Complementary Food Formulated FromOrange Flesh Sweet Potato, Soybean and Date Palm Flour Blends Improve on the Functional, Vitamins And Mineral Properties Children Formulas

ABSTRACT

This study evaluated the functionalproperties, vitamins and mineral compositionof complementary foods produced from orange flesh sweet potato(OFSP), soybean and date palm flour blends**.** The samples were formulated by material balancing with all samples having 16% protein/ 100g. The samples were ascribed the following codes; CON, CFA, CFB, CFC, CFD and CFE. Sample CON being a commercial product used for control while the others were experimental formulations. The samples were subjected to functional, vitamin and minerial analysis using standard method.Results of the functional properties of flour blends were as follows; bulk density (0.66-0.91 g/ml), water absorption capacity (1.82-2.63 g/ml), oil absorption capacity (1.39-1.72 g/ml), gelatinization temperature (69.98-80.04□), foam capacity (29.61-64.31%) swelling capacity (2.75-3.60 g/ml) and there were significant differences between some of the flour blends at ($p< 0.05$). Vitamin analysis obtained the following rang of values; Vitamin A (110.32-685.63 µg/100g), Vitamin B1 (0.42-0.85mg/100g), Vitamin B2 (0.41-0.49mg/100g), Vitamin B3 (2.55-4.21mg/100g), Vitamin B6(0.30-1.03mg/100g), Vitamin B9(27.32-193.85mg/100g), Vitamin C (11.03-65.15mg/100g). The experimental samples were very rich in vitamin A which is an essential nutrient that helps to build up the immune system of infants against a number of infectionsand sustains the integrity of the epithelial linings.Mineral composition results were obtained as follows; Calcium (261.84-351.32mg/100g), Potassium (632.85-718.23mg/100g), Sodium (35.85-190.11mg/100g), Phosphorus (292.87-546.72mg/100g), Iron (10.73-19.91mg/100), Zinc (5.33-25.34mg/100g) and Iodine (47.32-90.19mg/100g).These minerals play crucial roles in osmotic regulation, various physiological functions in body processes and are necessary for maintaining overall health and well-being.

Key words: OFSP, Soybean, Dates, Complementary foods.

Introduction

Complementary food (CF) is any healthful and energy containing solid, semisolid or liquid meal consumed by infants besides human milk or formula (Okoronkwo et al., 2023). They are essentially introduced from the period of 4-6 months when breast milk considered being the choicest and safest meal for young babies, can no longer provide the nutrients and energy requirements needed to enable the child to grow and thrive (Amagloh et al., 2012). According to WHO 1998, it is any food other than breast milk given to a breastfeeding child and the process is called complementary feeding practice. Complementary food is mostly prepared in the form of thin porridges or gruels. When breast milk alone is no longer sufficient, complementary feeding can meet the additional nutritional requirements of the infants. Complementary feeding begins at 6 months when transition from exclusive breastfeeding to semi-solid foods begins and continues up to the age of 24 months (Alemayehu et al., 2014) where most infant need additional foods, to complement the breast milk and make certain nutrient to provide enough energy and nutrients for normal growth. This goal is only achieved when these foods are prepared and feed to the infants under hygienic conditions and given in adequate proportions. The main concern is making sure that there is no gap between nutrient requirements and what a child is able to consume, absorb and utilize. Most infants suffer from malnutrition not because of the economic status of the country but because of inability to utilize the available raw materials to meet their daily requirements

Sweet potato (*Ipomoea batatas L.)* is one of the world's most important, versatile and underexploited food crops (Olatunde *et al.,* 2020).The sweet potato tuber grows underground, ranges in flesh colour from white, cream to yellow, purple or orange, and is high in soluble carbohydrates, minerals and vitamins. Sweet potato roots have high nutritional value,energy content and other micronutrients such as vitamin A, C, potassium, iron and zinc. Notwithstanding, it is low in protein and fat contents; hence, the need to complement it with legumes which will boost the protein contents of the complementary foods, thus the use of soy bean.

Soybean (*Glycine max L.*) products have been proven to be good substitutes for animal products as they offer a "complete" protein profile, containing almost all the essential amino acids (except methionine) and a range of water-soluble and fat soluble vitamins. Soybean flour is among the products increasingly consumed in sub Saharan Africa and has been reported to be good a source of protein, lipid and other essential nutrients (Mmari et al., 2017). In as much as we want the food product to be rich nutritionally and functionally, it also has to be palatable for the concerned to enjoy while consuming. Thus the use of date fruit as a sweetener and nutrient enhancer is very important

Date palm fruit (*Phoenix dactylifera L.)* is a good source of sugar (around 70–80 % sugar content), depending on the species and maturity stage of the fruits likes glucose, fructose, and sucrose which are easily absorbed by the body to provide energy (Abdul *et al*., 2022). Date fruit contains a considerable amount of moisture (12–14), crude fibre (4.5–5.0), protein (2.0–2.5), fat (1.8–2.4), and ash (1.7–1.9) which is essential for children's growth and developments (Abdul *et al*., 2022).. The vitamin content in date fruit is low but interestingly, the content of B-complex vitamins is high in date fruits. Date contains a high amount of minerals (selenium, magnesium, potassium, calcium and phosphorus) which is essential for the development of strong bones and teeth(Abdul *et al*., 2022). Dates is also rich in antioxidants and phenolic compounds and also contains antimicrobial properties (Abdul *et al*., 2022). This will help to improve on the storage stability of the complimentary food formulations.

Statement of the problem

Most infants suffer from protein energy malnutrition not because of the economic status of the country but because of inability to utilize the available raw materials to meet their daily requirements *(Amagloh et al., 2012).*Locally accessible ingredients such as sweet potatoes, soybean and date palm fruit are still highly underutilized in formulating complementary foods despite the fact that they are highly available, nutritionally rich, low in anti-nutritional with good functional properties, and forms a low viscous porridge.

Methodology

The research used a combination of quantitative approach to determine the vitamins and mineral composition (AOAC 2015) and a qualitative approach to evaluate the functionalproperties of food formulations.

Procurement of Materials

Sweet potato was obtained from the National Roots and Crops Research Institute (NRCRI), UMUDIKE. Soybeansand dates palm fruits were obtained from the Wurukum Market, Makurdi. Nestle Cerelac was obtained from a local supermarket in Makurdi. Procured materials were taken to the CEFTER Food Processing Laboratory, Benue state university for processing.

Equipment

Standard equipment from the CEFTER food processing laboratory was used for the processing of the products. This equipment included but not limited to knives, bows, trays, driers, blender, mixer, oven, sieves (0.5 mm), measuring cylinder and weighing scale. Standard analytical equipment from the Chemistry laboratory were used for lab analysis

Preparation of Raw Materials

Standard processing procedures and chemicals were used in the preparation of the flours and complementary food formulations

Sweet Potato flour

Mature orange-flesh sweet potato tubers (*Ipomoea batatas*), was cleaned and trimmed manually using knives. They were washed, peeled and sliced using a manual food slicer in to smaller sizes of approximately 10 mm thickness to facilitate the drying process. The sliced sweet potatoes were blanched for 5mins at 70°C and dried in air circulating oven (Gallenkamp S/No 90/02/190, UK) at 60°Cfor 48 h according to the method of (Marcel et al., 2021) with slight modification. The dried samples were milled to pass a 0.5 mm sieve for flour blends (Truong et al., 2018).

Soy bean flour

The soy bean seeds were sorted, washed and soaked in water for 24 hours. The soaked beans were placed in a sieve and the water drained off. The beans were then boiled for 30 minutes to inactivate enzyme activity and also to make decortication easy. The soybeans were dehulled by robbing between palms and the peels drain off using potable water. It was then oven dried at 60 °C for 48 h in a hot-air oven, after which they were roasted at 120°C for 30 mins. The roasted beans were milled with a laboratory mill (Laboratory Blender of model KM 901D; Kenwood Electronic, Hertfordshire, UK) into flour. The flour were sieved through a 0.5 mm mesh sieve (Olatunde et al., 2020).

Date Palm flour

The date flour was prepared by sorting the date palm nuts to remove all foreign particles and washing. It was followed by de-seeding through the manually cutting the nut using knife and removing the seed. The inside was cleaned and size reduction of the nut for efficient drying and milling processes. The pulp with the pericarp was then oven dried at 60 □ for 72 h (Ahaotu *et al.*, 2021). The dried pulp was milled into fine flour using laboratory blender. The flour was then sieved through a 0.5 mm mesh sieve (British Standard) to obtain fine homogenous particle size flour and packaged.

Food Product and Diet Formulation

Flours from orange-fleshed sweet potatoes,soy beans, and Date palm fruits were blended in different proportions as presented in Table 1, to develop varieties of complementary flour of composite mixtures obtained from different levels/percentages of flour substitution. This ratios were arrived at, based on their protein content through material balancing to give 16 g protein/100g food as recommended by (WFP, 2018) and UNICEF 2016 for infant diets. Therefore, from the treatment combinations, five samples (CFA, CFB, CFC, CFD & CFE) were generated with the aid of the material balancing and Nestle Cerelac as standards.

Table 1 Sample Formulation of Complimentary Food

Samples	Orange-fleshed Sweet potato (%)	Soybean Flour (%)		Date (%)
		Boiled/Oven-dried	Sun-dried/Toasted	
CON	/	/	/	/
CFA	57.5	42.5	/	/
CFB	48	42	/	10
CFC	48	21	21	10
CFD	58	/	42	/
CFE	47.5	/	41.5	10

KEY:

CON: Nestle Cerelac

CFA: Boiled and Oven-dried Soy Flour/Orange Fleshed Sweet Potato

CFB: Date palm, Boiled and Oven-dried Soy Flour/Orange Fleshed Sweet Potato

CFC: Date palm, Boiled and Oven-dried/Sun-dried and toasted Soy Flour/Orange Fleshed Sweet Potato

CFD: Non-Sweetened Sun-dried and toasted Soy Flour/Orange Fleshed Sweet Potato

CFE: Sweetened Sun-dried and toasted Soy Flour/Orange Fleshed Sweet Potato

Analysis

Functional properties of complementary food formulations

The functional properties (Bulk density, Water Absorption Capacities (WAC), Oil Absorption Capacities (OAC), Gelatinization temperature, Foaming capacity, Swelling Capacity of complementary food formulationswere determined by the method described in Okoronkwo *et al.*, (2023)

Determination of Vitamins Content of complementary food formulations

Vitamin A was determined by the calorimetric method described by AOAC 2012. Vitamins B_1, B_2, B_3, B_6,$B_9$and Vitamin C were determined through the spectrophotometric method, described by (Abuengmoh et al., 2022). Exactly 10 g of the sample was extracted with 50 ml EDTA/TCA (50 g in 50 ml of water) extracting Solution for I hour and filtered through a What man filter paper into a 50ml volumetric flask and made up to the mark with the extracting solution. Twenty (20 ml) of theextract was pipetted into a 250 ml conical flask and 10 ml of 30% KI was added and also 50ml of distilled water added. This was followed by 2 ml of 1% starch indicator. This was titrated against 0.01 ml $CuSO_4$ solution to a dark end point.

Determination of mineral elements of the flours and their complementary blends formulations

Calcium (Ca), Zinc (Zn), Iron (Fe) was determined using Atomic Absorption Spectrophotometer (AAS) as described by AOAC, (2012). One gram (1 g) of the sample was first digested with 30 ml of aqua regia, which was a mixture of concentrated HNO_3 and HCl, in a ratio of 1:3. The digested sample was filtered and increased up to 50 ml with deionized water. The aliquots of the digested filtrate were used for AAS using filters that match the different elements (AOAC, 2012).The sodium (Na) content was determined using flame emission photometer (Sherwood Flame Photometer 410, Sherwood Scientific Ltd. Cambridge, UK) with NaCl as the standards

(AOAC 2012). The potassium (K) content was determined using flame emission photometer (Sherwood Flame Photometer 410, Sherwood Scientific Ltd. Cambridge, UK) with KCl as the standards (AOAC 2012).Phosphorous concentration in the sample was measured colourimetrically using the molybdovanadate methodused by(Abuengmoh et al., 2022)

Statistical Analysis

Experiments were conducted in triplicates and analysis of variance (one way ANOVA) were performed and results were separated using the Multiple Ranges Duncan's test ($p < 0.05$) on a statistical software of Statistical Package for the Social Sciences (SPSS), Version 28. The mean values and standard deviations were calculated where appropriate, reported with differences considered at 95% significant level(Yakum et al., 2024).

Results and Discussion

Functional Properties of complementary food formulations

The functional properties of flours analysed were as shown in Table 2. The functional properties determined were bulk density, water absorption capacity, oil absorption capacity, gelation temperature, foam capacity, and swelling capacity

Table 2: Functional Properties of complementary food formulations

Samples	Bulk Density (g/ml)	WAC (g/ml)	OAC (g/ml)	GT (°C)	FC (%)	SC (g/ml)
CON	$0.91^{a}\pm0.01$	$2.63^{a}\pm0.01$	$1.39^{c}\pm0.01$	$69.98^{c}\pm0.01$	$64.31^{a}\pm0.01$	$2.75^{c}\pm0.01$
CFA	$0.81^{b}\pm0.01$	$1.82^{c}\pm0.01$	$1.43^{b}\pm0.01$	$71.81^{b}\pm0.02$	$29.61^{e}\pm0.02$	$3.45^{ab}\pm0.01$

CFB	0.73^{bc} ±0.01	1.92^{c}±0.01	1.50^{b}±0.01	73.13^{b}±0.02	35.17^{d}±0.02	3.18^{b}±0.02
CFC	0.69^{c}±0.01	2.06^{b}±0.01	1.57^{ab}±0.02	76.36^{ab}±0.02	40.61^{c}±0.02	3.22^{b}±0.02
CFD	0.67^{c}±0.01	2.18^{b}±0.01	1.63^{a}±0.02	78.14^{a}±0.02	46.36^{bc}±0.01	3.60^{a}±0.01
CFE	0.66^{c}±0.01	2.31^{ab}±0.01	1.72^{a}±0.02	80.04^{a}±0.02	52.41^{b}±0.01	3.43^{ab}±0.01

Values are mean ± standard deviation of triplicate determinations.

Mean scores in columns with same letters are not significantly different (p>0.05).

Key

CON: Nestle Cerelac

CFA: Non-Sweeten Boiled and Oven-dried Soy Flour/Orange Fleshed Sweet Potato

CFB: Sweeten-Boiled and Oven-dried Soy Flour/Orange Fleshed Sweet Potato

CFC: Sweetened-Boiled and Oven-dried/Sun-dried and toasted Soy Flour/Orange Fleshed Sweet Potato

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CFE: Sweetened Sun-dried and toasted Soy Flour/Orange Fleshed Sweet Potato

Bulk density of complementary food formulations

The bulk density ranged from 0.66 (g/ml) in sample to 0.91 (g/ml) in sample CON. It was observed that the bulk density increased significantly (p< 0.05) based on the treatment method of the soy bean four. The samples with sun-dried and toasted soy flour showed the least bulk density compared to the samples with boiled and oven-dried soy flour. The sun-dried and toasted soy bean was well dried with the least moisture content thus making the seeds to be milled into smaller particle size than the boiled and oven-dried soy bean grain and hence the reduction in bulk density. This result was similar to the findings of (Bello et al., 2020) where the values of bulk density in malted food formulations were significantly (p< 0.05) lower than the values in the non-malted food formulations The significance of this is that the less bulky flour has higher nutrient density, since more flour can be packaged in the same given volume. There was significant (p< 0.05) increase in bulk density of Nestle Cerelac food formulation.

Water absorption capacity (WAC)of complementary food formulations

The water absorption capacity (WAC) ranged from 1.82 (g/ml) in sample to 2.63 (g/ml) in sample CON. It was observed that the water absorption capacity increased significantly ($p< 0.05$) based on the treatment method of the soy bean four. The samples with boiled and oven-dried soy flour showed the least water absorption capacity compared to the samples with sun-dried and toasted soy bean flour. The sun-dried and toasted soy bean was well dried with the least moisture content than the later thus making the samples to absorb more water than the samples with boiled and oven-dried soy bean flour and hence the increase in water absorption capacity. This result was similar to the findings of (Bello et al., 2020) where the values of water absorption capacity in malted food formulations were significantly ($p< 0.05$) higher than the values in the non-malted food formulations. There was significant ($p< 0.05$) increase in water absorption capacity of Nestle Cerelac food formulation. Water absorption capacity or characteristics represent the ability of a product to associate with water under conditions where water is limited.

Oil absorption capacity (OAC)of complementary food formulations

The oil absorption capacity (OAC) ranged from 1.39 (g/ml) in sample CON to 1.72 (g/ml) in sample CFE. There was a significant difference ($p< 0.05$) between samples CON every other sample. It was also observed that the oil absorption capacity increased significantly ($p< 0.05$) based on the treatment method of the soy bean four. The samples with boiled and oven-dried soy flour showed moderate oil absorption capacity compared to the samples with sun-dried and toasted soy bean flour that recorded the highest value of oil absorption capacity. This result was similar to the findings of (Bello et al., 2020) where the values of oil absorption capacity in malted food formulations were significantly ($p< 0.05$) higher than the values in the non-malted food formulations. The water and oil binding capacity of food protein depend upon the intrinsic factors like amino acid composition, protein conformation and surface polarity or hydrophobicity. The ability of the proteins of these flours to bind with oil makes it useful in food system where optimum oil absorption is desired. This makes flour to have potential functional uses in foods such as sausage production. The OAC also makes the flour suitable in facilitating enhancement in flavour and mouth feel when used in food preparation.

Gelatinization temperature (GT)of complementary food formulations

The gelatinization temperature (GT) of the blended food formulations ranged from 69.98 ºC in sample CON to 80.04 ºC in sample CFE. The samples with boiled and oven-dried soy flour were significantly ($p<0.05$) different from the samples sun-dried and toasted soy flour. This implies that the processing method of soy bean flour greatly influences the. It was also observed that the gelatinization temperature increased significantly ($p< 0.05$) based on the processing method of the soy bean four. The samples with boiled and oven-dried soy flour showed lower gelatinization temperature compared to the samples with sun-dried and toasted soy bean flour that recorded the highest value of gelatinization temperature. This result was similar to the findings of (Bello et al., 2020) where the values of oil absorption capacity in malted food formulations were significantly ($p<0.05$) higher than the values in the non-malted food formulations.

Foam capacity of complementary food formulations

The foam capacity ranged from 29.61 % in sample CFA to 64.31 % in sample CON. It was observed that the foam capacity increased significantly ($p< 0.05$) based on the treatment method of the soy bean four. The lowest foam capacity was observed for sample CFA (29.61%) and the samples with boiled and oven-dried soy flour were significantly ($p<0.05$) different from the samples sun-dried and toasted soy flour. The samples sun-dried and toasted soy flour recorded higher values of foam capacity. The highest value was observed for sample CON (64.31%) and it was also significantly different from other samples. Protein in the dispersion may cause a lowering of the surface tension at the water air interface, thus always been due to protein which forms a continuous cohesive film around the air bubbles in the foam

Swelling capacityof complementary food formulations

The swelling capacity ranged from 2.75 g/ml in sample CON to 3.60 g/ml in sample CFD. It was observed that the swelling capacity increased significantly ($p< 0.05$) in samples with higher ratios of orange-fleshed sweet potato. The lowest swelling capacity was observed for sample CON (2.75 g/ml). The samples with soy bean flour and orange-fleshed sweet potato flour only were significantly ($p<0.05$) different/higher than the samples that had date palm pulp flour. The swelling capacity of flours depends on size of particles, types of variety and types of processing methods or unit operations. As per results, the flour of orange-fleshed sweet potato has more swelling capacity as compared to date palm pulp flour. This result agrees with those of (Bello et al., 2020)who worked on food formulations from malted, non-malted maize and *Moringa oleifera*. They observed that swelling capacity increase with addition of *Moringa oleifera* which could be as a result of Moringa oleifera containing more fibre than sorghum and soybean. The malted flour whose starch was already dextrinised could not swell as much as the non-malted food formulations The higher swelling index of the non-malted samples and also with addition of *Moringa oleifera* seed flour was as a result of starch and fibre.

Vitamin Composition of complementary food formulations

The study evaluated the vitamin composition of complementary food formulations as shown in Table 3. The vitamins that were determined were vitamin A, vitamin $B_{1,}$ vitamin $B_{2,}$ vitamin B_3 vitamin B_6,vitamin $B_{9,}$ vitamin C

Table 3: Vitamin content in the complementary food formulations

Samples	Vit. A (µg /100g)	Vit. B_1 (mg/100g)	Vit. B_2 (mg/100g)	Vit. B_3 (mg/100g)	Vit. B_6 (mg/100g)	Vit. B_9 (µg/100g)	Vit. C (mg/100g)
CON	$110.32^{c}\pm0.03$	$0.42^{c}\pm0.21$	$0.41^{c}\pm0.01$	$4.21^{a}\pm0.01$	$0.30^{b}\pm0.01$	$27.32^{c}\pm0.01$	$65.15^{a}\pm0.01$
CFA	$685.63^{a}\pm0.04$	$0.83^{a}\pm0.01$	$0.47^{a}\pm0.02$	$2.96^{b}\pm0.02$	$0.63^{b}\pm0.01$	$175.86^{ab}\pm0.11$	$11.03^{d}\pm0.01$
CFB	$584.11^{b}\pm0.35$	$0.61^{b}\pm0.01$	$0.44^{b}\pm0.00$	$2.73^{b}\pm0.02$	$0.63^{b}\pm0.02$	$147.63^{b}\pm0.06$	$16.93^{b}\pm0.02$
CFC	$585.63^{b}\pm0.04$	$0.71^{ab}\pm0.01$	$0.45^{b}\pm0.01$	$2.55^{b}\pm0.02$	$0.74^{ab}\pm0.02$	$165.78^{ab}\pm0.18$	$16.74^{b}\pm0.02$
CFD	$679.28^{a}\pm0.09$	$0.85^{a}\pm0.01$	$0.49^{a}\pm0.01$	$2.86^{b}\pm0.02$	$1.03^{a}\pm0.01$	$185.83^{a}\pm0.11$	$15.58^{c}\pm0.02$
CFE	$588.24^{b}\pm0.08$	$0.71^{ab}\pm0.01$	$0.46^{ab}\pm0.01$	$2.66^{b}\pm0.02$	$0.97^{a}\pm0.02$	$193.85^{a}\pm0.04$	$17.42^{b}\pm0.01$

Values are mean ± standard deviation of triplicate determinations. Mean scores in columns with same letters are not significantly different ($p>0.05$).

Key

CON: Nestle Cerelac

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CFE: Sweetened Sun-dried and toasted Soy Flour/Orange Fleshed Sweet Potato

Vitamin A content in the complementary food formulations.

The vitamin A content of the complementary food blend ranged from 110.32 (µg/100 g) in sample CON to 685.63 (µg/100 g) in Sample CFA. It was observed that the vitamin A content increased significantly ($p< 0.05$) in samples with higher ratios of orange-fleshed sweet potato. The lowest vitamin A content was observed for sample CON 110.32 µg/100 g. The samples with soy bean flour and orange-fleshed sweet potato flour only were significantly ($p<0.05$)

different/higher than the samples that had date palm pulp flour. The vitamin A content of samples depends on the quantity of the orange-fleshed sweet potato flour in the sample since orange-fleshed sweet potato is rich in β-carotenes which is pro-vitamin A. As per results, the flour of orange-fleshed sweet potato has more vitamin A as compared to date palm pulp flour. This result agrees with those of (Okoronkwo et al., 2023)who worked on complementary food formulations from Solid-State Fermentation of Fonio, Soybean and Orange-Fleshed Sweet Potato Blends. One of the easiest ways to introduce more vitamin A into an infant's diet is by the addition of carotene-rich plant-based foods. Vitamin A helps in the prevention of xerophthalmia and keratomalacia of the eyes (Okoye et al., 2021). Vitamin A is an essential nutrient that helps to build up the immune system of infants against a number of infections and sustains the integrity of the epithelial linings (Okoronkwo et al., 2023).

4.4.2 Vitamin B_1 (Thiamine) content in the complementary food formulations.

The vitamin B_1 (Thiamine) content of the complementary food blend ranged from 0.42 mg/100g in sample CON to 0.85 mg/100g in sample. It was observed that the vitamin B_1 content increased significantly ($p<0.05$) in samples with higher ratios of orange-fleshed sweet potato. The lowest vitamin B_1 content was observed for sample CON 0.42 mg/100g and it was significantly ($p<0.05$) different from all the other formulations. The samples with soy bean flour and orange-fleshed sweet potato flour only were significantly ($p<0.05$) different/higher than the samples that had date palm pulp flour. Thiamine helps in the treatment of beriberi and in the maintenance of healthy attitude in humans (Okoye et al., 2021). The vitamin $B_1$of the complementary food formulations depends largely on the quantity of the orange-fleshed sweet potato flour in the sample since orange-fleshed sweet potato is a vegetable and is very rich in vitamins. There were significant ($p<0.05$) differences between the complementary food formulations not containing date palm pulp flour and those containing date palm pulp flour(Okoronkwo et al., 2023). Vitamins are very important for fighting against diseases in the body

4.4.3 Vitamin B_2 (Riboflavin) content in the complementary food formulations.

The vitamin B_2 (Riboflavin) content of the complementary food blend ranged from 0.41 mg/100g in sample CON to 0.49 mg/100g in sample CFA. It was observed that the vitamin B_2 content increased significantly ($p<0.05$) in samples with higher ratios of orange-fleshed sweet potato. The lowest vitamin B_2 content was observed for sample CON 0.41 mg/100g and it was significantly ($p<0.05$) different from all the other formulations. Riboflavin is essential for growth and development in infants and young children (Okoye et al., 2021). The samples with soy bean flour and orange-fleshed sweet potato flour only were significantly ($p<0.05$) different/higher than the samples that had date palm pulp flour. The vitamin $B_2$of the complementary food formulations depends largely on the quantity of the orange-fleshed sweet potato flour in the sample since orange-fleshed sweet potato is a vegetable and is very rich in vitamins. Vitamins are very important for fighting against diseases in the body. There were significant ($p<0.05$) differences between the complementary food formulations not containing date palm pulp flour and those containing date palm pulp flour(Okoronkwo et al., 2023).

4.4.4 Vitamin B_3 (Niacin) content in the complementary food formulations.

The vitamin B_3 (Niacin) content of the complementary food blend ranged from 2.55 mg/100g in sample CFC to 4.21 mg/100g in sample CON. It was observed that the vitamin B_3 content increased insignificantly ($p<0.05$) in samples with higher ratios of orange-fleshed sweet potato. The lowest vitamin B_3 content was observed for sample CFC comprising of dates, boiled and oven-dried/sun-dried/toasted soy flour and orange-fleshed sweet potato (2.55 mg/100g) and it was not significantly ($p<0.05$) different from all the other formulations except sample CON. Niacin is a component of the respiratory co-enzyme (NAD) that is responsible for tissue oxidation in the body. This result agreed with those observed by Okoye et al., (2021). The vitamin B_3 content of the complementary food formulations depends slightly on the quantity of the orange-fleshed sweet potato flour in the sample since orange-fleshed sweet potato is a vegetable and is very rich in vitamins. There was a significant ($p<0.05$) differences between sample CON and all other complementary food formulation.

4.4.5 Vitamin B_6 (Pyridoxine) content in the complementary food formulations.

The vitamin B_6 (Pyridoxine) content of the complementary food blend ranged from 0.30 mg/100g in sample CON to 1.03 mg/100g in sample CFA. It was observed that the vitamin B_6 content increased significantly ($p<0.05$) in samples with sun-dried and toasted soy flour. The lowest vitamin B_6 content was observed for sample CON 0.30 mg/100g and it was significantly ($p<0.05$) different from all the other formulations. The samples with sun-dried and toasted soy flour were significantly ($p<0.05$) different/higher than the samples that were made of boiled and oven-dried soy flour. The vitamin B_6 content of the complementary food formulations depends slightly on the quantity of soy bean flour and it processing method since boiling will cause some of the vitamins to leach out.There were significant ($p<0.05$) differences between the complementary food formulations made of boiled and oven-dried soy flour andsun-dried and toasted soy flour (Okoronkwo et al., 2023).

4.4.6 Vitamin B_9 (Folic acid) content in the complementary food formulations.

The vitamin B_9 (Folic acid) content of the complementary food blend ranged from 27.32 mg/100g in sample CON to 193.85 mg/100g in sample CFD. It was observed that the vitamin B_6 content increased significantly ($p<0.05$) in samples with sun-dried and toasted soy flour. The lowest vitamin B_6 content was observed for sample CON 0.30 mg/100g and it was significantly ($p<0.05$) different from all the other formulations. This result agreed with those observed by Okoye et al., (2021). The samples with sun-dried and toasted soy flour were significantly ($p<0.05$) different/higher than the samples that were made of boiled and oven-dried soy flour. The vitamin B_6 content of the complementary food formulations depends slightly on the quantity of soy bean flour and it processing method since boiling caused some of the vitamins to leach out.Folic acid functions as a co-enzyme in the body. There were significant ($p<0.05$) differences between the complementary food formulations made of boiled and oven-dried soy flour andsun-dried and toasted soy flour (Okoronkwo et al., 2023).

4.4: Vitamin C (Ascorbic acid) content in the complementary food formulations.

The vitamin C (Ascorbic acid) content of the complementary food blend ranged from 11.03 mg/100g in sample CFA to 65.15 mg/100g in sample CON. It was observed that the vitamin C content increased significantly ($p<0.05$) in samples with addition of date palm pulp flour. The lowest vitamin C content was observed for sample CFA (11.03 mg/100g) and it was significantly ($p<0.05$) different from all the other formulations. The vitamin C content of the complementary food formulations was generally low compared to that of sample CON. This result agreed with those observed by Okoye et al., (2021). Sample CON (Nestle Cerelac) contained more than the RDI; this could be because it is a fortified food (Okoronkwo et al., 2023). The RDI of vitamin C for infants of 7–12 months is 50 mg/day. Vitamin C helps to form and repair red blood cells, bones and tissues; it also helps cuts and wounds to heal, boosts the immune system and keep infections away. Ascorbic acid is important in the prevention of scurvy. There were significant ($p<0.05$) differences between the complementary food formulations not containing date palm pulp flour and those containing date palm pulp flour (Okoye et al., 2021).

Mineral Composition of complementary food formulations

The research study also evaluated the mineral composition of the bread samples as shown in Table 4. The minerals that were determined included potassium, calcium, sodium, magnesium, phosphorus, and Iron

Table 4: Mineral composition of complementary food formulations

Samples	Ca (mg/100g)	K (mg/100g)	Na(mg/100g)	P (mg/100g)	Fe (mg/100g)	Zn (mg/100g)	I_2 (µg/100g)
CON	$351.32^{a}\pm0.03$	$632.85^{c}\pm0.01$	$190.11^{a}\pm0.01$	$292.87^{b}\pm0.21$	$10.73^{c}\pm0.01$	$25.34^{a}\pm0.01$	$47.32^{b}\pm0.01$
CFA	$261.84^{c}\pm0.09$	$696.68^{b}\pm0.06$	$35.85^{b}\pm0.04$	$539.14^{a}\pm0.03$	$16.52^{b}\pm0.02$	$5.33^{c}\pm0.02$	$90.07^{a}\pm0.12$
CFB	$264.24^{b}\pm0.11$	$711.23^{a}\pm0.06$	$37.35^{b}\pm0.02$	$544.73^{a}\pm1.02$	$18.12^{ab}\pm0.02$	$6.86^{bc}\pm0.02$	$90.10^{a}\pm0.01$
CFC	$264.82^{b}\pm0.08$	$715.37^{a}\pm0.06$	$38.66^{b}\pm0.18$	$545.47^{a}\pm0.58$	$18.72^{ab}\pm0.02$	$6.42^{bc}\pm0.02$	$90.17^{a}\pm0.01$
CFD	$262.45^{c}\pm0.11$	$706.68^{ab}\pm0.06$	$37.85^{b}\pm0.13$	$542.92^{a}\pm0.05$	$17.82^{b}\pm0.02$	$6.67^{bc}\pm0.02$	$90.15^{a}\pm0.11$
CFE	$265.35^{b}\pm0.05$	$718.23^{a}\pm0.06$	$39.72^{b}\pm0.02$	$546.72^{a}\pm0.15$	$19.91^{a}\pm0.02$	$7.43^{b}\pm0.02$	$90.19^{a}\pm0.01$

Values are mean ± standard deviation of triplicate determinations.

Mean scores in columns with same letters are not significantly different ($p>0.05$).

Key

CON: Nestle Cerelac

CFA: Non-Sweeten Boiled and Oven-dried Soy Flour/Orange Fleshed Sweet Potato

CFB: Sweeten-Boiled and Oven-dried Soy Flour/Orange Fleshed Sweet Potato

CFC: Sweetened-Boiled and Oven-dried/Sun-dried and toasted Soy Flour/Orange Fleshed Sweet Potato

CFD: Non-Sweetened Sun-dried and toasted Soy Flour/Orange Fleshed Sweet Potato

CFE: Sweetened Sun-dried and toasted Soy Flour/Orange Fleshed Sweet Potato

Calcium (Ca) content in the complementary food formulations

The Calcium, content of the complementary food blend ranged from 261.84 mg/100g in sample CFA to 351.32 mg/100g in sample CON. It was observed that the Calcium content increased significantly ($p<0.05$) in samples with addition of date palm pulp flour. The lowest Calcium content was observed for sample CFA (261.84 mg/100g) and it was significantly ($p<0.05$) different from all the other formulations. All the samples contained more than the minimum recommended daily intake (WFP, 2018). The RDI of Calcium for infants of 7–12 months is 260 mg/day. Calcium helps to build strong and teeth. Calcium is also necessary for the optimal growth and development of infants and young children. There were significant ($p<0.05$) differences between the complementary food formulations not containing date palm pulp flour and those containing date palm pulp flour. All these minerals are needed for the osmotic regulation of the body processes.

Potassium (K) content in the complementary food formulations

The Potassium content of the complementary food blend ranged from 632.85 mg/100g in sample CON to 718.23 mg/100g in sample CFE. It was observed that the Potassium content increased significantly ($p<0.05$) in samples with sun-dried and toasted soy flour. The lowest Potassium content was observed for sample CON (632.85 mg/100g) and it was significantly ($p<0.05$) different from all the other formulations. The samples with sun-dried and toasted soy flour were significantly ($p<0.05$) different/higher than the samples that were made of boiled and oven-dried soy flour. The Potassium content of the complementary food formulations depends slightly on the quantity ofdate palm pulp flour. There were significant ($p< 0.05$) differences between the complementary food formulations containing date palm pulp flour and those without date palm pulp flour. Potassium is an indispensable micronutrient that is necessary for cell metabolism by maintaining the sodium potassium pump and electrolytes.

Sodium (Na) content in the complementary food formulations

The Sodium content of the complementary food blend ranged from 35.85 mg/100g in sample CFA to 190.11 mg/100g in sample CON. It was observed that the Sodiumcontent increased significantly ($p<0.05$) in samples with addition of date palm pulp flour. The lowest Sodium content was observed for sample CFA (35.85 mg/100g) and it was significantly ($p<0.05$) different from all the other formulations. All the samples contained more than the minimum recommended daily intake (WFP, 2018). Sodium is an indispensable micronutrient that is necessary for cell metabolism by maintaining the sodium potassium pump and electrolytes.

Phosphorus (P) content in the complementary food formulations

The Phosphorus content of the complementary food blend ranged from 292.87 mg/100g in sample CON to 546.72 mg/100g in sample CFE. It was observed that the phosphorus content increased significantly ($p<0.05$) in samples with addition of date palm pulp flour. The lowest phosphorus content was observed for sample CON (292.87 mg/100g) and it was significantly ($p<0.05$) different from all the other formulations. The samples with sun-dried and toasted soy flour were not significantly ($p<0.05$) different/higher than the samples that were made of boiled and oven-dried soy flour. The phosphorus content of the complementary food formulations depends slightly on the quantity ofdate palm pulp flour.

Iron (Fe) content in the complementary food formulations

The Iron content of the complementary food blend ranged from 10.73 mg/100g in sample CON to 19.91 mg/100g in sample CFE. It was observed that the iron content increased significantly ($p<0.05$) in samples with addition of date palm pulp flour. The lowest iron content was observed for sample CON (10.73mg/100g) and it was significantly ($p<0.05$) different from all the other formulations. The samples with sun-dried and toasted soy flour were not significantly ($p<0.05$) different/higher than the samples that were made of boiled and oven-dried soy flour. The iron content of the complementary food formulations depends slightly on the quantity ofdate palm pulp flour.

Zinc (Zn) content in the complementary food formulations

The Zinc content of the complementary food blend ranged from 5.33 mg/100g in sample CFA to 25.34 mg/100g in sample CON. It was observed that the Zinccontent increased significantly ($P<0.05$) in samples with addition of date palm pulp flour. The lowest Zinc content was observed for sample CFA (5.33 mg/100g) and it was significantly ($p<0.05$) different from all the other formulations. All the samples contained more than the minimum recommended daily intake (WFP, 2018). Zinc is an indispensable micronutrient that is necessary for protein synthesis, cell growth and differentiation, immune function and intestinal transport of water and electrolytes. Symptoms of zinc deficiency include dermatitis, retarded growth, diarrhea, etc. All age groups of the population are at risk of zinc deficiency, but infants and young children are the most vulnerable. Zinc supplementation trials conducted over the last few decades in children from developing countries have clearly demonstrated the positive benefits of improved zinc status, including improved growth rates and reductions in the incidence of various infectious diseases (Assohoun et al., 2013)

Iodine (I_2) content in the complementary food formulations

The Iodine content of the complementary food blend ranged from 47.32 (μg/100g) in sample CON to 90.19 (μg/100g) in sample CFE. It was observed that the iodine content increased significantly ($P<0.05$) in samples with addition of date palm pulp flour. The lowest iodine content was observed for sample CON (47.32 µg/100g) and it was significantly ($p<0.05$) different from all the other formulations. The samples with sun-dried and toasted soy flour were not significantly ($p<0.05$) different/higher than the samples that were made of boiled and oven-dried soy flour. The iodine content of the complementary food formulations depends slightly on the quantity ofdate palm pulp flour. Iodine is a mineral contained in some foods that the body need in order to produce thyroid hormones. This hormone regulates the body's metabolism as well as many other vital activities. Thyroid hormones are also required by the body for appropriate bone and brain development during pregnancy and infancy. The dietary reference value (DRV) is 150µg of iodine per day for adults over the age of 18. During pregnancy and lactation, requirements increase to 200µg per day (food code Service, 2013)

Conclusion

The food formulations showed that there was a significant difference between some of the flour blends at ($p< 0.05$) and this was surely due to the different proportions and processing methods of the individual flours. The experimental samples were very rich in vitamin A which is an essential nutrient that helps to build up the immune system of infants against a number of infections and sustains the integrity of the epithelial linings.

The content of essential minerals in the samples included calcium, phosphorus, sodium, iron, zinc, iodine, and potassium. These minerals play crucial roles in osmotic regulation, various physiological functions in the body and are necessary for maintaining overall health and well-being.

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