PRODUCTION, CHEMICAL AND SENSORY EVALUATION OF COOKIES FORTIFIED WITH *MORINGA OLEIFERA* LEAVES

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ABSTRACT

Background: Consumption of snacks such as cookies is increasing in recent times especially in developing countries such as Nigeria. Most of these snacks are lacking in micronutrients which could lead to hidden hunger.

Objective: To produce and determine the chemical composition and sensory attributes of cookies with *moringa* leaves.

Methods: *Moringaoleifera* leaves were gotten from Imo State University farm, Nigeria. Baking ingredients were purchased from Owerri main market, Imo state. The moringa leaves were sorted, washed, dried and milled into flour and packaged in an airtight container prior to analysis. The cookies produced from wheat flour was fortified with moringa leaves using standard procedures in the proportion of 100:0% (WC-A), 98:2% (WMC-B), 95:5% (WMC-C) and 90:10% (WMC-D). Proximate, micronutrient, phytochemical and sensory evaluations were determined using standard methods. Statistical package for social sciences (SPSS) version 20.0 was used in analyzing the data.

Results: Significant (P<0.05) increase was observed in the proximate composition ranging from 5.67%-6.30% (moisture), 13.44%-17.03% (protein), 2.14%-2.62% (fat), 3.40%-4.84% (ash), 4.7%-6.17% (fiber) and 63.38%-70.67% (carbohydrate). Mineral content of the samples shows significant increase (P<0.05) as the substitution of moringa leaves increases on calcium, potassium, manganese, zinc, phosphorous, magnesium and copper ranging from 24.4-58.2mg/100g, 315.14-496.08mg/100g, 15.63-31.48mg/100g, 2.99-3.49mg/100g, 211.31-229.30mg/100g, 205.42-214.08mg/100g and 0.97- 2.30mg/100g respectively. Vitamin composition of the samples shows that values significantly increased from 0.39mg/100g-0.86mg/100g (vitamin A), and 1.15mg/100g-2.00mg/100g (vitamin C). The phytochemical composition of the cookies significantly decreased (P<0.05) ranging from 0.012mg/100g to 0.022mg/100g (alkaloid) and 0.20mg/100g to 0.010mg/100g (tannin) but increased in flavonoid 0.445mg/100g to 0.685mg/100g. The sensory attributes of the cookies WC-A, WMC-B, and WMC-C were significantly (P<0.05) similar but significantly (P<0.05) different from WMC-D. The fortification of moringa leaves in cookies production should be encouraged.

Conclusion: Moringa leaves improved the nutrient content of the cookies and can be used as fortificants in cookies production.

Key words: Moringa leaves, cookies, nutrient, fortification

INTRODUCTION

*Moringa oleifera*specie of the *moringaceae*family is widely cultivated in both Asian and African countries (1). *Moringa oleifera* is generally regarded as the tree of life or miracle plant because of its benefits especially in nutrition and medicine (2). It originates from Pakistan, Bangladesh, Sub. Himalayan tracts of Indian and Afghanistan (3). Moringa leaf according to Anwar *et al.* (4) is useful as an alternative foods source to alleviate malnutrition among the children. Studies have shown that moringa leaves contains more vitamin A than carrots, more calcium than milk, more iron than spinach,more vitamin C than orange, more potassium than bananas, and protein quality comparable to milk and eggs (5). It is used as food fortificants in meals especially in African countries like Nigeria, Ghana, Ethiopia, Malawi and East Africa (6). Recent studies shows that moringa can be used in food processing to enhance the nutritional quality of foods like complementary food (7), herbal biscuits (8), bread (9), yogurt (10), soup as vegetable (13).

Studies on *Moringa oleifera*reported that it has abundant bio-available nutrient such as minerals and vitamins (14, 15, and 16), antioxidant and bioactive food compounds (17) and essential amino acids (14, 18, 19, 20, 21,).

Cookies are very significant in bakery industry (8) because of its soft chewing texture when compared to biscuit. It is consumed as snack food especially in the developing countries (22,23). Snack foods are growing fast in the food industry with little or no micronutrient fortification. This has given rise to increased prevalence of overweight and obesity coupled with increased sedentary lifestyle (24). Thisincrease in snacking suggests its impact on energy regulation in adolescence (25) and adults.

Snacking leads to less meal consumption with its consequence on healthier food choices (26) and better nutrient intake (27). Prevalence of snacking among children, adolescent and adults shows a significant increase in the last few decades in countries such as America (28), Scotland (29), Portuguese (30) and Asia (31).Savige *et al.*(32) hypothesized that, it is associated with meal skipping, but can serve as a medium to provide essential nutrients to the population, if it is readily available and accessible.

However, *M. oleifera* leaves are underutilized because it is not normally included in ready-to-eat (RTE) convenience food products (33). It has some limitations which include astringent taste, aftertaste bitterness and dark green colour. Sengev *et al.* (34) reported that supplementation of 5% moringa leaf flour in bread making gave an unacceptable product despite its high nutrient content. But Nwakalor, (35) suggested that 10% moringa leaf can be used in wheat cookies production. There is paucity of literature on fortification of cookies with moringa leaves in Nigeria. Therefore, the objective of the study is to determine the nutrient composition of cookies fortified with moringa leaf.

MATERIALS AND METHODS

Sample Procurement

*Moringaoleifera*leaves (MOL) was gotten from Imo state University farm. The ingredients for the production of the cookies (such as wheat flour, baking powder, nutmeg, butter/margarine, coaster sugar, vanilla essence, egg, milk) was purchased from Owerri main market, Imo state.

Processing of samples

The *moringa* leaves were separated from stalk, washed, dried in a ventilated room for three days. It was milled into flour and sieved using 710 $\mu m$and packaged in polyethylene pouches. The wheat flour was also sieved to remove unwanted matter and packaged in a polyethylene pouches. Samples were stored in a refrigerator prior to baking

Formulation of flour blends

Four different blend proportions including the control were formulated using mixtures of wheat flour and MOL in the ratio of 100:0, 98:2, 95:5 and 90:10 respectively**.**

Sample	Wheat (%)	Moringa (%)
WC-A	**100**	**0**
WMC-B	**98**	**2**
WMC-C	**95**	**5**
WMC-D	**90**	**10**

Key:

WC-A – 100% wheat cookies

WMC-B = 98% wheat: 2% moringa cookies blend

WMC-C = 95% wheat: 5% moringa cookies blend

WMC-D = 90% wheat: 10%moringa cookies blend

Recipe for cookies preparation

Ingredients

Recipe for cookies preparation was carried out according to Okpala and Ekwe (36) with little modification.

INGREDIENTS	QUANTITY
Wheat/Moring flour blend	300g
Baking powder	2tsp
Grounded nutmeg	½ tsp
Margarine	115g
Sugar (granulated cane)	200g
Vanilla essence	½ tsp
Egg	1large sized
Milk	125ml
Salt	½ tsp
Water	70mls

Method

- Sieve thebaking powder and nutmeg into a small bowl.
- Add wheat/moringa flour blend, salt, and sugar together into the bowl.
- Cream the butter or margarine, egg, milk and vanilla essence together until the mixture is light and fluffy.
- Add water
- Knead to make soft dough.
- Roll out the dough and cut into desired shapes with cookies cutters with 32mm and thickness 5mm.
- Transfer to a greased baking trays.
- Bake until golden brown for about 10-12 minutes at 180℃ in a baking oven.
- Allow to cool on wire at 27℃ for 30 minutes.
- Package in a polyethylene pouches.

Proximate Composition Analysis

Proximate composition of the cookies was determined using the standard method of the Association of Official Analytical Chemist, AOAC (37). Moisture content was determined using Gravimetric analysis by air oven drying of 2grams of sample at 105℃ for 5 hours. Macro kjeldahl method was used to determine protein content. Soxhlet solvent extraction method was used to determine ash content by weighing 5g of charred sample into a tarred porcelain crucible incinerated at 600℃ for 6 hours in muffle furnace till ash was obtained. Carbohydrate was estimated using difference method (%fat - %protein+%ash+%fiber+%moisture).

Micronutrient Composition Analysis

Determination of mineral content of the samples was determined using the method described by Onwuka (38). Potassium and phosphorous was determined by

flame photometry method, calcium and magnesium was determined by versande EDTA complexiometric titration, phosphorous was determined by spectrometric (yellow) method, while Zn, Cu and Mn were determined using the atomic absorption spectrophotometer method.
Vitamin C (ascorbic acid) was determined using AOAC (37). Spectrophotometric method by Pearson (39) was used to determine Beta carotene.

Phytochemical Compositions
Alkaloids, tannins and flavonoid content of the cookies were evaluated using the methods as described by AOAC (37).

Sensory Evaluation
Sensory acceptability of the cookies was conducted with 50 semi-trained panelists comprising of students of Nutrition and Dietetics Department, Imo State University, Nigeria. Aroma, colour, taste, texture and overall acceptability were rated on a 9-point Hedonic scale, ranging from 1 = like extremely to 9 = dislike extremely (38). The judges were provided with glasses of water to rinse their mouth after testing.

Statistical Analysis
Data obtained were subjected to analysis of variance (ANOVA) to compare the sample mean using the Statistical Packages and Service Solution (SPSS) 22.0 Version. The least significant difference was calculated at 5% level of significance between means using turkey test.

RESULTS
Proximate
The proximate composition of wheat-moringa cookies (WMC) shows that sample WMC-D was significantly (P<0.05) higher than other samples with increased substitution of moringa (table 1). Moisture content ranged from (5.67%-6.30%), WMC-B had the highest moisture content (6.30%) and WC-A. Control had the lowest moisture content (5.67%). Samples differed significantly (P<0.05) from each other, except sample WMC-C and WMC-D.Increased protein content was observed with increase in the level of moringa substitution with the values ranging from 13.44%-17.03%. WMC-D had the highest protein content (17.03%) and WC-A had the lowest protein content (13.44%). All samples were significantly different (P<0.05) from each other except samples WMC-D and WMC-C.Crude fat content also increased with increased level of moringa substitution ranging from 2.14%-2.62%. Sample WMC-D had the highest fat content (2.62%) and WC-A had the lowest fat content 2.14%. Samples WC-A and WMC-B were significantly different (P<0.05) from samples WMC-C and WMC-D.Ash content increased as moringa substitution increases with values ranging from 3.40%-4.84%. Sample WMC-D had the highest ash content (4.84%) and WC-A had the lowest ash content (3.40%). All samples were significantly different (p<0.05) from each other. Sample WMC-D had the highest fiber content (6.17%) and WC-A had the lowest fiber content (4.7%). Samples were significantly different from each other except sample WC-A and WMC-B which had no significant difference. The carbohydrate content of the samples significantly decreased from 70.67%-63.38%. WMC-D had the lowest carbohydrate content (63.38%) and WC-A had the highest carbohydrate content (70.67%).

Micronutrient Composition
Mineral
Table 2 shows the mineral content of the cookies. There was an increase in calcium content from 24.42mg/100g to 31.48mg/100g. WMC-D had the highest calcium content (31.48mg/100g) while WC-A had the lowest calcium content (24.42mg/100g). All samples were significantly different (P<0.05) from each other. Potassium content significantly increased from 315.14mg/100g to 496.08mg/100g. WC-A had the lowest potassium content (315.14mg/100g) while WMC-D had the highest potassium content (496.08mg/100g). There was an increase in manganese content from 15.63mg/100g to 31.48mg/100g. WMC-D had the highest manganese content (31.48mg/100g) and WC-A had the lowest manganese content (15.63mg/100g).There was an increase with increase in moringa leaves powder substitution in zinc form 2.99mg/100g to 3.49mg/100g. Sample WMC-D had the highest zinc content (3.49mg/100g) and WC-A had the lowest zinc content (2.99mg/100g). All the samples are significantly different except samples WC-A and WMC-B.

Phosphorus was significantly increased from 211.31mg/100g to 229.30mg/100g. Sample WMC-D had the highest phosphorous content (229.30mg/100g) and WC-A had lowest content (211.31mg/100g). All samples were significantly different (P<0.05) from each other. The result shows that the magnesium content of all cookies samples was significantly high as the substitution increases ranging from 214.08mg/100g to 205.42mg/100g.WC-A had the lowest magnesium content (205.42mg/100g) and WMC-D had the highest magnesium content (214.08mg/100g). The result shows that the copper content significantly increased from 0.97mg/100g to 2.30mg/100g. WC-A had the lowest copper content (0. 97mg/100g) and WMC-B had the highest copper content (2.30mg/100g). All samples were significantly different except WMC-B and WMC-C.

Vitamin
The result shows that the vitamin A content of all cookie samples ranged from 0.39mg/100g to 0.86mg/100g. WMC-D had the highest vitamin A

content (0.86mg/100g) and WC-A had the lowest vitamin A content (0.39mg/100g). All samples were significantly different (P<0.05) from each other (table 3).The results shows that the vitamin C content of all cookies samples ranged from 1.15mg/100g to 2.00mg/100g. WMC-D had the highest vitamin C content (2.00mg/100g) and WC-A had the lowest vitamin C content (1.15mg/100g). All samples were significantly different from each other except samples WMC-C and WMC-D.

Phytochemical Composition

Alkaloid content of all cookie samples ranged from 0.012mg/100g to 0.022mg/100g. Sample WC-A had the highest alkaloid content (0.022mg/100g) and WMC-D had the lowest alkaloid content (0.012mg/100g). Samples WC-Aand WMC-B which had no significant difference were significantly different (p=0.05) from samples WMC-C and WMC-D.

Flavonoid content of the samples ranged from 0.445mg/100g to 0.685mg/100g. Sample WMC-D was significantly (p<0.05) higher (0.685mg/100g) than other samples with W-A having the lowest flavonoid content (0.445mg/100g).Tannin content of the samples ranged from 0.20mg/100g t0 0.010mg/100g. WMC-C had the lowest tannin content (0.002mg/100g) and WC-A had the highest tannin content (0.20mg/100g) (Table 4).

Sensory Evaluation

The sensory attributes of the cookies were presented in Table 5. Aroma scores ranged from 5.25 in WMC-D to 8.0 in WC-A, colour 5.75 in WMC-D to 8.45 in WMC-D, taste 5.25 in WC-A to 8.20 in WC-A, texture 5.90 in WMC-D to 7.95 in WC-A and overall acceptable 5.85 in WMC-D to8.25 in WC-A. Also the sensory attributes of WC-A, WMC-B, and WMC-C were similar (P<0.05) but significantly (P<0.05)different from WMC-D.

Table 1: Proximate Composition of Wheat-Moringa Cookies

Cookies samples	%Moisture	%Protein	%Fat	%Ash	%Fibre	%Carbohydrate
WC-A	$5.67^{c}\underline{+}0.04$	$13.44^{c}\underline{+}0.21$	$2.14^{b}\underline{+}0.04$	$3.40^{d}\underline{+}0.02$	$4.7^{c}\underline{+}0.03$	$70.67^{a}\underline{+}0.14$
WMC-B	$6.30^{a}\underline{+}0.03$	$15.0^{b}\underline{+}0.21$	$2.15^{b}\underline{+}0.01$	$3.87^{c}\underline{+}0.03$	$5.34^{c}\underline{+}0.14$	$67.20^{b}\underline{+}0.18$
WMC-C	$6.12^{b}\underline{+}0.03$	$16.93^{a}\underline{+}0.42$	$2.48^{a}\underline{+}0.03$	$4.6^{b}\underline{+}0.03$	$5.9^{b}\underline{+}0.21$	$63.96^{c}\underline{+}9.356$
WMC-D	$6.0^{b}\underline{+}0.03$	$17.03^{a}\underline{+}0.03$	$2.62^{a}\underline{+}0.05$	$4.84^{a}\underline{+}0.03$	$6.17^{a}\underline{+}0.42$	$63.38^{d}\underline{+}0.07$
LSD(P=0.05)	0.0302	0.0296	0.0343	0/067	0.0285	0.1210

*Mean scores of 4 cookie samples ($\underline{+}$) standard deviation, mean scores with different super script letter on the same column are significantly different (P <0.05). Values are means of three replicate.

Key:

WC-A (control) = 100% wheat cookies
WMC-B = 98% wheat: 2% moringa cookies blend
WMC-C = 95% wheat: 5% moringa cookies blend
WMC-D = 90% wheat: 10%moringa cookies blend

Table 2: Mineral Composition of Wheat-Moringa Cookies

Cookies sample	Ca (mg/100)	K (mg/100)	Mn (mg/100)	Zn (mg/100)	P (mg/100)	Mg (mg/100)	Cu (mg/100)
WC-A	$24.4^{d}\underline{+}.03$	$315.14^{d}\underline{+}.03$	$15.63^{d}\underline{+}.04$	$229.30^{a}\underline{+}.02$	$211.31^{d}\underline{+}.03$	$205.42\underline{+}.00$	$0.97^{c}\underline{+}.01$
W-MRG-B-B	$51.05^{c}\underline{+}.02$	$320.50^{c}\underline{+}.03$	$30.11^{c}\underline{+}.01$	$221.48^{b}\underline{+}.04$	$217.85^{c}\underline{+}.04$	$210.11^{c}\underline{+}.01$	$1.01^{c}\underline{+}.01$
W-MRG-B-C	$52.31^{b}\underline{+}.04$	$324.13^{b}\underline{+}.04$	$30.96^{b}\underline{+}.04$	$217.85^{c}\underline{+}.04$	$221.48^{b}\underline{+}.04$	$210.69^{b}\underline{+}.01$	$1.08^{b}\underline{+}.03$
W-MRG-B-D	$58.2^{a}\underline{+}.03$	$496.08^{a}\underline{+}.04$	$31.48^{a}\underline{+}.03$	$211.31^{d}\underline{+}.03$	$229.30^{a}\underline{+}.02$	$214.08^{a}\underline{+}.05$	$2.30^{a}\underline{+}.02$
LSD(P=0.05)	0.0287	0.0341	0.0318	0.0112	0.0328	0.03021	0.0194

*Mean scores of 4 cookie samples, ($\underline{+}$) standard deviation, mean scores with different super script letter on the same column are significantly different (P < 0.05). Values are means of three replicate.

Key:

WC-A (control) = 100% wheat cookies
WMC-B = 98% wheat: 2% moringa cookies blend
WMC-C = 95% wheat: 5% moringa cookies blend
WMC-D = 90% wheat: 10%moringa cookies blend

Table 3 Vitamin A and C Composition of Wheat-Moringa Cookies

Cookies samples	Vitamin A ($\mu g/100$)	Vitamin C (mg/100)
WC-A	0.39^{d}±0.01	1.15^{c}±0.42
WMC-B	0.52^{c}±0.00	1.38^{b}±0.57
WMC-C	0.66^{b}±0.01	1.92^{a}±0.85
WMC-D	0.86^{a}±0.01	2.00^{a}±0.01
LSD (P=0.05)	0.00612	0.05568

*Mean scores of 4 cookie samples, (±) standard deviation, mean scores with different super script letter on the same column are significantly different (P < 0.05). Values are means of three replicate.

Key:
WC-A (control) = 100% wheat cookies
WMC-B = 98% wheat: 2% moringa cookies blend
WMC-C = 95% wheat: 5% moringa cookies blend
WMC-D = 90% wheat: 10%moringa cookies blend

Table 4: Phytochemical Composition of Wheat-Moringa Cookies

Cookies samples	Alkaloids	Flavonoids	Tannin
WC-A	0.022^{a}±0.002	0.445^{b}±0.021	0.20^{a}±0.00
WM-B-B	0.021^{a}±0.007	0.490^{b}±0.014	0.010^{c}±0.00
WM-B-C	0.011^{b}±0.001	0.485^{b}±0.007	0.002^{b}±0.00
WM-B-D	0.012^{b}±0.002	0.685^{a}±0.007	0.011^{C}±0.00
LSD(p=0.05)	0.0017	0.0137	0.006

*mean scores of 4 cookie samples, (±) standard deviation, mean scores with different super script letter on the same column are significantly different (P <0.05).
Key:
WC-A (control) =100% wheat cookies
WMC-B = 98% wheat: 2% moringa cookies blend
WMC-C = 95% wheat: 5% moringa cookies blend
WMC-D = 90% wheat: 10%moringa cookies blend

Table 5: Sensory Attributes of Wheat-Moringa Cookies

Cookies sample	Colour	Aroma	Taste	Texture	Overall acceptability
WC-A	8.45^{a}±0.8	8.0^{a}±1.2	8.20^{a}±1.1	7.95^{a}±1.1	8.25^{a}±1.1
W-MRG-B-B	7.70^{a}±0.9	7.70^{a}±0.7	8.0^{a}±0.7	8.0^{a}±0.8	8.10^{a}±0.8
W-MRG-B-C	7.55^{a}±0.9	7.25^{a}±1.1	7.25^{a}±1.1	7.55^{a}±1.1	7.3^{a}±0.8
W-MRG-B-D	5.75^{b}±1.7	5.25^{b}±1.9	5.25^{b}±1.9	5.90^{b}±1.7	5.85^{b}±1.6
LSD (P= 0.05)	0.36382	0.37081	0.39852	0.37992	0.38096

*Mean scores of 20 panelists, (±) standard deviation, mean scores with different super script letter on the same column are significantly different (P <0.05).
Key: WC-A (control)=100% wheat cookies
WMC-B = 98% wheat: 2% moringa cookies blend
WMC-C = 95% wheat: 5% moringa cookies blend
WMC-D = 90% wheat: 10%moringa cookies blend

DISCUSSION

Proximate

Moisture content has been used as an index of determining the shelf life of food (40), especially during storage, packaging and distribution. The result of the study shows that the cookies would last long.The protein content of the cookies was lower than Mbanegen*et al*. (41) but consistent with Abioye and Aka (8). It was observed that, as the substitution level increases, the protein content of the cookies was increased. The protein content is adequate for preschoolers and can meet about 80% protein needs of school-aged children and adolescences. Moringa leaves are high in essential amino acids (14, 18, 19, and 21) and can be used as a vehicle to combat protein energy malnutrition. The consumption of the fiber rich food enhances the gastro intestinal tract (GIT) and lowers bad cholesterol in the blood (42). The study observed high fiber content though was lower than (43) but higher than (11). Ash content of the cookies was significantly (P<0.05) higher than (11) but lower than (41). However, Mbanegen*et al*. (41) studied on moringa flower as fortificant. Ash content is used in determining the micronutrient contained in a food product. Fortification of cookies with micronutrient rich material like moringa leaves can help to prevent hidden hunger. Carbohydrate content of the cookies significantly reduced as the substitution level increased. This is consistent with (11, 41), it could be as a result of the dilution effect of moringa leaves on the carbohydrate content of wheat (34).

Micronutrient Composition.

Micronutrients (vitamin and minerals) are important components of diet because of their physiological and metabolic functions in the body. Sample WMC-D (90:10) had the highest micronutrient content (C, K, Mn, Zn, Ph, Mg, Cu, Vitamin A and C) which could meet about 70% of the recommended nutrient intake (RNI) of both school age and adolescents. Calcium,vitamin A and C content were low when compared with RNI. This could be as a result of the sample formulation of WMC-D (90:10) as the highest. This is because; moringa has some limitations which include astringent taste, aftertaste bitterness and dark green colour. Senger*et al.* (36) reported that supplementation of 5% moringa leaf flour in bread making gave an unacceptable product despite its high nutrient content. But Nwakalor (37) suggested that 10% moringa leaf can be used in wheat cookies preparation.

Phytochemical Composition

Phytochemicals in diets have adverse and beneficial effects in human nutrition (44). This is because when they are above the recommended limit for safe feed, they bind with nutrients to form complexes that reduce nutrient bioavailability and impair growth especially in children (45). On the contrary, when they are used at low levels, they exhibit hypoglycemic, hypolipidemic and anticancer effects. Alkaloids, flavonoids and tannins content of moringa fortified cookies are below the safe recommendation in humans (46).

Sensory Attributes

The sensory evaluation of wheat-moringa cookies fortified with 2% and 5% moringa leaves were generally accepted than the 10% substitution even though it was nutritionally higher than the other samples. This disagrees with Abioye and Aka (7) and Nwakalor (35) that reported general acceptability of 10% of moringa leaves of 15% moringa leaf substitution in maize-Ogi and recommendation of 10% moringa leaves substitution in cookies production respectively. However, the cookies fortified with moringa leaves would make a good contribution to nutrient intake of the children and adolescents (47).

Conclusion

The nutrient composition of the cookies shows significant (P<0.05) variations. Sample WMC-D with 10% moringa leaf substitution had the highest nutritional value while sample WMC-A (0% moringa leaf) had the least values. However, sample WMC-B with 2% substitution and WMC-C with 5% substitution had similar acceptability with the control WC-A with 100% wheat.Therefore substitution with 5% moringa leaves may be adopted in cookies production.Moringa leaves could be used as a good vehicle in production of RTE convenience food products like cookies which will help in alleviating both micronutrient and macronutrient deficiency.

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