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Evaluation of vegetable milk from milk blends of soybean (G*lycine* max.) and African breadfruit seeds (*Treculia africana*)

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ABSTRACT

Breadfruit milk (BM) is an unpopular nutritive drink compared to soymilk and ia mostly consumed along with the seeds when boiled. Blending with soymilk will give a novel functional drink with enhanced nutritive value to prevent hidden hunger, enhance stability and may popularize the blend. Soymilk and BM from soaked and boiled dehulled African breadfruit were blended in 95:5%, 90:10% and 50:50% ratios, respectively, while 100% soymilk and 100% BM served as controls. Proximate, vitamin, mineral, anti-nutrient and physicochemical analyses were conducted on the milk blends using standard methods. Sensory properties were determined by subjective evaluation with semi-trained panellists. With increasing BM inclusion, proximate composition revealed increase in moisture content (93.60 to 94.05%) and carbohydrate (0.3 to 0.93%) while total solids (TS) (6.40 to 5.95%), ash (0.55 to 0.49%), fat (2.70 to1.85%) and protein (2.93 to 2.70%) decreased. Vitamin A (0.62 to 1.48 µg/100 mL) increased while vitamin B_1 (0.12 to 0.08 mg/100 mL) and vitamin C (4.05 to 3.21 mg/100 mL) decreased. Calcium (0.59 to 0.53 mg/100 mL), phosphorus (8.05 to 7.33 mg/100 mL), zinc (0.75 to 0.63 mg/100 mL) and iron (0.59 to 0.54 mg/100 mL) decreased. Flavonoid (0.15 to 0.09 mg/100 mL), saponin (0.13 to 0.9 mg/100 mL), tannin (0.39 to o.29 mg/100 mL), phytate (0.23 to 0.17 mg/100 mL) and oxalate (0.27 to 0.19 mg/100 mL) decreased. Titratable acidity (TTA) (0.23 to 0.26) and visible coagulation time (VCT) (15 to 19 days) increased while pH (6.33 to 5.59), and viscosity (0.48 to 0.45 mPa) decreased. General acceptability (7.01 to 6.41) decreased. The nutrient contents of all the milk blends varied due to increasing concentration effects of the ash, but were acceptable to the panellists mostly at lower levels.

Introduction

Milk is a white liquid secretion from the udder of mammals and is the primary source of nutrition for infant before they are able to digest different types of foods. Conversely, imitation milk is obtained from plants or vegetables, hence the name vegetable milk. Vegetable milk resembles animal milk in colour and texture and includes soy milk, rice milk, almond milk and coconut milk (Olivia, 2014). Vegetable milk is commonly produced from oil seeds and legumes such as soybeans, cowpea, Bambara nut, groundnut, melon seeds and cotton seed (Akinyele and Abudu, 1990). Vegetable milk neither contain milk fat nor other dairy products (Potter and Hotchkiss, 1995), but their similarity in functional properties, nutritive value and sensory characteristics with animal milk makes them potential animal milk substitutes (Enwere, 1998). Vegetable milk has also been used for replacing animal milk for babies who do not take human milk for ethical or medical reasons as in milk allergies and galactosaemic. Vegetable milk is recommended for those suffering from or prone to degenerative heart diseases that need milk with unsaturated fat, and to improve diet of those in need of protein (Akinyele and Abudu, 1990).

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Some of the problems associated with vegetable milk include beany flavour resulting from lipoxygenase oxidation of linoleic and linolenic acids, esters and triacylglycerol producing ketones and aldehydes (Mellor et al., 2010). The beany flavour affects their acceptability. Phase separation is another major problem for un-stabilized vegetable milk during storage. Instability of un-stabilized soymilk consistency has limited the widespread production, utilization and storage particularly in tropical countries (Nsofor et al., 1997; Okwunodulu et al., 2015).

Soymilk originated hundreds of years back in the orient where it is produced by grinding soaked soybeans into a puree, pressing to extract the milk and boil (Iwe, 2003). Soymilk is the most popular vegetable milk which had received very high research attention as reference vegetable milk due to absence of cholesterol and abundance of polyunsaturated fatty acids that point to its heart health implications (Osuji and Ubbonu, 2004). Soymilk is a stable off-white emulsion/suspension of oil (2%), water (88.50%), water soluble protein (3.5%), carbohydrate (2.9%), ash (0.5%) and others like calcium, iron, lecithin, riboflavin, isoflavones and vitamin E (Onyibe et al., 2009). Soymilk assumes the most predominant position in solving prevalent nutritional imbalances (Iwe, 2003) and in fighting hidden hunger. Soymilk resembles breast milk and cow's milk in health benefits, appearance, flavour and nutritive value when properly processed and it is a good candidate for infant food formulation (Osuji and Ubbaonu, 2004).

Breadfruit seed (*Treculia africana*) is a dietary component which has recently gained research attention due to its endowed health benefits. It is a rich source of vegetable oil. The BM is produced by draining water used in boiling dehulled cotyledons and by steeping dehulled seeds, mill, sieve and boil the filtrate (Onweluzo and Nwakalor, 2009). The milk of the boiled dehulled cotyledons is usually consumed together with the boiled cotyledons or drank latter. It is not as popular as soymilk as it is not the main course meal and often is eaten along with the boiled cotyledons without draining. Also, it has very low ambient storage stability. The milk contained more protein than fat and carbohydrate with very high moisture. Besides, it has highest phosphorous content than the rest minerals like calcium, iron and zinc (Onweluzo and Nwakalor, 2009). This study therefore aimed at production and evaluation of vegetable milk from blends of soymilk and BM.

Materials and methods

Source of raw materials

African breadfruit and soybean seeds were purchased from Ubani main market Umuahia in Abia State, Nigeria. Analyses were carried out at Food Science and Technology Laboratory in Michael Okpara University of Agriculture Umudike, Nigrtia.

Soymilk preparation

Soymilk from sprouted soybean batch was prepared according to the method described by Okwunodulu et al. (2017a) as shown in Figure 1. Soybean seeds were cleaned, sorted and steeped in clean water for 12 h, drained and allowed to sprout at room temperature for 72 h on jute sack spread on the floor. The beans were covered with black polyethylene and sprinkled with water regularly as soon as their surfaces were dried during sprouting. The sprouted beans were washed with water several times to reduce off odour and boiled in 0.5% $NaHCO_3$ solution for 20 min, drained, allow to cool and hand-dehulled. The hulls and the shoot were removed by water flotation to obtain soybean cotyledons which were milled in Q-link (Japan) kitchen blender with hot water (93 °C) in a ratio of 2.7 L hot water to 1 kg cotyledons (v/w) to obtain sprouted bean slurry. The slurry was screened through a double layered muslin cloth to obtain soymilk extract. This was prepared once.

Soaked breadfruit milk preparation

The method described by Onweluzo and Nwakalor (2009) was adopted. African breadfruit seeds were washed in excess volume of water to remove extraneous materials and immature seeds, drained and parboiled in water at 95 °C for 15 minutes with constant stirring (Fig. 2). The parboiled seeds were drained, allowed to cool and manually dehulled. The hulls and unwanted materials were removed by winnowing and cotyledons obtained were preserved for subsequent use. One kilogram (1 kg) of dehulled breadfruit cotyledons was washed and soaked in water for 6 h. Replacement of soaked water was done at every 2 h intervals to avoid fermentation, off-odour development and greasy substances to produce clean and tender seeds. The seeds were repeatedly washed with distilled water and wet-milled in a variable speed blender (SB-736, Sonic, Japan) with intermittent addition of distilled water. The slurry obtained was filtered through double layer linen cloth while the residue was rinsed twice with water for maximum extraction to obtain cotyledon: water ratio of 1:3 (w/v). The filtrate was boiled for 20 min with continuous stirring and filtered to obtain plain BM. This was prepared once.

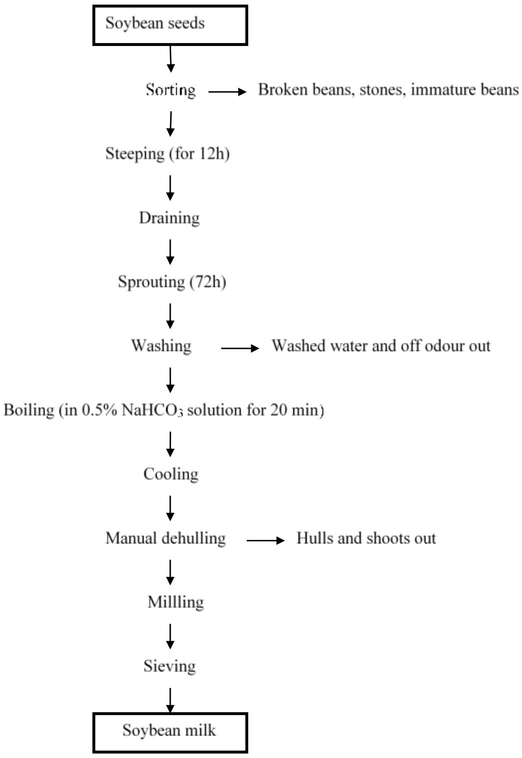

Fig. 1. Flow chart for the production of soymilk from sprouted soybean seeds (Okwunodulu et al., 2017a)

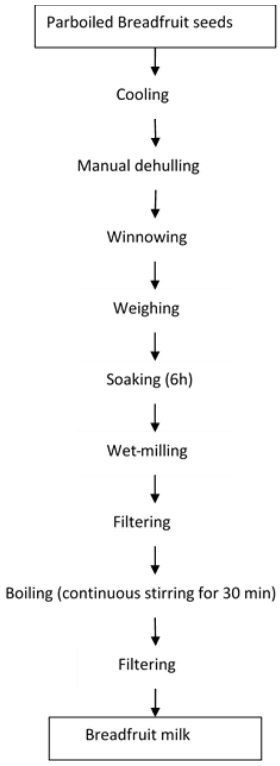

Fig. 2. Flow chart for production of soaked breadfruit milk from parboiled breadfruit seeds (Onweluzo and Nwakalor, 2009)

Formulation of milk blends

Soymilk and BM were blended in the ratio of 95:5, 90:10 and 50:50 as shown in plates 3, 4 and 5, respectively, while 100% soymilk and 100% BM served as controls as shown in Plates 1 and 2, respectively.

Analysis

Proximate Composition

Moisture content, total solids, ash, fat, crude protein and carbohydrate were determined using AOAC (2010) methods.

Vitamin composition

Vitamin A was determined according to the spectrophotometric protocol of Onwuka (2018) at 325 nm. Vitamin A was calculated as shown:

$$\text{Vitamin A (mg/100 g)} = \frac{100}{w} \times \frac{au}{as} \times c \qquad \text{Eq. 1}$$

Where:
au = absorbance of test sample
as = absorbance of standard solution
C = concentration of the test sample
w = weight of sample.

Vitamin B1 (*Thiamin*)

This was determined according to the method of Poornima and Ravishankar (2009).

Vitamin C

The titration method of Okwu and Josiah (2006) was used. The EDTA/TCA extracted sample was titrated against 0.01 mL $CuSO_4$ solution to a dark end point using 1% starch as an indicator. Vitamin C was calculated according to the formula:.

$$\text{Vitamin C (mg/100 g)} = 0.88 \times \frac{100}{10} \times \frac{Vf}{20} \times \frac{T}{1} \qquad \text{Eq. 2}$$

Where:
Vf = Volume of extract
T = Sample titre – blank titre

Calcium

Calcium was determined using the method described by Pearson (1976). Sample digest mixed with a pinch of Eriochrome Black-T-Indicator (EBT) and 2 mL of 0.1 N NaOH solution was titrated against 0.01 M EDTA. Calcium content was calculated as shown in the formula:

$$\text{Ca (mg/L)} = \frac{T \times M \times E \times 1000}{\text{Volume of sample used}} \qquad \text{Eq. 3}$$

Where:
T = Titre value
M = Morality of EDTA
E = Equivalent weight of calcium.

Phosphorous

This was determined with the vanadomolybdate (yellow) spectrometry described by James (1995). Absorbance was read at 420 nm and the phosphorous content was determined by the formula:

$$P = \frac{g}{100g} = \frac{100}{W} \times \frac{Au}{As} \times \frac{Vf}{Va} \qquad \text{Eq. 4}$$

Where:
W= weight of sample analyzed
Au = absorbance of test sample
As = absorbance of standard solution
Vf = total volume of filtrate
Va = Volume of filtrate analyzed.


Plate 1: 100% soymilk


Plate 2: 100% soaked BM


Plate 3: 95% soymilk and 5% soaked BM


Plate 4: 90% soymilk and 10% soaked BM


Plate 50% soymilk and 50 % soaked BM

Zinc

The method of AOAC (2010) was used. The atomic absorption spectrophotometric (AAS) readings of the samples digested with 20 mL of acid mixture (650 mL) concentrated HNO_3 and 80 mL perchloric acid (PCA) after diluting with distilled water was used to extrapolate on the plotted standard iron curve to determine the iron content using the formula:

$$Zn = \frac{Vf}{Vs} \times \frac{1}{10} \times \frac{100}{W} \times Df \quad \text{Eq. 5}$$

Where:
W= Weight of sample analysed
Vf = Volume of extract
Vs = Volume of extract used
Df = Dilution factor.

Iron

The spectrophotometric method described by James (1995) was used at wave length of 520 nm.

Phytate

The spectrophotometric protocol of Oberlease (1973) was used at wave length of 465 nm.

Saponin

Colorimetric method of (AOAC, 2010) was used and the saponin content was calculated as:

$$P_S = A_b \text{ x } S \text{ x } D_F \text{ x } 100 \text{ (mg g}^{-1}\text{ saponin)} \quad \text{Eq. 6}$$

Where:
P_S = Percentage of saponin
A_b = Absorbance
S = Slope
D_F = Dilution factor.

Tannin

The method of Pearson (1976) was used and the tannin content was calculated as follows:

$$\% \text{ Tannin} = \frac{A_n}{A_s} \text{ x C x } \frac{100}{W} \text{ x } \frac{V_f}{V_a} \quad \text{Eq. 7}$$

Where:
A_n= absorbance of test sample,
A_s = absorbance of standard sample
C = concentration of standard solution
Vf = Total volume of extract
Va = volume of extract analyzed
W = Weight of sample

Oxalate

Oxalate contents of the samples were determined using the three step method of Iwuoha and Kalu (1995).

pH

The pH was determined by the method described by Akpakpunam and Dedeh (1995) with pH meter.

Titratable acidity

The AOAC (2010) method was used. Sample dissolved in distilled water was mixed thoroughly with phenolphthalein indicator and titrated against standard sodium hydroxide solution until pink colour persisted for about 10-15 sec indicating complete neutralization.

Visible coagulation time (VCT)

The method described by Okwunodulu et al. (2015) was adopted. Visible coagulation time was obtained by observing for the time the samples take to separate into visible coagulum during ambient storage at every 24 h intervals.

Sensory evaluation

Sensory evaluation of the milk samples was conducted using randomly selected 25-member semi-trained panellists drawn from workers and students of Food Science and Technology Department of the University aged between 18 to 35 years. They were instructed on how to taste and score the samples before presenting the coded samples randomly with same type of plate to them in a well lighted room. Also, bottled water was presented to each panellist to rinse their mouths before and after each test. They were to taste each coded sample presented before them, evaluate their colour, taste, flavour, mouth feel and overall acceptability one after the other and score them on a 9-point hedonic scale. The scale ranged from 1 (dislike extremely) to 9 (like extremely) with 5 as neither like nor dislike (Iwe, 2010).

Statistical analysis

Data obtained were subjected to analysis of variance (ANOVA) of a completely Randomized design (CRD) using statistical package for Social Sciences (SPSS) version 16 at 5% ($p<0.05$) acceptable level. The means were separated using Duncan's New Multiple Test (DNMRT).

Results and discussion

Proximate Composition

The results are presented in Table 1. Moisture content (MC) of 100% soymilk (92.60%) was significantly ($p<0.05$) lower than 94.5% from 100% breadfruit milk which could stem from the higher bean: water ratio (1:3) in breadfruit milk than soymilk (1:2.7). This implied that soymilk could contain significant ($p<0.05$) higher soluble solids than BM. The variation was justified by the MC increase of the blends with increase in BM levels of inclusion in the formulations. This is reduction in soluble solids of the blends as MC correlate inversely with soluble solids. The MC of the milk blends (93.60 to 94.05) recorded in this work is higher than 86.93 to 90.67% reported for soy-walnut milk drinks (Bolarinwa et al., 2018). The MC of 100% soymilk was lower than 96.48% reported for soymilk (Okwunodulu and Nwabueze, 2019). Higher MC aids an in mastication, swallowing, and quenches thirst.

Total solids (TS) values of the milk blends decreased without significant ($p>0.05$) difference as BM levels of increase. Significant ($p<0.05$) higher TS value of soymilk (7.40%) than BM (5.20%) may have been the major contributor. Though the decrease (6.40 to 5.95%) was not significant ($p>0.05$), but is higher than 5.20% from 100% BM. The TS is a function of viscosity and mouth feel of the milk blends (Okwunodulu and Nwabueze, 2019).

Ash content of foods is an indication of the mineral content of the food. Significant ($p<0.05$) higher ash content of 100% soymilk (0.6%) than 100% BM 0.36% portends more mineral content in soymilk than BM. This may explain the reason for decrease in ash content of the milk blends with increase in BM concentration. Blending results in mineral content reduction compared to soymilk which is naturally deficient in mineral (Onweluzo and Nwakalor, 2009). Therefore, the milk blends will call for mineral fortification to meet the mineral need of the body. Mineral content range of the milk blends (0.49 to 0.55%) was higher than 0.14 to 0.19% from soy-walnut milk drinks (Bolarinwa et al., 2018), but lower than 1.32 to 196 reported for common evaporated milk sold in Nigerian markets (Adebiyi et al., 2007).

Significant ($p<0.05$) higher fat content of soymilk (3.20%) than BM (0.7%) recorded in this study validated the literature reports that soybean is an oil legume. Therefore, substituting soymilk with breadfruit milk reduced the fat content of the milk blends. Though fat lowering may reduce chances of rancidity, but energy, flavour and acceptability may be compromised as fat boosts energy and flavour as well as aids swallowing. Fat content range (1.85 to 2.70) of the milk blends was lower than 3.08 to 5.09% from soy-walnut milk drinks (Bolarinwa et al., 2018) and 7.52 to 8.83% from different brands of evaporated milk sold in Nigerian market (Adebiyi et al., 2007). Fat is a source of energy and fat soluble vitamins.

Significant ($p<0.05$) superior protein value (3.05%) of 100% soymilk over 100% BM (2.33%) may have been the reason behind the decreasing protein content of the milk blends with increasing BM concentration. The decrease was not significant as reflected in the non-significant ($p>0.05$) levels among the milk blends. The protein range of milk blends in this study (2.70 to 2.93%) was lower than 7.17 to11.34% reported for evaporated milk products (Adebiyi et al., 2007).

The 100% BM carbohydrate content (1.82%) was significantly ($p<0.05$) higher than 100% soymilk (0.55%) which increased the carbohydrate content of the milk blends when increasing concentration. Increased carbohydrate content of the milk blends may signify increase in their energy value, TS and viscosity as carbohydrate is their major contributor. The milk blends may likely undergo phase separation during ambient storage if the total solid (TS) increased beyond certain level unless stabilised. Very low carbohydrate value of 100% soymilk may be attributed to bean steeping and sprouting. Just like in protein, the levels of carbohydrate increase among the milk blends were not significant ($p>0.05$) and may not influence the viscosity and energy significantly unless at higher blending ratio. Carbohydrate range (0.3 to 0.9%) of the milk blends was lower than 1.8-6.89% reported for soy-walnut milk (Bolarinwa et al., 2018), 4.80% for Tiger nut-soymilk drink (Ukwuru et al., 2011) and 6.44 - 7.31% for carrot fortified soymilk (Udeozor, 2012). The difference may largely depend on material type and processing techniques adopted.

Vitamins composition

Results are presented in Table 2. Vitamin A content of the milk blends increased with increase in BM concentration. Significant ($p<0.05$) higher vitamin A content of BM (2.41 μg/100 g) than soymilk (0.49 μg/100 g) may be responsible. The difference may stem from higher carotene content (vitamin A precursor) of BM than soymilk (Friedman and Brandon, 1995; Omueti and Ajomale, 2005). Vitamin A increment in the blended samples was higher and therefore an improvement compares to soymilk as well the associated health benefits. Vitamin A is anti-oxidants which help in formation and maintenance of teeth, bones, soft tissues, white blood cells, lowers cholesterol, boosts immune system and vision (Onyeka, 2008).

Vitamin B_1 decreased significantly ($p<0.05$) with increasing concentration of BM in the blends because of significant ($p<0.05$) higher vitamin B_1 content of soymilk (0.13 mg/100 g) than BM (0.03 mg/100 g). Though the decrease may affect the health benefits, but the range (0.08 to 0.12 mg/100 g) was higher than that of 100% BM (0.03 mg/100g). The range of vitamin B_1 obtained in this study was lower than 1.51 to 1.61 mg/100 g from breadfruit-corn milk (Donald and Eucharia, 2018).

Table 1. Proximate composition of soymilk-breadfruit milk blends (%)

Samples	Moisture	Total Solids (%)	Ash	Fat	Protein	Carbohydrate
A	$92.60^{d}\pm0.14$	$7.40^{a}\pm0.14$	$0.60^{a}\pm0.00$	$3.20^{a}\pm0.14$	$3.05^{ab}\pm0.00$	$0.55^{c}\pm0.28$
B	$94.80^{a}\pm0.28$	$5.20^{c}\pm0.28$	$0.36^{f}\pm0.06$	$0.70^{g}\pm0.00$	$2.33^{c}\pm0.11$	$1.82^{ab}\pm0.23$
D	$93.60^{c}\pm0.14$	$6.40^{b}\pm0.14$	$0.55^{abc}\pm0.00$	$2.70^{b}\pm0.14$	$2.93^{abc}\pm0.04$	$0.30^{c}\pm0.21$
F	$93.60^{c}\pm0.14$	$6.40^{b}\pm0.14$	$0.51^{cd}\pm0.03$	$2.40^{c}\pm0.00$	$2.85^{abc}\pm0.07$	$0.57^{c}\pm0.21$
H	$94.05^{b}\pm0.21$	$5.95^{b}\pm0.21$	$0.49^{de}\pm0.02$	$1.85^{e}\pm0.07$	$2.70^{abc}\pm0.00$	$0.92^{c}\pm0.26$

Values are means ± standard deviation of triplicate determinations. Mean values in the same column with different superscript are significantly different ($p<0.05$). A is 100% soy milk, B is 100% soaked breadfruit milk, D is 95% soy milk and 5% soaked breadfruit milk, F is 90% soy milk and 10% soaked breadfruit milk and H is 50% soy milk and 50% soaked breadfruit milk.

Table 2. Vitamins composition of soymilk-breadfruit milk blends

Samples	Vitamin A (μg/100 g)	Vitamin B_1(mg/100 g)	Vitamin C (mg/100 g)
A	$0.49^{h} \pm 0.06$	$0.13^{a} \pm 0.01$	$4.28^{a} \pm 0.25$
B	$2.41^{a} \pm 0.08$	$0.03^{g} \pm 0.01$	$2.17^{f} \pm 0.00$
D	$0.62^{fg} \pm 0.04$	$0.12^{ab} \pm 0.00$	$4.05^{ab} \pm 0.04$
F	$0.85^{d} \pm 0.00$	$0.10^{cd} \pm 0.00$	$3.82^{bc} \pm 0.00$
H	$1.48^{b} \pm 0.03$	$0.08^{ef} \pm 0.01$	$3.21^{d} \pm 0.04$

Values are means ± standard deviation of triplicate determinations. Mean values in the same column with different superscript are significantly different ($p<0.05$). A is 100% soymilk, B is 100% soaked breadfruit milk, D is 95% soymilk and 5% soaked breadfruit milk, F is 90% soymilk and 10% soaked breadfruit milk, and H is 50% soymilk and 50% soaked breadfruit

The variation could be due to corn which is high in B-vitamins. Vitamin B_1 is part of the eight nutrients that make up the B-complex family and plays an important role among others in red blood cell formation, cognitive function, sugar oxidation, digestion, improves appetite and an anti-stress (ProHealth, 2018).

Vitamin C content of soymilk (4.28 mg/100 g) in this study was significantly ($p<0.05$) higher than BM (2.17 mg/100 g) which could be due to variety. Soybean may have contained more vitamin C than breadfruit seeds. This variation may have caused the significant ($p<0.05$) decrease in vitamin C content of the blends with increase in breadfruit concentration. But the decrease was still higher than vitamin C content of 100% BM. Vitamin C content of 100% BM (2.17 mg/100 g) was lower than 3.38 to 4.21 mg/100 g reported by Onweluzo and Nwakalor (2009) from BM and higher than 2.0 mg/100 g from diary milk (Badejo, 1999). The variations may be due to variety and processing technique employed as vitamin C is water soluble and heat labile. Vitamin C is a powerful antioxidant that helps the body form and maintain connective tissues, including bones, blood vessels, and skin (Onyeka, 2008).

Mineral composition

The results are presented in Table 3. Due to significant ($p<0.05$) higher calcium content of 100% soymilk (0.66 mg/100 g) than BM (0.51 mg/100 g), calcium content of the milk blends decreased with increasing concentration of BM. Despite the decrease, calcium content range of the blends (0.51 to 0.59 mg/100 g) was higher than that of BM (0.51 mg/100 g). This calcium range is higher than 0.08 to 0.25 mg/100 g reported for kunnu-soymilk blends (Sowonola et al., 2005), but lower than 26 to 59.5 mg/100 g for soymilk-walnut milk blends (Bolarinwa et al., 2018). The difference could be due to materials used. Calcium is important in blood clothing, muscle contraction enzyme metabolic processes, bone formation and neurological functions (Olatidoye et al., 2017).

Phosphorous content of milk blends significantly decreased with increase in BM concentration. This could be tagged to significant higher phosphorus content of soymilk (8.33 mg/100 g) than BM (6.40 mg/100 g). Despite the decrease, phosphorous content of all the milk blends were higher than that of BM and therefore phosphorous improvement compared to BM unlike soymilk. Phosphorous range (7.33 to 8.05 mg/100 g) of the milk blends was higher than 0.17 to 0.48 reported by Sowonola et al. (2005) for kunnu-soymilk drinks. Phosphorus synergizes with calcium, magnesium, manganese, vitamins A, C and D, chlorine and protein in bone formation (Olatidoye et al., 2017).

Zinc content (0.63 to 0.75 mg/100 g) of the milk blends decreased with increasing BM concentration due to significant (p<0.05) higher zinc content of soymilk (0.79 mg/100 g) than BM (0.4 mg/100 g). This decrease was still an improvement to BM as the zinc content of all the milk blends were higher unlike soymilk. Higher zinc content (3.58 to 3.83 mg/100 g) reported by Madukwe and Eme (2012) from carrot powder fortified soymilk than those from this study could be due to presence of carrot which is rich in minerals. Consumers of these milk blends may benefit normal growth with good health.

Iron content of the milk blends deceased with increasing BM concentration. This could be attributed to the significant (p<0.05) higher zinc content of the soymilk (0.59 mg/100 g) than the BM (0.49 mg/100 g) The decrease was still higher than BM value, but without significant (p<0.05) effect on iron content of soymilk. The milk blends along with other iron containing foods will help in reducing anaemic problem in children from poor and low income earners parents in developing countries (Bolarinwa et al., 2018).

Anti-nutrient composition

The results are presented in Table 4.

Though the flavonoid content of 100% soymilk (0.17 mg/100 mL) was significantly (p<0.05) higher than BM (0.06 mg/100 mL), both values were very low signifying their safety. Besides, the decreasing flavonoid content of the milk blends with increasing levels of BM was a double assurance of their consumption safety. Low anti-nutrient content of soymilk, BM and milk blends could be attributed to their natural composition and the processing methods adopted like soaking, sprouting and boiling.

Saponin, like flavonoid, content of the milk blends decreased significantly (p<0.05) with increasing levels of BM due to significant (p<0.05) higher saponin content of soymilk (0.13 mg/100 mL) than BM (0.07 mg/100 mL). This notwithstanding, both milk and milk blends are safe due to low levels of their saponin contents. Also, as saponin is not completely destroyed during cooking (Obizoba and Atii, 1991) and of nutritionally beneficial in trace amounts because of their hypocholesterolemic activity (Onimawo and Akubor, 2005), they will make good and safe functional drinks.

Despite significant (p<0.05) higher tannin content of 100% soymilk (0.4 mg/100 mL) than 100% BM (0.07 mg/100 mL), all the values were very low signifying safety. The significant (p<0.05) decrease in tannin content of the milk blends with increasing BM levels of inclusion also attested to their safety. Tannins are mostly located in the seed coat; therefore steeping, dehulling and cooking reduce their levels (Obizoba and Atii, 1991; Onwuka, 2006).

Phytate content of milk blends decreased significantly (p<0.05) as the levels of BM increased probably due to significant (p<0.05) higher phytate content of 100% soymilk (0,24 mg/100 mL) than BM (0.12 mg/100 mL). Phytates are heat stable and not degraded during cooking (Davies and Reid, 1979) but can be effectively reduced by enzyme phytase (Zhang et al., 2007). Sprouting, intense heating ultra-filtration (Sethi et al., 2016) and steeping reduce phytic acid as most of plant food anti-nutrients are water-soluble (Onwuka, 2006). Anti-nutrients cause poor mineral bioavailability.

Like other anti-nutrients, oxalate content of the milk blends decreased as the BM levels increased which made them safe for human consumption as their levels were very low (0.19 to 0.27 mg/100 mL). This oxalate decrease in the milk blends was lower than that of soymilk (0.28 mg/100 mL) which is still double safety assurance.

Table 3. Mineral composition of the soymilk- breadfruit milk blends (mg/100 g)

Samples	Calcium	Phosphorous	Zinc	Iron
A	0.66^{a}±0.03	8.33^{a}±0.18	0.79^{a}±0.04	0.59^{ab}±0.04
B	0.51^{f}±0.00	6.40^{e}±0.00	0.40^{d}±0.00	0.49^{d}±0.02
D	0.59^{c}±0.00	8.05^{ab}±0.00	0.75^{ab}±0.00	0.59^{ab}±0.00
F	0.55^{de}±0.03	7.78^{b}±0.13	0.71^{b}±0.21	0.56^{bc}±0.00
H	0.53^{ef}±0.00	7.33^{c}±0.11	0.63^{c}±0.04	0.54^{c}±0.01

Values are means ± standard deviation of triplicate determinations. Mean values in the same column with different superscript are significantly different (p<0.05). A is 100% soy milk, B is100% soaked breadfruit milk, D is 95% soy milk and 5% soaked breadfruit milk F is 90% soy milk and 10% soaked breadfruit milk, H is 50% soy milk and 50% soaked breadfruit milk.

Table 4. Anti-nutritional content of soymilk- breadfruit milk blends (mg/100 mL)

Samples	Flavonoid	Saponin	Tannin	Phytate	Oxalate
A	0.17^{a}±0.03	0.13^{a}±0.01	0.40^{a}±0.03	0.24^{a}±0.01	0.28^{a}±0.00
B	0.06^{g}±0.01	0.07^{de}±0.01	0.24^{e}±0.03	0.12^{e}±0.00	0.20^{d}±0.00
D	0.15^{ab}±0.00	0.13^{ab}±0.01	0.39^{a}±0.01	0.23^{a}±0.01	0.27^{ab}±0.00
F	0.14^{bc}±0.01	0.10^{c}±0.01	0.33^{bc}±0.01	0.20^{b}±0.01	0.25^{bc}±0.00
H	0.09^{ef}±0.00	0.09^{cd}±0.01	0.29^{cd}±0.01	0.17^{c}±0.01	0.19^{d}±0.01

Values are means ± standard deviation of triplicate determinations. Mean values in the same column with different superscript are significantly different (p<0.05). A is100% soy milk, B is 100% soaked breadfruit milk, D is 95% soy milk and 5% soaked breadfruit milk, F is 90% soy milk and 10% soaked breadfruit milk, H is 50% soy milk and 50% soaked breadfruit milk.

Physicochemical compositions

The results are presented in Table 5.

The pH of the milk blends decreased without significant (p>0.05) difference as BM levels increased. This could probably stem from lack of significant (p>0.05) pH different between 100% soymilk and 100% BM. The pH value of 100% soymilk (6.38) was lower than 6.66 from 100% sprouted soybean (Okwunodulu et al., 2017b). The pH decrease (6.33 to 5.59) which is more than 100% BM (5.4) signified increase in acidity. These pH levels may not have any significant (p>0.05) effect on the stability of milk blends (VCT). Higher milk pH values are more stable, acceptable and devoid of precipitation and phase separation (Okwunodulu et al., 2017b). The pH range of the milk blends (6.33 to 5.59) is within 6.07 to 6.67 from raw cow's milk (Gemechu et al., 2015) and slightly higher than 4.95 to 5.61 reported by Bolarinwa et al. (2018) for soy-walnut milk drinks. The pH values of all the milk samples were less acidic and will be acceptable by ulcer patients (David, 1986).

Titratable acidity (TTA) of 100% BM (0.21) was insignificantly (p>0.05) higher (0.31) than 0.21 from BM. The higher the pH value, the lower the TTA (Table 5) which depicts acidity increase and the associated storage effects. The TTA of the milk blends increased without significant (p>0.05) variation with increase in BM level of inclusion may be due to slight difference between them. The TTA values recorded in this work (0.23 to 0.26) is higher than 0.16 to 0.21% from raw cow milk (Gemechu et al., 2015) but lower than 0.03 to 0.08 from plain soymilk beverages (Terhaag et al., 2013).

Viscosity of the milk blends decreased without significant (p>0.05) variations with increasing levels of BM inclusion. Significant (p<0.05) higher viscosity of 100% soymilk (0.48 mPa) than 100% BM (0.41 mPa) may be responsible. This slight variation may imply that the blending ratios had no noticeable effect on the viscosity. This analogized with TS results which substantiated the dependency of viscosity on TS. Therefore, the milk blends may likely have no noticeable variations in mouth feel, acceptability, consistency and ambient stability between them (Onweluzo and Nwakalor, 2009).

The VCT is the time taken to observe visible phase separation which was significantly (p<0.05) higher in 100% soymilk (17 days) than in 100% BM (15 days). Significant (p<0.05) increase in VCT of milk blends with increasing inclusion levels of BM could be explained by the decrease in TS and viscosity. This agreed with the report of Okwunodulu et al. (2017b) that low TS which results in low viscosity increases the VCT of soymilk while high TS results in high viscosity and reduces same unless stabilized. Higher VCT (19 days) of sample H (50% soymilk and 20% breadfruit milk) with least TS (5.95) than the rest samples justified the inverse relationship of TS and viscosity with VCT. The range of VCT obtained in this study is within the range of 15 to 27 days reported by Osuji and Okafor (2012) for soymilk and 10 to 20 days from sprouted soy milk by Okwunodulu et al. (2015).

Table 5. Physicochemical composition of soymilk-breadfruit milk blends

Samples	pH	TTA	Vis (mPa)	VCT (days)
A	6.38^{a}±0.03	0.20^{a}±0.01	0.48^{a}±0.01	17.00^{b}±0.14
B	5.40^{a}±0.03	0.31^{a}±0.03	0.41^{b}±0.00	15.00^{d}±0.28
D	6.33^{a}±0.01	0.23^{a}±0.00	0.48^{a}±0.01	15.00^{d}±0.14
F	6.28^{a}±0.01	0.25^{a}±0.01	0.47^{a}±0.01	16.00^{c}±0.14
H	5.59^{a}±0.01	0.26^{a}±0.01	0.45^{a}±0.01	19.00^{a}±0.21

Values are means ± standard deviation of triplicate determinations. Mean values in the same column with different superscript are significantly different (p<0.05). A is100% soy milk, B is 100% soaked breadfruit milk, D is 95% soy milk and 5% soaked breadfruit milk F is 90% soy milk and 10% soaked breadfruit milk, H is 50% soy milk and 50% soaked breadfruit milk. TTA is total titratable acidity, TS is total solid and VCT is visible coagulation time. Vis is viscosity.

Table 6. Sensory scores of soymilk-breadfruit milk blends

Samples	Colour	Aroma	Taste	Mouth feel	General Acceptability
A	7.85^{a}±1.14	7.90^{a}±0.89	8.15^{a}±1.57	8.10^{a}±1.12	8.01^{a}±0.79
B	6.55^{b}±1.05	6.00^{b}±0.86	6.10^{c}±1.12	5.80^{c}±0.83	6.20^{c}±0.95
D	7.02^{b}±1.21	6.89^{a}±0.20	7.05^{b}±0.87	6.90^{b}±0.12	7.01^{b}±0.59
F	6.85^{b}±0.12	6.89^{a}±1.09	7.01^{b}±0.87	6.81^{b}±0.52	6.97^{b}±0.21
H	6.21^{c}±0.01	6.32^{b}±0.03	6.52^{bc}±0.02	6.31^{c}±0.01	6.41^{c}±0.52

Values are means ± standard deviation of triplicate determinations. Mean values in the same column with different superscript are significantly different (p<0.05). A is 100% soy milk, B is100% soaked breadfruit milk, D is 95% soy milk and 5% soaked breadfruit milk, F is 90% soy milk and 10% soaked breadfruit milk, H is50% soy milk and 50% soaked breadfruit milk.

Sensory evaluation

The results are presented in Table 6. Colour acceptability decreased with increasing levels of BM inclusion in the milk blends probable due to significant higher soymilk colour acceptability (7.85) (Plate 1) than BM (6.55) in Plate 2. This colour variation could be as a result of caramelization due to more heat exposure to soymilk sugar released during soybean sprouting (Egbo, 2012) than BM. Also, their carbohydrate composition may be a factor as well. May be that of BM was not hydrolyzed enough to effect colour change. Colour range of milk blends (6.21 to 7.02) in this study was within 6.76 to 7.23 reported by Donald and Eucharia (2018) from breadfruit-corn milk. There was no significant (p>0.05) variation between the blends of 95:5% and 90:10% respectively for soymilk and BM (Plates 3 and 4). But significant (p<0.05) difference between them and 50:50% blend (Plate 5) testified yhe dependency of colour variations also on the blending ratio.

Increasing levels of BM decreased the aroma preference of the milk blends by the panellists due to significant (p<0.05) higher soymilk aroma (7.90) than BM (6.00). The aroma variation could be attributed to familiarity and cooked flavour development when soy milk is subjected to severe heating (Adeleke *et al.*, 2000; Egbo, 2012). Aroma range of the milk blends ranked between like slightly to like moderately.

Taste acceptability of the milk blends decreased with significant (p<0.05) variation as BM levels of inclusion increased may be because of the dilution effect of lower taste score of BM (6.10). Despite the decrease (7.05 to 6.52), the taste (like moderately) was more than 6.10 (like slightly) from BM which signified improvement of BM taste acceptability unlike soymilk which was liked very much by the panellists. The taste variation could be attributed to water ratio used and familiarity of the panellists with soymilk unlike BM.

Mouth feel was rated between liked slightly to like moderately by the panellists. Mouth feel of the milk blends decreased with significant (p<0.05) variation as the levels of BM increases. This could be as a result of higher water ratio of BM. The results of TS and viscosity also justified the mouth feel reduction.

General acceptability is an overall assessment of the sensory characteristics of any product by the panellists (Iwe, 2010). Any product that records highest acceptable levels in most of the sensory parameters is preference most (Oluwole, 2009). General acceptability of the milk blends decreased without significant (p<0.05) variation as BM increases. This may stem from BM which had significant (p<0.05) lower acceptability than soymilk. Among all the milk blends, 95: 5% was the most preferred (7.01) which translate to like moderately in the 9-point hedonic scale while the least was from 50: 50% blend (6.41) which was like slightly. This was justified by significant (p<0.05) acceptability variations of 50:50% milk blend and BM with the rest samples.

Conclusion

With increasing breadfruit milk concentration, MC, carbohydrate, vitamin A, titratable acidity and visible coagulation time increased while ash, fat, protein, vitamin B_1, vitamin C, calcium, phosphorous, zinc, iron, anti-nutrients, pH, total solids, viscosity, and acceptability decreased. Therefore, blending of soymilk and breadfruit milk gave acceptable vegetable milk with improved ambient storage stability and nutrient compositions. The blending should not be more than 50:50 ratios to avoid compromising most valuable nutrients and total rejection. Blending breadfruit milk with other vegetable milk should be explored.

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