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Nutritional Analysis of Varied Processing and Complementary Food Formulations with Sorghum, Cowpea and Carrot

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Abstract The effects of sorghum cultivars (pelpeli and chakalari white), sorghum processing methods (undehulled, roasted and malted), cowpea (0%, 30%) and carrot (0%, 10%) supplementations on amino acids profiles and micronutrients of complementary food produced from several formulations were evaluated. The flours of sorghum, cowpea and carrot were blended guided by 2x2x3x2 factorial design experiment plus one commercial sample as control in producing 25 complementary food formulations. Amino acid profile, vitamin and mineral contents of complementary food produced from 25 complementary food formulations were determined using standard methods. Amino acid profile was determined with Technicon Sequential Multi sample (TSM) Amino Acid Analyzer after the samples have been dried, defatted, hydrolyzed and evaporated. Atomic Absorption Spectrophotometer (AAS) and High Performance Liquid Chromatography (HPLC) were used to determine minerals and vitamins contents of the complementary foods, respectively. Data obtained were statistically analyzed. Complementary foods that were fortified with cowpea had higher scores of most of the essential amino acids than in unprocessed samples. There was slight increase in vitamins in malted fortified formulations than in unprocessed and unfortified formulations. Malted Sorghum cultivars that were fortified with cowpea and carrot had higher mineral contents than roasted samples. Malting had significantly improved the minerals of the complementary food formulations.

Keywords: *sorghum, malting, roasting, cowpea, carrot, complementary food*

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1. Introduction

Protein Energy Malnutrition (PEM) and micronutrient deficiencies have continued to pose challenges to infants and children in Nigeria due to poor feeding practices, lack of adequate and good quality complementary foods, high cost of commercial complementary formulas, low quality of protein and low protein digestibility [1] of plant-based single diets [2]. FAO/WHO [3] reported that special emphasis should be placed on the micronutrient composition, nutrient bioavailability and utilization of local diets because these are directly associated with more than 50% of childhood morbidity and mortality in the developing world [4]. During complementary feeding period, the child needs nutritionally adequate complementary foods in addition to the mother`s milk. This is due to the increasing nutritional demands of the growing baby [5] and the food plays a vital role in the all-round growth, development and mental health of the children.

Attempts have been made by many scientists [6-11] in this environment to produce complementary foods with available indigenous food commodities and results obtained were awesome. Most of the materials used for the formulation of the complementary foods by these scientists were pearl millet, broken rice fractions and malts from these grains. There is scanty information on the use of indigenous sorghum cultivars in the production of these complementary foods. However, Lawan et al. [12] have reported the proximate composition, antinutrient factors and functional properties of complementary foods produced from the mixtures of indigenous undehulled, roasted and malted sorghum cultivars, cowpea and carrot. The results obtained showed that malting and roasting reduced the anti nutrient factors of the indigenous sorghum cultivars. Addition of cowpea and carrot also improved the nutrient bioavailability of the complementary food blends. Amino acid profile and micronutrients of such complementary foods from the aforesaid mixtures are yet to be reported.

Indigenous sorghum cultivars are cheap, readily available and cultivated within a short period of two months as compared to other grains. The use of sorghum alone in preparation of complementary foods is inadequate for the optimal nutrition of the infant, due to its protein quality. The quality of protein could be improved by combination of cereals and legumes in order to obtain complete essential amino acids profile [6,13,14].

Vitamin A, an important requirement for improvement of vision and healthy growth can be obtained from plant foods rich in β - carotene such as carrot, a precursor of Vitamin A. There is the need for use of indigenous sorghum cultivars, cowpea and carrot to produce nutritious, cheap and available complementary foods if malnutrition to be tackled among the rural dwellers and low income earner in urban cities in this environment. Apart from malnutrition which can be tackled with the aforesaid cereal grain, grain legumes and carrot using appropriate processing methods, there is problem of childhood lead poisoning which has been reported in Zamfara state of Northern Nigeria [15,16]. In view of the mentioned concern, the needs to determine the lead content of foods particularly complementary foods in Northern Nigeria cannot be over emphasized. Therefore, it was against this background that the objectives of the study were set to determine amino acid profile, vitamin, mineral and lead contents of complementary food produced from several formulations using indigenous sorghum cultivars (pelpeli white and chakalari white), cowpea - early variety (yar'arba'in) and carrot.

2. Materials and Methods

The material for this research included indigenous sorghum cultivars (pelpeli white and chakalari white) purchased from Biu market, Cowpea (Yar'arba'in) and carrot from Gamboru Vegetables Market, in Biu and Jere Local Governments, respectively, Borno State, Nigeria. Experimental samples were taken using the quartering procedures of Lees [17].

2.1. Roasting of Sorghum Cultivars

Five kilograms of each sorghum cultivars (pelpeli and chakalari) was cleaned and washed, drained and roasted for 30 min at 180°C. The roasted grains were milled using disc attrition mill and sieved as shown in Figure 1 [6].

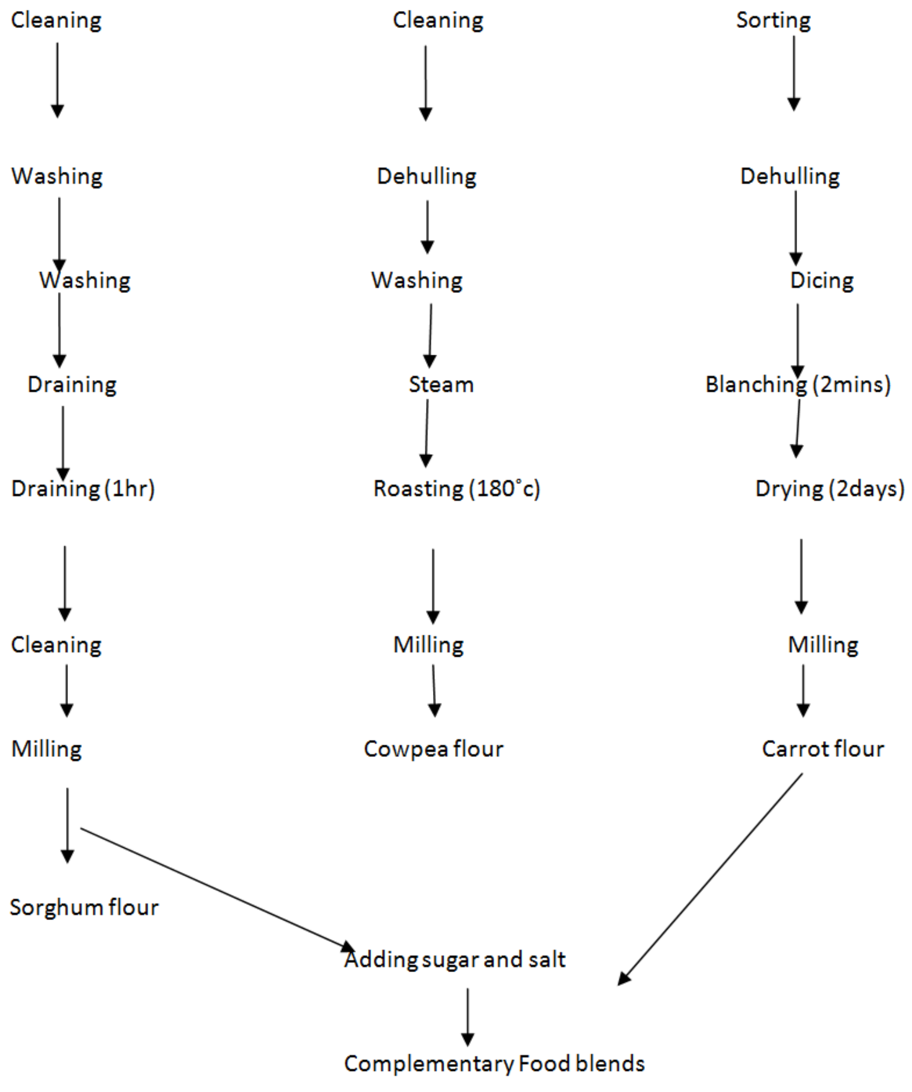

Figure 1. Complementary food from flour blends of sorghum, cowpea and carrot (Adapted from Badau *et al*., 2005)

2.2. Malting of sorghum cultivars

Malted sorghums were prepared as described by Badau et al. [6]. The sorghum cultivars (pelpeli white and chakalari white) were cleaned and soaked in water (w/v) for 16 h, after which there were spread on a clean moist Jute bag for germination. Water was sprinkled during germination occasionally to keep the grain moist. Germination was carried out for 72 h after which there were sun dried and dehusked to remove shoots. The malted grains were milled and sieved (Figure 1).

2.3. Soaking and dehulling of Cowpea

Two kilograms of cowpea was cleaned and soaked in water at an ambient temperature (32°C) for 5 min. The cowpea was dehulled using mortar and pestle, after which it was washed and dried in doom drier for 48 h. The dried grain was milled and sieved as shown in Figure 1 [6]. The carrot (5kg) was sorted, washed and diced. The diced carrot was steam blanched for 2 min and dried under shade for 48 h and milled (Figure 1) using disc attrition mill [18].

2.4. Formulation of the Complementary Food Blends

The complementary foods were formulated using sorghum and cowpea in the ratio of 70:30 as described by Almeida-Dominguez et al. [14] and Badau et al. [6]. A 2×3×2×2=24 factorial design was used to formulate the complementary blends as shown in Table 1.

2.5. Amino Acid Analyses

The amino acid profile in the samples was analyzed using method described by Benitez [19]. The complementary foods were all dried to a constant weight, defatted, hydrolyzed, evaporated in a rotary evaporator and later loaded into Technicon Sequential Multi-sample Amino Acid Analyzer (TSM).

2.6. Chemical Score (Amino Acid Score)

Chemical score was calculated as described WHO/FAO [20].

2.7. Vitamin Content Determination

Vitamin content was determined by the methods described by Angelika et al. [21]. The vitamins that were determined were vitamin B1, B2, B3, B6 and vitamin A.

2.8. Minerals Determination

The minerals contents of the samples were determined with Atomic Absorption Spectrophotometer (AAS) and relevant methods AOAC [22]. The minerals determined were calcium, iron, zinc, sodium, magnesium, potassium and lead.

2.9. Statistical Analysis

The data generated was subjected to analysis of variance (ANOVA) as described by Gomez and Gomez [23] and means separated using Duncan multiple range test at 5% level of significance [24].

Table 1. Formulation of complementary food blends

Formulations	Undehulled Chakalari (g)	Undehulled pelpeli (g)	Roasted chakalari (g)	Roasted pelpeli (g)	Malted chakalari (g)	Malted Pelpeli (g)	Cowpea (g)	Carrot (g)
UCW 001	100	-	-	-	-	-	-	-
UCW 901	90	-	-	-	-	-	-	10
UCW 703	70	-	-	-	-	-	30	-
UCW 621	63	-	-	-	-	-	27	10
UPW 001	-	100	-	-	-	-	-	-
UPW 901	-	90	-	-	-	-	-	10
UPW703	-	70	-	-	-	-	30	-
UPW 621	-	63	-	-	-	-	27	10
RCW 001	-	-	100	-	-	-	-	-
RCW 901	-	-	90	-	-	-	-	10
RCW 703	-	-	70	-	-	-	30	-
RCW 621	-	-	63	-	-	-	27	10
RPW 001	-	-	-	100	-	-	-	-
RPW 901	-	-	-	90	-	-	-	10
RPW 703	-	-	-	70	-	-	30	-
RPW 621	-	-	-	63	-	-	27	10
MCW 001	-	-	-	-	100	-	-	-
MCW 901	-	-	-	-	90	-	-	10
MCW 703	-	-	-	-	70	-	30	-
MCW 621	-	-	-	-	63	-	27	10
MPW 001	-	-	-	-	-	100	-	-
MPW 901	-	-	-	-	-	90	-	10
MPW 703	-	-	-	-	-	70	30	-
MPW 621	-	-	-	-	-	63	27	10

Sorghum Cultivars: Undehulled Chakalari White (UCW); Undehulled Pelipeli White (UPW); Roasted Chakalari White (RCW); Roasted Pelipeli White (RPW); Malted Chakari White (MCW); Malted Pelipeli White (MPW).

3. Results and Discussions

3.1. Amino Acids Profile of the Complementary Food Formulations

Results revealed that complementary foods with malted sorghum cultivars chakalari and pelpeli had high amino acid contents compared to the other formulations. The formulations contain all the essential amino acids. The reference scores of most essential amino acids are in the formulated complementary foods without malt. The increase was noticed in leucine, isoleucine, valine, phynylalanine and arginine (Table 2). Higher scores of amino acids were obtained from malted sorghum cultivars and formulated complementary foods that were supplemented with cowpea as shown in Table 1. This increase in amino acids could be presumably due to increase in amino acid during germinating process that are produced in excess of the requirements and tend to accumulate in the free amino acid pool [25]. Wang and Field [26], and Marero et al. [13] also reported significant increase in lysine, methionine and tryptophan of germinated sorghum, maize and rice compared to the ingeminated grains. The chemical score indicated that threonine is the first limiting amino acid. Lysine, methionine and tryptophan had the least amino acid values in the formulated complementary foods as shown in Table 2. This indicates that most of the essential amino acids fall short of the reference values. Amino acid content of complementary food is a particular relevant issue in infant feeding where protein energy malnutrition (PEM) has continued to pose challenges in developing countries. This according to other researchers is due to poor feeding associated with plant-based single diets [2,18]. This short fall is a matter of concern as this will tend to limit the utilization of the amino acids in the metabolic process of the body [27]. Complementary foods with high essential amino acids level such as presented in Table 2 may be important for healthy growing infant with high weight. Essential amino acids are required for children with high weight than in children with low weight [28]. The amino acids composition of the complementary foods met the requirement for essential amino acids of infants.

3.2. Vitamins of the Formulated Complementary Foods

The results of some vitamins are presented in Table 3. There were significant (P<0.05) difference in the vitamin contents of the formulations. There was slight increase of vitamins in the malted formulations than in formulations without malt. The increase or decrease in vitamins varied with the nature of raw material, processing methods and supplementations. The slight increase in B complex vitamins in malted formulations could be due to natural malting process of cereals as influenced by several factors. Increase in vitamins in malted cereal/ legume blends has been observed by Marero et al. [13]. He reported the increase in concentration of niacin, thiamin (3-55%), riboflavin, (22-221%) and other vitamins in certain grain legumes after germination. Generally; complex vitamins help regulate appetite and are necessary for proper growth, development and metabolism [29].

3.3. The Mineral Contents of the Formulated Complementary Foods

The result of the mineral contents of the formulated complementary foods is presented in Table 5. The result of the formulations showed significant (P<0.05) difference. The iron content ranged from 0.98±0.02 to 24.03±0.02. MPW703 had the highest iron content of 24.03±0.02 and RPW 001 had the least value of 0.98±0.02. Samples that were fortified with cowpea and carrot had higher minerals content than unfortified samples. However, complementary food formulations that contained malted sorghum cultivars and were fortified with cowpea and carrots had higher mineral contents than complimentary food formulations than with roasted Chakalari and pelpeli complementary foods. Malting has significantly improved the minerals [30] of the formulated complementary foods as obtained from the results. The minerals obtained from the complementary foods perform specific function in the human body. Calcium helps in bone development and its deficiency can lead to improper development of bone in growing children leading to various deformities of the skeletal systems [31]. Calcium contributes towards bone and teeth formation, muscle contraction and blood clotting. Iron is necessary for the prevention of aneamia. Zinc function as a nutrient and dietary supplement. It is believed to be necessary for nucleic acid metabolism, ‘protein synthesis and cell growth.

There was no trace of lead in the complementary foods. Lead is harmful and its presence in food is not a healthy development [32]. The concentrations of calcium, sodium and potassium were within recommended values and are good for growing children from 6 to 59 months.

WHO and UNICEF [33] have identified iron deficiency anemia, Vitamin A deficiency, Iodine deficiency disorder and zinc deficiency as the micronutrients of health significance with high prevalence among childhood diseases and high mortality in developing countries. The variation in mineral content of the formulated complementary foods could be because of the different ratios of the blend formulations during production. Many researchers also reported similar deficiency in complementary foods [30,34,35,36,37].

The recommended daily intake (RDI) for iron content is between 10-8mg [37]. There is the need to improve on the concentrations of calcium, sodium, potassium, iron and zinc in the formulated complementary foods by fortifying the complementary foods with minerals as these minerals are essential for the formation of strong bones and teeth [38].

According to Codex Standard FAO/WHO [39], the recommended levels (mg/100g) of calcium, magnesium, sodium, potassium, iron, copper and zinc for infant formulas are 50mg, 6mg, 20mg, 80mg, 1mg,0.6mg and 0.5mg/100g respectively. A high calcium intake may incite the intestinal absorption of iron, zinc and other essential, minerals.

Table 2. Essential Amino Acids Composition and chemical score of Formulated Complementary food[1]

Formulations	Essential Amino Acids (g/100 g Protein)									
	Leucine	Lysine	Isoleucine	Phenylalanine+	Tyrosine	Valine	Methionine+	Cysteine	Threonine	Tryptophan
UCW001	10.82^{ab}(154)	2.51^{de}(46)	3.01^{ch}(75)	4.08^{bg}	3.44^{ch}(125)	4.09^{ca}(82)	1.17^{eh}	1.21^{fd}(68)	2.99^{cj}(75)	1.20^{dh}(120)
UCW901	10.30^{ac}(147)	4.19^{bh}(76)	3.80^{cd}(95)	6.30^{ba}	4.47^{bg}(180)	6.20^{ah}(124)	2.21^{dg}	2.12^{dh}(124)	4.83^{ce}(121)	2.04^{dg}(204)
UCW703	8.78^{af}(125)	2.60^{dg}(47)	3.14^{cg}(79)	4.26^{be}	3.79^{ch}(134)	4.15^{bd}(83)	1.23^{fd}	1.33^{ej}(73)	3.41^{cg}(85)	1.34^{eg}(134)
UCW621	8.99^{ag}(128)	2.87^{dg}(52)	3.34^{ch}(84)	4.96^{be}	3.44^{dg}(140)	4.50^{bf}(90)	1.28^{fg}	1.21^{ec}(71)	3.61^{cg}(90)	1.36^{dh}(136)
UPW001	7.00^{aj}(100)	3.04^{cf}(43)	3.21^{ce}(80)	4.43^{ba}	3.78^{cd}(137)	4.38^{bj}(88)	1.07^{dj}	1.21^{dh}(65)	3.16^{cg}(79)	1.42^{dh}(142)
UPW901	8.99^{ah}(128)	4.29^{bd}(78)	3.21^{ch}(80)	5.67^{be}	4.13^{bg}(163)	5.00^{bd}(100)	2.16^{dh}	1.87^{eh}(115)	4.16^{bj}(104)	2.10^{dh}(210)
UPW703	7.65^{ba}(109)	3.39^{ch}(62)	3.31^{ce}(83)	4.97^{bg}	3.96^{cj}(149)	4.79^{bj}(96)	1.23^{fd}	1.63^{fd}(82)	3.39^{cj}(85)	1.52^{eg}(152)
UPW621	7.53^{ah}(108)	3.18^{cg}(58)	3.27^{ca}(82)	4.52^{be}	3.78^{cj}(138)	4.53^{bd}(91)	1.17^{eh}	1.39^{eg}(73)	3.27^{cb}(82)	1.47^{eg}(147)
RCW001	10.15^{ag}(145)	3.68^{ca}(67)	3.34^{cj}(84)	4.96^{bd}	3.09^{ch}(134)	4.38^{bd}(88)	1.47^{dh}	1.09^{gf}(73)	3.49^{ch}(87)	0.99^{gj}(99)
RCW901	10.59^{ag}(151)	5.20^{bd}(95)	4.52^{bg}(113)	5.85^{bf}	4.47^{bj}(172)	5.55^{bi}(111)	2.24^{dj}	2.06^{hi}(123)	4.30^{bh}(108)	1.74^{fe}(174)
RCW703	7.59^{be}(108)	2.12^{df}(39)	2.29^{dg}(57)	3.02^{ch}	2.58^{eg}(93)	3.10^{ce}(62)	1.04^{ed}	0.85^{fg}(54)	2.25^{cd}(56)	0.76^{fc}(76)
RCW 621	7.18^{ab}(103)	2.01^{cd}(37)	2.16^{cd}(54)	2.92^{dh}	2.41^{bc}(89)	3.01^{bd}(60)	0.91^{df}	0.78^{cd}(48)	2.27^{cd}(57)	0.70^{efg}(70)
RPW001	6.80^{ab}(97)	5.04^{bc}(92)	3.67^{de}(92)	4.26^{de}	3.96^{cg}(137)	4.28^{cf}(86)	1.39^{df}	1.45^{ef}(81)	3.36^{cf}(84)	1.52^{de}(152)
RPW901	10.30^{ac}(147)	8.67^{ab}(158)	5.21^{ad}(130)	6.21^{af}	5.85^{cf}(201)	5.91^{cd}(118)	2.30^{de}	2.00^{dg}(123)	4.44^{df}(111)	2.60^{db}(260)
RPW703	6.01^{bd}(86)	3.92^{dc}(71)	2.29^{df}(57)	3.55^{cf}	3.61^{ch}(119)	3.51^{cd}(70)	1.26^{eg}	1.09^{dc}(67)	3.00^{cg}(75)	1.21^{ed}(121)
RPW621	6.39^{bb}(91)	4.03^{dg}(73)	2.68^{ed}(67)	3.81^{ch}	3.00^{ch}(113)	3.80^{ch}(76)	1.15^{ed}	1.15^{dh}(66)	2.99^{dh}(75)	1.28^{eh}(128)
MCW001	3.24^{cg}(46)	3.54^{cd}(64)	4.17^{ca}(104)	1.21^{eh}	2.72^{dh}(66)	1.66^{fe}(33)	5.58^{be}	6.52^{be}(346)	3.39^{cc}(85)	5.29^{bd}(529)
MCW901	10.97^{ab}(157)	3.18^{dc}(58)	3.50^{bd}(88)	3.99^{ch}	2.24^{dg}(104)	3.80^{cd}(76)	1.34^{eh}	1.21^{eh}(73)	3.00^{cf}(75)	1.18^{dh}(118)
MCW703	12.84^{ab}(183)	3.63^{cf}(66)	3.66^{cg}(92)	4.43^{bc}	3.61^{cg}(134)	5.64^{eh}(113)	1.81^{ef}	1.57^{ed}(97)	3.80^{ce}(95)	1.26^{ed}(126)
MCW621	11.15^{ab}(159)	3.02^{cg}(55)	3.34^{ch}(84)	3.99^{ce}	3.09^{cg}(118)	4.97^{bd}(99)	1.57^{ef}	1.33^{eh}(83)	3.08^{ch}(77)	1.00^{ef}(100)
MPW001	11.29^{ah}(161)	3.53^{cf}(64)	4.03^{db}(101)	4.66^{dc}	3.61^{ce}(138)	4.65^{bg}(93)	1.55^{fe}	1.39^{eg}(84)	3.25^{ce}(81)	1.23^{ea}(123)
MPW901	11.29^{ab}(161)	3.10^{cd}(56)	3.60^{cg}(90)	4.08^{ca}	3.27^{cfe}(123)	5.20^{bf}(104)	1.60^{ed}	1.45^{ef}(87)	3.25^{cg}(81)	1.13^{eg}(113)
MPW703	12.61^{aa}(180)	4.69^{be}(85)	5.24^{ba}(131)	5.14^{be}	4.65^{ca}(163)	5.20^{bf}(104)	2.08^{dh}	1.57^{fc}(104)	4.00^{ca}(100)	1.58^{da}(158)
MPW621	10.85^{ac}(155)	3.02^{cg}(55)	3.53^{dc}(88)	4.08^{cb}	2.06^{df}(102)	3.68^{ch}(74)	1.20^{df}	1.15^{dh}(67)	2.88^{df}(72)	0.99^{eg}(99)
Control	7.47^{ad}(107)	3.42^{cf}(62)	3.31^{cd}(83)	3.90^{cb}	3.10^{ce}(117)	3.71^{cg}(74)	2.24^{dh}	1.21^{dh}(99)	3.11^{ce}(78)	1.26^{dg}(126)
FAO/WHO (1973)	7.0	5.5	4.0		6.0	5.0		3.5	4.0	1.0

Sorghum Cultivars: Undehulled Chakalari White (UCW); Undehulled Pelipeli White (UPW); Roasted Chakalari White (RCW); Roasted Pelipeli White (RPW); Malted Chakari White (MCW); Malted Pelipeli White (MPW). [1]Mean of three replications. [a-J]Means within each Colum not followed by the same superscripts are significantly different (P<0.05). Values in bracket are chemical score of individual amino acid in the complementary food formulate.

Table 3. Vitamins Content of Formulated Complementary Foods (mg/ml)

Formulations	B1	B2	B3	B6	A ((μg/100g)
UCW001	0.0996^{l}	0.0953^{c}	0.0498^{l}	0.0274^{c}	193
UCW901	0.1107^{e}	0.0441^{r}	0.0524^{j}	0.0236^{i}	198
UCW703	0.1143^{e}	0.0742^{i}	0.0598^{c}	0.0173^{n}	197
UCW621	0.1043^{j}	0.0774^{f}	0.0333^{u}	0.0241^{h}	199
UPW001	0.1088^{g}	0.0771^{g}	0.0448^{o}	0.0204^{m}	182
UPW901	0.0062^{t}	0.0445^{q}	0.0422^{q}	0.0242^{a}	194
UPW703	0.1172^{e}	0.0777^{e}	0.0566^{d}	0.0171^{n}	190
UPW621	0.0691^{s}	0.0722^{l}	0.0611^{b}	0.0232^{j}	194
RCW001	0.1113^{d}	0.0762^{h}	0.0552^{g}	0.0246^{a}	184
RCW901	0.1132^{c}	0.0456^{p}	0.0442^{p}	0.0254^{f}	196
RCW703	0.1083^{h}	0.1272^{b}	0.0365^{t}	0.0233^{j}	191
RCW621	0.0947^{p}	0.0782^{d}	0.0556^{f}	0.0246^{a}	182
RPW001	0.0977^{o}	0.0733^{j}	0.0452^{n}	0.0257^{e}	191
RPW901	0.0771^{r}	0.0314^{s}	0.0262^{v}	0.0221^{l}	186
RPW703	0.1083^{h}	0.0735^{j}	0.0544^{h}	0.0104^{q}	196
RPW621	0.0986^{n}	0.1491^{a}	0.0541^{i}	0.0242^{a}	179
MCW001	0.1012^{k}	0.0662^{n}	0.0377^{s}	0.0173^{n}	198
MCW901	0.0031^{v}	0.0442^{r}	0.0386^{r}	0.0116^{p}	188
MCW703	0.1072^{i}	0.0781^{d}	0.0563^{e}	0.0282^{b}	195
MCW621	0.1011^{k}	0.0592^{o}	0.0492^{m}	0.0141^{o}	190
MPW001	0.1092^{f}	0.0744^{i}	0.0515^{k}	0.0255^{ef}	199

Sorghum Cultivars: Undehulled Chakalari White (UCW); Undehulled Pelipeli White (UPW); Roasted Chakalari White (RCW); Roasted Pelipeli White (RPW); Malted Chakari White (MCW); Malted Pelipeli White (MPW)

[1]Mean of three replications

[a-s]Means within each Colum not followed by the same superscripts are significantly different (P<0.05)

Table 4. Mineral Contents of sorghum cultivars (PPM)

Sorghum Cultivars	Sodium	Iron	Calcium	Potassium	Zinc	Lead
UCW	0.62^{a}	6.29^{b}	0.04^{b}	0.52^{d}	1.32^{a}	-0.71^{b}
UPW	0.52^{b}	1.88^{a}	0.06^{b}	0.76^{c}	0.91^{b}	-0.71^{b}
RCW	0.52^{b}	2.40^{d}	0.05^{b}	0.53^{d}	0.62^{d}	-1.13^{d}
RPW	0.45^{c}	0.98^{f}	0.04^{b}	0.81^{c}	0.63^{d}	-0.84^{c}
MCW	0.51^{b}	3.12^{c}	0.18^{a}	0.85^{a}	0.81^{c}	-0.86^{c}
MPW	0.42^{c}	1.75^{e}	0.04^{b}	0.44^{e}	0.91^{b}	-0.28^{a}

Sorghum Cultivars: Undehulled Chakalari White (UCW); Undehulled Pelipeli White (UPW); Roasted Chakalari White (RCW); Roasted Pelipeli White (RPW); Malted Chakari White (MCW); Malted Pelipeli White (MPW)

[1]Mean of three replications

[a-d]Means within each Colum not followed by the same superscripts are significantly different ($P<0.05$).

Table 5. Mineral Contents of Formulated Complementary Foods (PPM)

Formulations	Iron	Sodium	Calcium	Potassium	Zinc	Lead
UCW 001	6.290^{h}	0.62^{e}	0.04^{def}	0.54^{j}	1.32^{d}	-0.71^{gh}
UCW 901	4.45^{m}	0.70^{ab}	0.03^{ef}	0.90^{b}	1.55^{a}	-0.53^{e}
UCW 703	2.35^{s}	0.45^{hi}	0.04^{def}	0.91^{b}	1.21^{f}	-0.42^{d}
UCW 621	3.71^{o}	0.63^{de}	0.02^{f}	0.65^{i}	1.42^{b}	-0.84^{i}
UPW 001	6.86^{a}	0.52^{g}	0.06^{d}	0.76^{ef}	0.91^{k}	-0.71^{h}
UPW 901	5.08^{j}	0.66^{cd}	0.02^{f}	0.92^{b}	1.54^{a}	-1.26^{k}
UPW 703	11.57^{f}	0.64^{de}	0.05^{e}	0.10^{m}	0.81^{l}	-0.27^{c}
UPW 621	3.58^{p}	0.63^{de}	0.15^{c}	0.76^{ef}	1.23^{f}	0.00^{a}
RCW 001	2.40^{r}	0.52^{g}	0.05^{de}	0.53^{j}	0.62^{m}	-1.13^{j}
RCW 901	5.65^{i}	0.70^{ab}	0.04^{def}	0.83^{cd}	1.38^{c}	-0.68^{g}
RCW 703	4.53^{l}	0.44^{ij}	0.03^{ef}	0.72^{gh}	1.12^{hi}	-0.72^{h}
RCW 621	$4.u78^{k}$	0.68^{bc}	0.03^{f}	0.77^{e}	1.32^{d}	-0.84^{i}
RPW 001	0.98^{u}	0.45^{ij}	0.04^{def}	0.81^{d}	0.63^{m}	-0.84^{i}
RPW 901	5.66^{i}	0.69^{bc}	0.03^{ef}	0.83^{cd}	1.41^{bc}	-0.85^{i}
RPW 703	4.50^{l}	0.44^{ij}	0.44^{a}	0.73^{fgh}	1.11^{i}	-0.72^{h}
RPW 621	4.77^{k}	0.67^{bc}	0.03^{ef}	0.75^{efg}	1.31^{d}	-0.71^{gh}
MCW 001	3.12^{q}	0.51^{g}	0.18^{b}	0.85^{c}	0.81^{l}	-0.86^{i}
MCW 901	13.20^{d}	0.62^{e}	0.04^{def}	0.10^{n}	1.34^{d}	-0.56^{f}
MCW 703	16.42^{c}	0.48^{h}	0.03^{ef}	0.96^{a}	1.16^{g}	-0.54^{ef}
MCW 621	3.80^{n}	0.62^{e}	0.03^{ef}	0.81^{d}	1.14^{gh}	-0.72^{h}
MPW 001	1.75^{t}	0.42^{k}	0.04^{def}	0.44^{k}	0.91^{k}	-0.28^{c}
MPW 901	10.64^{g}	0.58^{f}	0.04^{def}	0.71^{h}	1.16^{g}	-0.13^{b}
MPW 703	24.03^{a}	0.45^{i}	0.05^{e}	0.70^{h}	1.02^{j}	-0.86^{i}
MPW 621	12.18^{e}	0.72^{a}	0.05^{de}	0.22^{l}	1.28^{e}	0.00^{a}
CONTROL	7.53^{a}	135.14^{a}	450.54^{a}	ND	4.58	0.00^{a}

Sorghum Cultivars: Undehulled Chakalari White (UCW); Undehulled Pelipeli White (UPW); Roasted Chakalari White (RCW); Roasted Pelipeli White (RPW); Malted Chakari White (MCW); Malted Pelipeli White (MPW)

[1]Mean of three replications.

4. Conclusion and Recommendation

The result observed that supplementing cereal and legume improved the amino acid profile of the complementary food formulations. The Malting process may be useful to improve the vitamin and mineral contents of the formulated complementary foods and assist meeting nutrient requirements of the growing infant.

References

[1] Nnakwe, N. The effect causes of protein energy malnutrition in Nigerian children. *Nutrition Research*, 15(6), 785-794, 1995.

[2] Temple V I., Badomosi, E. J., Ladeji, O. and Solomon, M. Proximate chemical composition of three locally formulated complementary food. *West African Journal Biological Science*, 5, 134-143, 1996.

[3] FAO/WHO. Safety Evaluation of Certain Mycotoxins in Food. Prepared by 56th Meeting of the Joint Expert Committee on Food Additives (JECFA). FAO Food and Nutrition Paper 74 and WHO Additives Series 47. Food and Agriculture Organization (FAO) of the United Nation (UN)/World Health Organization (WHO), Geneva, 2001.

[4] SCN. *Nutrition for improved development outcomes* 5th report on the world nutrition situation standing committee on nutrition (SCN) Geneva, 2004.

[5] Amankwah,E.A, Barimah,J, Nuamah,A,k,M. and Nnaji,C,O. Formulation of weaning food from fermented maize, rice, soybean and fishmeal. *Pakistan Journal of Nutrition*, 8 (11), 1747-1752, 2009.

[6] Badau, M. H., Jideani, I. A. and Nkama, I. Production, acceptability and microbiological evaluation of weaning food formulation. *Journal of Tropical Pediatrics*, 53(3), 166-172, 2006a.

[7] Badau, M. H, Jideani, I.A Nkama, I. Reological behaviour of weaning food formulations as affected by addition of malt. *International Journal of Food Science and Technology*, 41: 1222-1228, 2006b.

[8] Badau, M. H., Bristone, C., Igwebuike, J. U. and Danbaba, N. Production, viscosity, microbiological quality and sensory properties of complementary food blends of improved rice cultivars, soybean and sorghum malt. *Pakistan Journal of Nutrition*, 15(9), 849-856, 2016.

[9] Danbaba, N., Nkama, I., Badau, M. H. and Ndindeng, A. S. Development, nutritional evaluation and optimization of instant weaning porridge from broken rice fractions and bambara groundnut {Vigna subterranean (L) Verdc} blends. *Nigerian Food Journal*, 34(1): 116-132, 2016.

[10] Danbaba, N., Nkama, I., Badau, M. H. and Idakwo, P. Y. Influence of extrusion conditions on nutritional composition of rice-bambara groundnut complimentary foods. *Arid Zone Journal of Engineering, Technology and Environment,* 14(4): 559-582, 2018a.

[11] Danbaba, N., Nkama, I., Badau, M. H. and Idakwo, P. Y. Statistical modeling and optimization of processing conditions of twin-screw extruded rice-legume complimentary gruel. *Arid Zone Journal of Engineering, Technology and Environment* 14(4): 693-712, 2018b.

[12] Lawan, H.K., Badau, H.M., Chibuzo, E.C.,and Fannah, M.A. Proximate Composition, Antinutritional Factors and Functional Properties of Complementary Food as Affected by Sorghum Processing Methods, Addition of Cowpea and Carrot. *International Journal of Food Science and Nutrition*, 3(2): 145-154, 2018.

[13] Marero, L. M., E. M. Payuwo,E.M. Aguinald,A.R and Homma,S. Nutritional characteristics of weaning foods prepared from germinated cereals and legumes. *Journal of Food Science*, 53: 1399-1402, 1988.

[14] Almeida - Domingue Z, H. D., Serna - Saldivar, S. O., Gomez, M. H and Rooney, L. W. Production and nutritional value of weaning foods from mixtures of pearl millet and cowpeas. *Cereal Chemistry*, 7 (1): 14-18, 1993.

[15] Lo, YC., Dooyema, C. A., Neri, A., Durant, J., Jeffere, T., Medina-Marino, A., de Ravello, L., Thoroughman, D., Davis, L., Dankoli, R. S., Samson, M. Y., Ibrahim, L. M., Okechukwu, O, Umar-Tsafe, N. T., Dama, A. H. and Brown, M. J. Childhood lead poisoning associated with gold ore processing: a village-level investigation-Zamfara state, Nigeria. *Environmental Health Perspective*, 120 (10), 1450-1455, October, 2012.

[16] Getso, K. I., Hadeijia, I. S., Sabitu, K., Nguku, P. M., Poggensee, G., Aliyu, H. M., Yelwa, H., Sani-Gwarzo, N. and Oyemakinde, A. A prevalence and determinats of childhood lead poisoning in Zamfara state, Nigeria. Journal of Health and Pollution, 6:1-9, 2014.

[17] Lees, R. Food Analysis: Analytical and Quality Methods for the Food Manufacturer and Buyer, 3rd Edn. Leonard Hill Books, London, 1975.

[18] Badamosi, E. J, Ibrahim L.M and V.J. Temple. Nutritional Evaluation of a locally formulated weaning food, JUTH-PAP. *West African Journal Biological Sciences*, 3, 85-93, 1995.

[19] Benitez, L. V. Amino acid and fatty acid profiles in aquaculture nutrition studies, In: S.S. DeSilva (ed), fish Nutrition Research in Asia in: *Proceedings of the third Asian Fish Nutrition network meeting, Asian Fish Society*. Special Publication, Asian fisheries Society, Manila Philippines, 1989.

[20] FAO/WHO. Energy and Protein requirements. Report of joint FAO/WHO ad Hoc Expert Committee. WHO Technical Reports Series No. 522: Geneva FAO/WHO, 1973.

[21] Angelika, G. H. and Rainer, S. HPLC for Food Analysis. Angilent Technologies Company, Germany, 2001.

[22] AOAC. *Official Method of Analysis*. 18th Ed. Association of Official Analytical Chemists Arlington, V,.A.; USA, 2000.

[23] Gomez, A.K, and Gomez,A.A. *Statistical Procedure for Agricultural Research*. 2nd edition, John Wiley, New York, 1983.

[24] Duncan, D. E. *Multiple range and Multiple f-tests, biometrics*. 11, 1-42, 1955.

[25] Chen, L. C., Chowdhurry, A. K. M. A. and Huffman, S. L. Anthropometric assessment of energy-protein malnutrition and subsequent risk of mortality among pre-school aged children. American Journal of Clinical Nutrition 33, 1836 - 1845, 1980.

[26] Wang, Y.D. and Field, M.L. Germination of Corn and Sorghum in the Home to Improve Nutritive Value. *Journal of Food Science*, 43, 1113-1115, 2006.

[27] AOAC. *Association of Official Analytical Chemistry, official method of Analysis*, 14th edition Washington D.C, 1990.

[28] Wikipedia. Http://en.wikipedia.org/wiki/infant, 2011.

[29] Fattal-Valevski, A., Azouri-Fattal, I., Greenstein, Y.J., Guindy, M., Blau, A., and Zelnik, N. Delayed Language Development due to Infantile defiency, 51(8), 679-34, 2009.

[30] Badau, M.H., Nkama, I. and Jideani, I.A. Phytic acid and hydrochloric acid extractability of minerals in pearl millet as affected by germination time and cultivars. *Food Chemistry*, 92 (3): 425-435, 2005.

[31] Gahlawat. P., and Sehgal. S. The influence of roasting and malting on the total and extractable mineral contents of human weaning mixtures from Indian raw materials. *Food Chemistry*, 46(3), 253-256, 1993.

[32] Bryce-smith, D. Lead and brain function. In *Food AND Health: Science and Technology*, (Birch, G.G and Parker, J.K. eds). Applied Science Publishers, London, 1980.

[33] WHO and UNICEF. Global Immunization Vision and Strategy 2006 - 2015. World Health Organization (WHO) and United Nations Children's Fund (UNICEF). Geneva: World Health Organization and United Chiklren's Fund, 2005.

[34] Gupta, C. and Sehgal, S. Development, acceptability and nutritional value of weaning food mixtures. Plant Foods for Human Nutrition 41: 107 - 116, 1991.

[35] Derbyshire, E, Brennan, C, S, Li, W. and Bokhari, F. Iron deficiency- is there a role for the food industry. *International Journal of Food Science and Technology*, 45: 2443-2248, 2010.

[36] Elemo, G.N.Elemo,B.O, Okafor, J.N.C. Preparation and Nutritional Composition of a weaning food formulated from germinated sorghum.(sorghum bicolor) and steamed cooked cowpea(vigna unguiculata). *American Journal of Food Technology*, 6: (5), 413-421, 2011.

[37] Habwe, F. O., Walingo, M. K., Abukutsa-Onyango, M. O. and Oluoch, M. O. Iron content of the formulated East African indigenous vegetable recipes. African Journal of Food Science, 3(12), 393 - 397, 2009.

[38] Reddy, N. R., Pierson, M. D., Sathe, S. K. and Salunkhe, D. K. Phytates in Cereals and Legumes. CRC Press, Inc. Boca Raton, Florida, 1989, 66 - 69.

[39] FAO/WHO. Codex Alimentarius Commission. Report of the 22nd Session of the Joint Food and Agriculture of the United Nations (FAO)/ World Health Organization (WHO), Geneva, 23rd to 28th June, 1997.