.48±0.11[d]	0.14	6.08 ± 0.11[d]	1.86	19.09 ± 0.13[d]	0.67	0.59 ± 0.12[b]	20.55
B1mg	0.23 ± 0.08[b]	34.65	0.41 ± 0.15	36.13	0.10 ± 0.02[b]	24.43	0.24 ± 0.08[b]	32.23	0.59 ± 0.13[b]	21.57
B2mg	0.12 ± 0.08[b]	63.76	0.00 ± 0.00	141.42	0.09 ± 0.08[b]	85.78	0.01 ± 0.01[b]	54.39	5.07 ± 0.10[a]	1.95
E mg	0.12 ± 0.08[b]	69.55	0.18 ± 0.09b	51.64	0.12 ± 0.08[b]	63.55	0.10 ± 0.04[b]	37.91	150.10 ± 0.13[e]	0.09
B9 µg	0.00 ± 0.00	141.42	0.00 ± 0.00	141.42	0.00 ± 0.00	141.42	0.00 ± 0.00	141.42	15.09 ± 0.12[f]	0.80
K µg	2.08 ± 0.11[a]	5.11	126.97±0.09[e]	0.07	2.08 ± 0.12[a]	5.60	2.10 ± 0.13[a]	6.41	2.08 ± 0.11[g]	5.11
B5mg	0.41 ± 0.09[b]	20.69	0.72 ± 0.11[b]	15.25	0.12 ± 0.08[b]	67.05	0.44 ± 0.08[b]	18.28	0.51 ± 0.08[b]	15.40Z
Total	77.50 ± 0.81	488.52	221.26 ± 0.79	470.24	25.09 ± 0.68	545.43	42.36 ± 0.76	366.84	910.86 ± 1.28	86.42

Discussion Based on Estimated Vitamins needed from Complementary Foods by Level of Breast Milk Intake (WHO/FAO/UNU. 98
Values with different superscripts are statistically significant at $p<0.05$

Consuming MACP and UMISP can prevent scurvy, can enhance the production of neurotransmitters, and boost immunity. The results also showed that although values of vitamin C were higher than higher than that of other vitamins, MACP still had a significantly (P<0.05) higher Vitamin C value than all other samples.
Vitamin E was significantly (P<0.05) low for 6-23 months-old infants. One to three years old require 6mg/day. The low values are understandable because plants do not make vitamin E. Vitamin E deficiency can lead to reduction of phagocytes and gradual necrosis of the central nervous system thus resulting in neuropath disturbances, cardiomyopathy, and hematological disorders in infants.[23]
In Vitamin K, UMACP had a higher value than RDA requirement for 6-23 months old with low, average, and high breast milk intake. Therefore, an infant consuming the product UMACP might lead to vitamin toxicity. In this study, the fermentation process involving sieving, filtering, and drying at 60°C might have contributed to the reduction of vitamins in the co-fermented mixture It was observed that UMACP was more enhanced in vitamins A, B1, B3, B4, B5,B6 and B9 while in UMISP, vitamins B3, C, B2, B9 and E were more enhanced. Co-fermented mixture of MACP was more enhanced in vitamins C, B2, E, and K. However, the co-fermented MISP was more enhanced in vitamins A, B1, B4, B5, B6, and K. Generally co-fermented millet/sweet potato/pigeon pea MISP was more enhanced in vitamins than co-fermented maize/carrot/pigeon pea MACP.
Minerals as micronutrients form components of enzymes/ co-factors that are needed for body metabolic activities in the body.[24] Adequate intakes of some minerals like iron, zinc, phosphorus, potassium, magnesium, zinc, and calcium are essential for normal growth, and development of infants.[25] In Nigeria, inadequate dietary intake of these minerals is prevalent among infants of 0-24 months of low socio-economic mothers, thereby contributing to their deficiency among infants.[26] According to,[27] the sodium value in MISP, would meet 9-11months of high breast milk intake while that of MACP was comparable to the value for 0-6 months on average breast milk intake

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therefore the consumption of MACP may not lead to infancy blood pressure.[28]
Potassium, a building block of body tissue it aids in osmotic pressure and pH balance of the body cells for growth.

Potassium value of MACP was comparable to the value for 0-6 months on low breast milk intake and 12-23 months on average breast milk intake. Therefore, consumption of MACP will prevent anemia, impaired psychomotor development, and improve immune function.[29] Calcium creates a balance when K, Mg, or Na is in excessive amount in the body. Its deficiency may result in rickets, growth retardation, and biochemical hyperparathyroidism in infants. Calcium value in MACP was comparable to the requirement for 12-23mo on average breast milk intake, while the value of MISP was comparable to that of 0-6 on high breast milk intake and 9-11months on average and high breast milk intake.[27] Consumption of both products can prevent rickets and reduce bone density because over 99% of the total calcium of the body is located in the bone, where it accounts for 39% of the total body bone mineral content.[13] Magnesium is an activator of many enzymes, growth retardation and immunologic dysfunction. The magnesium values of MACP and MISP were significantly higher than required for 0-23 months. Children in Nigeria have intakes of magnesium many times higher than the estimated need. Large doses of magnesium consumption cause irregular heartbeat, coma, and death.[7]

Table 3: Minerals (mg/100g) B-Carotene RE/100g contents of MACP and MISP

	MACP		MISP	
Minerals	**MEAN**	**CV%**	**MEAN**	**CV%**
Na	172.60 ± 0.14[a]	0.08	185.85 ± 0.17[a]	0.04
K	575.08 ± 0.11[b]	0.02	635.28 ± 0.11[b]	0.02
Ca	193.45 ± 0.07[c]	0.04	232.88 ± 0.11[c]	0.05
Mg	95.51 ± 0.16[d]	0.16	128.39 ± 0.12[d]	0.09
Zn	7.79 ± 0.12[e]	1.54	12.86 ± 0.08[e]	0.66
Fe	5.51 ± 0.15[e]	2.70	13.76 ± 0.08[e]	0.57
Mg	0.00 ± 0.00	28.28	2197.89 ± 0.13[f]	0.01
B-carotene	6102.17 ± 0.10[f]	0.00	2197.90 ± 0.13	0.01

Values with different superscripts are statistically significant at $p < 0.05$

Table 4: Mineral Safety Index for Some Major Minerals of MACP and MISP

sample	Na			Mg			Ca			Fe			Zn		
	TV	CV	D	TV	CV	D	TV	CV	D	TV	CV	D	TV	CV	D
MACP	4.8	4.31	0.49	15	17.89	-2.89	10	4.84	5.16	6.7	3.62	3.08	33	42.35	-9.35
MISP	4.8	4.65	0.15	15	24.06	-9.06	10	5.82	4.18	6.7	9.18	-2.48	33	70.40	-37.40

Legend: TV = table value; CV =calculated value; D = difference. Calculation of Mineral Safety Index:

Zinc is necessary for the absorption and utilization of vitamin A, which prevents growth faltering and diarrhea. Over 99% of the total calcium of the body is located in the bone, where it accounts for 39% of the total body bone mineral content.[13] The value of zinc in MISP was significantly higher than required for 0-23 months (using the British and Krebs standards), while that of MACP was comparable to that of 11-23 months on average breast milk intake (British standard). Zinc deficiency, which is prevalent in Nigerian infants due to high phytates diet according to WHO,[26] is associated with impaired growth, anorexia and immune disorders, and copper uptake.[13]
Iron facilitates the oxidation of carbohydrates, protein, and fats. The value of iron in MACP was comparable to the values for 11-23 months in low and average breast milk intake, iron value of MISP 13.70mg/100g was comparable to the value for 11-23 months. . The Scientific Committee on Food recommended daily intake of 6 mg for infants aged 0.5-1 year, assuming 15% absorption of the daily intake[30]**.** Manganese is considered one of the least toxic of the trace elements when consumed orally.[12] It is essential for bone structure and normal functioning of the nervous system. The values which were comparable in both samples values were significantly (P<0.05) low for requirement of complementary food for 0-23 -month-old infants.
The low contents of some minerals in both samples might be due to the loss from soaking and sieving during the fermentation process and the presence of some anti-nutritional factors in the raw materials, which might have also formed a complex with some minerals thereby decreasing their contents. About 400 µg RE carotenoid daily allowance was recommended for pre-school children[27.] MISP had a significantly (P<0.05) higher value of 6.102 µRE/100g than MACP of 2.198 µRe/100g (Table 2). The presence of higher β-carotene in MACP might have been contributed from sweet potato which is potentially richer in β-carotene than carrot. Sample MISP had a significantly (P<0.05) higher value of 6.102 µRE/100g than MACP of 2.198 µRe/100g.
Table 4 revealed the standards for mineral safety index (MSI) of elements Na, Mg, Ca, Fe and Zn 18, while Table 4 showed the calculated MSI Table of MACP and MISP. The minerals whose MSI calculated values (CV) are higher than the table MSI tabulated value (TV) were Mg and Zn. MISP also had a higher CV value of Fe. The CV of Na was comparable to TV in both mixtures. For Na, the difference (D) was 0.49 for MACP and 0.15 for MISP.

Table 5: Statistical analysis for Mineral Safety Index of Some Minerals of MACP and MISP

	MACP		MISP	
	Mean	**CV%**	**Mean**	**CV%**
Na	3.2 ± 2.36[a]	73.74	3.2 ± 2.64[a]	82.58
Mg	11.93 ± 1.26[b]	94.35	16.04 ± 1.12[b]	106.71
Ca	6.67 ± 2.89[c]	43.35	6.67 ± 3.00[c]	44.99
Fe	4.47 ± 1.95[a]	43.69	6.12 ± 6.14[c]	100.37
Zn	28.12 ± 27.86[d]	99.09	46.8 ± 27.86[d]	59.54

Values with different superscripts are statistically significant at $p<0.05$

Mg and Zn had negative values in both samples, which show that they were abnormally present in both mixtures; consumption of any of the products might overload the body with Mg and Zn.
The value of iron was lower in MACP than the standard value, while the value was higher in MISP with a negative value of -2.48 therefore the high iron level in MISP can inhibit zinc absorption and can also lead to iron poisoning in infants.[9]

Conclusion

Commercial complementary formula foods are beyond the financial reach of Nigeria low socio-economic mothers. Therefore, it is important to prepare complementary foods from locally available raw materials with the simple processing method of co-fermentation. The results from this work showed that complementary foods can be prepared from co-fermented maize/carrots/pigeon pea or millet/sweet potato/pigeon pea to meet the macro nutritional needs of infants and

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babies. However, certain aspects like the detailed microbial activities during co-fermentation, bioavailability of nutrients need investigation.

Conflict of Interest

The authors declare no conflict of interest.

Authors' Declaration

The authors hereby declare that the work presented in this article is original and that any liability for claims relating to the content of this article will be borne by them.

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