International Food Research Journal 25(5): 2033-2041 (October 2018)
Journal homepage: *http://www.ifrj.upm.edu.my*

Development and quality evaluation of soy-walnut milk drinks

[1*]Bolarinwa, I. F., [2]Aruna, T. E., [1]Adejuyitan, J. A., [3]Akintayo, O. A. and [1]Lawal, O. K.

[1]Department of Food Science and Engineering, Ladoke Akintola University of Technology, P.M.B. 4000, Ogbomoso, Oyo State, Nigeria
[2]Department of Food Science and Engineering, Kwara State University, Kwara State, Nigeria
[3]Department of Home Economics and Food Science, University of Ilorin, Ilorin, Nigeria

Article history

Received: 7 August 2017
Received in revised form: 27 September 2017
Accepted: 14 October 2017

Keywords

Soy-walnut milk
Proximate composition
Physico-chemical properties
Sensory attributes

Abstract

Beverages are used to quench thirst, and are taking with snacks as lunch in some countries. In many developing countries, beverages are commonly produced from cereals and starchy roots but rarely from legumes and nuts, which are rich in protein and other nutrients. Thus, most local beverages in developing countries are low in nutrient and not nutritionally beneficial to consumers. Imported beverages on the other hand are expensive and calorie dense. They are mostly produced from synthetic colorants, flavorings and sweeteners, which could be toxic to the body. In this study, soy-walnut milk drinks were produced from various proportions (0:100; 10:90; 30:70; 50:50) of un-malted or malted soymilk and walnut milk blends. The proximate composition, mineral content, physicochemical properties and sensory attributes of the soy-walnut drinks were evaluated. The range of the proximate composition of the soy-walnut milk drinks were 86.93-90.67%, 1.96-2.87%, 3.08-5.09% , 0.14-0.30%, and 2.18-6.89%, for moisture, proteins, fat, ash and carbohydrate, respectively. The mineral content of the soy-walnut milk drinks ranged from 0.97-2.38 ppm for iron, 22.13- 59.51 ppm for magnesium, 26.08-35.08 ppm for calcium, 2.71-3.25 ppm for sodium and 1.38-2.14 ppm for zinc. The physicochemical contents ranged from 4.95 -5.36%, 9.34-13.17%, 3.4-3.9% and 0.25 – 0.42%, for pH, total solid, total soluble solid, and total titratable acidity, respectively. Results of the sensory attributes indicated that soy-walnut drinks produced from 10% un-malted and 30% malted soymilk substitution were most preferred to consumers. Soy-walnut milk drinks could help in solving the problem of protein malnutrition and micronutrient deficiency problems in developing countries and increase the utilization of walnut in Africa.

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Introduction

Beverages are convenient diets that are widely accepted for their thirst-quenching and refreshing properties (Akonor *et al*., 2014). Some beverages also have the ability to provide consumers with energy and other nutrients. Beverages are generally produced from a wide variety of raw material of both plant and animal origin including fruits, vegetables, cereal grains and milk from animal mammalian gland. They provide consumers with proteins, vitamins and minerals (Mudambi *et al*., 2006). Some beverages serve as substitute in filling human nutritional deficit because of the nutrients they contain while some are consumed as source of stimulant.

A number of fruit drinks and vegetable juices manufactured from fruit juices and vegetables, and other natural ingredients are popular and are sold and consumed worldwide. The demand for these drinks and beverages is largely based on their nutritive value, flavor, aroma and color. Fermented alcoholic and non-alcoholic beverages produced from cereal grains or fruits are also consumed globally (Pyler and Thomas, 2000). Non-alcoholic beverages are classified as stimulant and refreshing, though their major constituent is water (Omotoso *et al.*, 2014).

Soybean *(Glycine max)*, a grain legume, is one of the richest and cheapest sources of plant protein that is cultivated and readily available in developing countries (Liu and Chang, 2012). It is used in various forms in many parts of the world. The diets of people in many developing countries comprise mainly starchy roots, cereals and few legumes. Soybeans and products derived from them have recently served as an important source of protein in the diet of millions of people in developing nations. Soymilk, a watery extract of whole soybean is rich in water soluble protein, carbohydrate and oil (Adebayo-Tayo *et al*., 2008). It is growing in popularity in the developing

*Corresponding author.
Email: *ifbolarinwa@lautech.edu.ng.*

countries of Africa in recent years. The popularity of soymilk as a beverage worldwide has been attributed to its low cholesterol and lactose, in addition to its ability to reduce bone loss and menopausal symptoms, prevention and reduction of heart diseases and certain cancers (Iwe, 2003; Kolapo and Oladimeji, 2008; Odu and Egbo, 2012).

Walnut (*Juglans regia* L) a member of Juglandaceae family and African walnut *(Tetracarpidium conophorum)* are one of the finest nuts of temperate and tropical regions (Mehmet *et al.*, 2010). Walnut is a highly nutritious plant. It contains high content of protein, magnesium, copper, folic acid, potassium, fiber and vitamin E (Anderson *et al*., 2001). It is also a good source of high quality protein and contain 18~24% protein on a dry weight basis (Sze-Tao and Sathe, 2000; Mao and Hua, 2012).

Diet supplemented with walnuts has been reported to reduce blood cholesterol and lower the ratio of serum concentrations of low density lipoprotein: high density lipoprotein by 12% (Sabate *et al.*, 1993; Savage, 2001). Walnuts have also been reported to reduce the risk of coronary heart disease (FDA, 2004; Feldman, 2002). This effect has been associated with the blend of nutrients and phytochemicals found in the nuts (Serrano *et al.*, 2007). Despite all these findings, walnut consumption remains low in Nigeria and other developing countries of Africa. In temperate region, ripe walnuts are mostly eaten as dessert nuts or used in cakes, desserts and confectionery. In tropical regions, walnuts are predominantly consumed boiled as snacks.

Every citizen of developing nation should have right to optimal nutrition, which guarantee daily intakes of energy, nutrients and bioactive and other compounds to improve some body functions and reduce the risk of some diseases (Ashwell, 2002). Optimal nutrients could be made available to the poor and low income earners in developing countries through the incorporation of walnut in their frequently consumed foods.

Previous studies have reported the development of nutritious and health supporting drink from soymilk and sea buckthorn syrup (Maftei *et al.*, 2012), soymilk and carrot (Banigo *et al.*, 2015) and soy-mushroom drink (Farzana *et al.*, 2017). The objectives of this study are therefore to produce soy-walnut drinks from the blends of walnut milk and un-malted or malted soymilk and to determine the proximate and mineral content, physicochemical properties, and consumer acceptability of the milk drinks.

Materials and Methods

Fresh walnuts, soybeans and sugar were purchased from a local market in Ogbomoso, Oyo state, South West, Nigeria. All other reagents were of analytical grade. Experiment was carried out at Food Chemistry and Food Processing laboratory at the Department of Food Science and Engineering, Ladoke Akintola University of Technology (LAUTECH), Ogbomoso, Oyo State, Nigeria.

Sample preparation

The walnuts and soybeans were sorted in order to remove foreign materials, cracked walnuts and soybeans (which may affect the taste and keeping quality of the milk drinks) and washed using distilled water.

Production of malted soybeans

The cleaned soybeans were malted following the method described by Adelekan and Oyewole (2010) with slight modification. The soybeans were soaked in distilled water at ambient temperature for 12 hr. At the end of the soaking period, the moisture content of the beans had increased to 45%. The hydrated beans were spread on a moist jute bag (which had been previously sterilized by boiling in distilled water for 30 mins) placed on a tray and kept in a cabinet. The soybeans were allowed to malt for 4 days. The malted soybeans were dried in a cabinet drier (60^{o}C) until a moisture content of 11-12% was reached.

Production of walnut milk

Fresh walnuts (1 kg) were sorted, washed with distilled water, placed in pot half-filled with portable water and boiled (1hr) on a gas cooker set at medium setting. The walnut coats were removed manually and the cooked nuts were sliced into smaller pieces (0.5 cm thickness) and ground with the addition of water (1:2 w/v) into walnut slurry using a blender (Q-link auto-clean blender, model: S-2815). The walnut slurry was sieved using muslin cloth (25 μm) to extract the milk. The walnut milk extract was pasteurized at 75^{o}C for 5 mins and cooled rapidly in a water bath at room temperature, filled in sterilized bottles and stored at 4^{o}C prior to analysis.

Production of soymilk

The method described by Susu *et al*. (2013) was slightly modified for the production of soybean milk. Soybeans (1 kg) were sorted, washed with distilled water and soaked in portable water (1:3 w/v) for 12 hr, drained and blanched for 5 mins. The blanched soybeans were allowed to cool at room temperature and de-hulled by rubbing the beans between the two palms. The de-hulled soybeans were cleaned using water (1:5 w/v). The cleaned soybeans were ground using a blender (Q-link auto-clean blender, model:

S-2815). The resulting slurry was sieved using muslin cloth (25 µm) and the milk extract was boiled for 15 mins and cooled in a water bath at ambient temperature, filled in sterilized bottles and stored at 4°C prior to analysis.

Production of soymilk from malted soybean

Malted soybean was used to produce malted soymilk using the method described for the production of soymilk (described in section 2.4 above).

Production of soy – walnut milk drinks

Freshly produced soymilk (from soybeans or malted soybeans) and walnut milk were blended together at various proportions (0:100, 10:90, 30:70, 50:50), pasteurized, hot filled in sterilized bottles, cooled rapidly in a water bath at room temperature and stored at 4°C prior to analysis. The flow chart for the production of soy-walnut milk drink is presented on Figure 1.

Proximate composition

The samples obtained from the different blends of malted and un-malted soymilk and walnut milk were analyzed for moisture, protein (N*6.25), ash, crude fibre and crude fat (AOAC, 1990). Carbohydrate was determined by difference.

Mineral analysis

Selected mineral contents (calcium, zinc, magnesium, iron and sodium) of the soy-walnut milk drinks were determined by using atomic absorption spectrophotometer (AAS) method (AOAC, 2000).

Physicochemical analysis

The pH of the samples was determined by using a calibrated digital pH meter (Hanna®, USA). Total solid content was determined according to the procedure described by Liu and Change (2012). The soluble solid/brix level was measured by specific gravity using a bench top digital refractometer. Titratable Acidity was determined according to AOAC (1990) method.

Sensory analysis

The six soy-walnut milk drink samples and the control sample (100% walnut milk) were subjected to sensory evaluation using 20 randomly selected panelists consisting of students and staff of Ladoke Akintola University of Technology (LAUTECH), Ogbomoso, Oyo state, Nigeria. The milk drinks were evaluated for colour, taste, flavour, mouth feel and overall acceptability, using a 9- point hedonic scale.

Statistical analysis

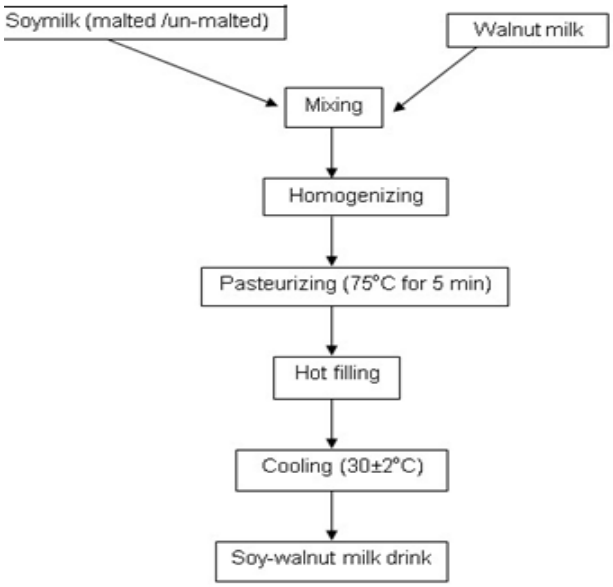


Figure 1. Flow chart for the production of soy-walnut milk drink

All data obtained in this study was subjected to statistical analyses using SPSS version 15.0. Analysis of Variance (ANOVA) was conducted on the mean values of triplicate determinations of each sample. Means were separated using Duncan Multiple Range test with significance level at $P<0.05$.

Results and Discussion

Proximate composition of soy-walnut milk drinks

The results of the proximate composition of the soy-walnut milk drinks are presented in Table 1. The moisture content of the milk drinks ranged from 86.93 - 90.67%. The moisture content of the milk drinks produced from malted and un-malted soybeans substitution (Samples: AM, BM, CM) and (Samples: A, B, C) were observed to decrease with increase in amount of soymilk substitution in the blends. The reduction in the moisture content of the soy-walnut milk could be due to the relatively high total soluble solid content (8.10 – 10.10°Brix) of plain soymilk (Terhaag *et al*., 2013). These results showed that addition of soymilk can increase the total solid content of walnut milk drinks. Sample A (10% soybeans substitution) had the highest moisture content (90.67%). This may be due to 10% soybeans substitution in the soy-walnut milk drinks. Sample CM (50% malted soybeans substitution) had the lowest moisture content (86.93%), this may be due to (50:50) equal quantity of raw materials used (malted soymilk and walnut milk). The moisture content (86.93 – 90.67%) of the soy-walnut milk drinks reported in this study was within the range of moisture content (92.02 – 93.29%) reported for Soymilk (Tunde-Akintunde and Souley, 2009)

Table 1. Proximate composition of soy-walnut milk drinks

Sample	Moisture (%)	Protein (%)	Fat (%)	Ash (%)	Carbohydrate (%)
A	90.67±0.08^{c}	1.96±0.10^{a}	5.05±0.06^{a}	0.14±0.00^{a}	2.18±0.08^{c}
AM	88.78±0.42^{bc}	2.01±0.04^{b}	5.09±0.11^{e}	0.30±0.00^{e}	3.82±0.35^{c}
B	90.46 0.01^{c}	2.23±0.03^{c}	4.44±0.06^{d}	0.15±0.00^{a}	2.72±0.81^{d}
BM	86.96±0.47^{ab}	2.33±0.10^{c}	3.76±0.08^{b}	0.26±0.00^{d}	6.69±0.56^{b}
C	87.53±2.41^{ab}	2.81±0.11^{d}	4.13±0.09^{c}	0.19±0.00^{b}	5.34±0.77^{d}
CM	86.93±0.14^{ab}	2.87±0.06^{d}	3.08±0.13^{a}	0.23±0.01^{c}	6.89±0.54^{b}
D	85.97± 0.21^{a}	1.70±0.01^{a}	7.37±0.13^{f}	0.20±0.01^{b}	4.76±0.08^{a}

Values are expressed as mean ± standard deviation of triplicate determination. Means with the same letters along the same column are not significantly different ($p>0.05$).Nd = not detected. A: 90% Walnut milk + 10% Soymilk; AM: 90% Walnut milk + 10% Malted Soymilk; B: 70% Walnut + 30% Soymilk; BM: 70% Walnut milk + 30% Malted Soymilk; C: 50% Walnut milk+ 50% Soymilk; CM: 50% Walnut milk + 50% Malted Soymilk; D: 100% Walnut milk

and Malted Soy-Kunnu Zaki beverage (83.98 – 91.67%) (Adelekan *et al.*, 2013), but higher than the moisture content (63.6-80.7%) of Kunnu produced from sorghum and sesame seeds (Makinde *et al.*, 2012) and the moisture content (73.87 – 76.13%) of Kunnu-Zaki from millet and Vigna-recemosa blends (Bolarinwa *et al*., 2015). The variation in the moisture contents of the beverages could be due to variation in the moisture content of the raw materials and the processing methods used for the production of the beverages. The relatively high moisture content of the soy-walnut milk drinks produced in this study indicates that the drinks have the potential of quenching thirst.

Protein content of the soy-walnut milk drinks increases as the addition of malted and un-malted soybean substitution increases in the milk drinks (Table 1). Malting of soybean seeds used in the production of malted soymilk resulted in significant increase in the crude protein content of the malted soy-walnut milk drinks. This is probably due to breakdown of protein compound into peptides and amino during malting. This shows that the biochemical reactions occurring during malting also affect the protein among other molecules in the germination seeds (Ade-omowaye *et al*., 2006). Sample CM (50% malted soybean substitution) had the highest protein content (2.87%) while sample A (10% soybeans substitution) had the lowest protein content (1.96%). The protein content of the soy-walnut milk drinks increases as the proportion of the malted soymilk increases in the milk blends. This could be because enzymes produced during germination leads to the hydrolysis of starch and proteins with release of sugar and amino acids. Proteolytic enzymes have also been reported to improve amino acid availability (Oluwole *et al*., 2012). Kirk-Uthmar (2007) also reported that during malting, protease enzymes were produced which possibly acted on the protein to produce peptides and amino acids from protein. Thus, addition of malted and un-malted soybeans at 50% substitution can be used to fortify the protein content of walnut milk drinks. The protein content (1.96 – 2.87%) of soy-walnut milk drinks obtained in this study is close to the protein content (3.38%) of plain soymilk (Olaoye *et al.*, 2006) and soy-corn milk (4.0%) reported by Kolapo and Oladimeji (2008). The protein content of the soy-walnut milk drinks produced in this study is significantly higher than the protein content (0.29 – 0.98%) of commercially available kunnu zaki in Bida, Nigeria (Akoma *et al*., 2014). Thus, the soy-walnut milk will not only quench consumers thirst but also supplement their protein intake. This indicates that the soy-walnut milk drinks is suitable for both adults and children.

The fat content of the soy-walnut milk drinks ranged from 3.08-5.09%. Sample AM (10% malted soybean substitution) had the highest fat content (5.09%) while sample CM (50% malted soybean substitution) had the lowest (3.08%) fat content (Table 1). The fat content (3.08 – 5.09%) of the soy-walnut milk drinks produced in this study was higher than the fat content of soymilk-kunnu blends (2.00 – 2.40%), soy-corn milk (4.14%) and plain soymilk (1.65 – 2.17%) (Sowonola *et al*., 2005; Kolapo and Oladimeji, 2008; Terhaag *et al*., 2013), but lower than the fat content (2.63 – 10.13%) of soy-malt beverage (Oluwole *et al.*, 2013).The relatively high fat content of the soy-walnut milk drinks may be attributed to the high fat content of the raw materials used (walnuts and soybeans) for the milk drink production. The fat content of the 100% walnut milk drink was 7.4%. Since the fat content of the soy-walnut milk drinks is relatively low, the milk drink can be kept at room

Table 2. Mineral content of soy-walnut milk drinks

Sample	Iron (ppm)	Magnesium (ppm)	Calcium (ppm)	Sodium (ppm)	Zinc (ppm)
A	0.97 ± 0.19^{a}	22.13 ± 0.08^{b}	26.08±0.26^{b}	2.71±0.23^{a}	1.38±0.13^{a}
AM	1.29±0.60^{c}	32.42±0.22^{d}	27.1.2±0.15^{b}	2.88±0.52^{b}	1.81±0.04^{b}
B	1.41±0.23^{cd}	28.80±0.52^{c}	28.00±0.72^{b}	2.52±0.11^{b}	1.57±0.93^{a}
BM	1.515±0.02^{d}	40.55±0.63^{e}	31.62±0.88^{c}	3.10±0.32^{c}	2.01±0.07^{b}
C	2.20±0.71^{e}	49.24±0.14^{f}	33.42±0.86^{c}	2.99±0.43^{c}	1.98±0.54^{b}
CM	2.38±0.20^{e}	59.51±0.06^{g}	35.08±0.95^{c}	3.25±0.81^{f}	2.14±0.21^{c}
D	0.64±0.14^{a}	19.85±0.32^{a}	23.63±0.07^{a}	1.64±0.38^{a}	2.02±0.04^{b}

Values are expressed as mean ± standard deviation of triplicate determination. Means with the same letters along the same column are not significantly different ($p>0.05$). Nd = not detected. A: 90% Walnut milk + 10% Soymilk; AM: 90% Walnut milk + 10% Malted Soymilk; B: 70% Walnut + 30% Soymilk; BM: 70% Walnut milk + 30% Malted Soymilk; C: 50% Walnut milk+ 50% Soymilk; CM: 50% Walnut milk + 50% Malted Soymilk; D: 100% Walnut milk.

temperature for 24 hours or it can refrigerated for 48 hours without going rancid.

Generally, the ash content of foods is an indication of the mineral content of the food. The ash content of the soy-walnut milk drinks produced from un-malted soybeans increases (0.14 – 0.19%) as the level of the soymilk increases in the substitution. The increment in the ash content of the soy-walnut milk drinks (samples A, B, C) could be attributed to the increase in the soymilk in the milk blends. Similarly, the ash content of the malted soy-walnut milk drinks increases (0.23 – 0.30%) as the addition of malted-soymilk increases in the blends. However, it was observed that the ash content of the malted soy-walnut milk drinks were higher than the ash content of the un-malted soy – walnut milk drinks. The higher ash content recorded for the malted soy-walnut milk drinks could be due to effect of biochemical changes that occur during soybean malting, which lead to the availability of the minerals.

The carbohydrate content of the soy-walnut milk drinks produced in this study ranged from 2.18 - 6.89%. Sample CM (50% malted soymilk substitution) had the highest (6.89%) carbohydrate content while sample A (10% un-malted soymilk substitution) had the lowest (2.18%) carbohydrate content. The reduction in the carbohydrate content of the un-malted soy-walnut milk drinks could be attributed to the high moisture content of the un-malted soymilk. The carbohydrate content (2.18 – 6.89%) of the soy-walnut milk drinks produced in this study was close to the carbohydrate content of Tigernut-soymilk drink (4.80%), carrot fortified soymilk (6.44 - 7.31%) and Tigernut milk (5.1 – 11.0%) (Ukwuru *et al*., 2011; Udeozor *et al*., 2012; Madukwe and Eme, 2012). The soy-walnut milk drinks with highest carbohydrate content would have higher calorific value, and will be a good source of energy to consumers.

Crude fibre was not detected in the soy-walnut milk drinks, probably because only the milky content (liquid content) of the legumes (soybeans) and the nut (walnut) was extracted and the solid raw materials were discarded during the production of the milk drinks.

Mineral composition of soy-walnut milk drinks

The mineral content of the soy-walnut milk drinks is presented in Table 2. The results of the mineral content of soy-walnut milk drinks obtained in this study showed that the milk drinks with the highest addition of malted soybeans had the highest value of minerals. The iron content of the milk drinks ranged from 0.97 – 2.38ppm. Sample CM (50% malted soybean substitution) had the highest iron content (22.38 ppm) while sample A (10% soybeans substitution) had the lowest iron content (9.67%). The iron content (0.97 – 2.38 ppm) of the soy-walnut milk drinks reported in this study was similar to the iron content (0.86 – 2.25 ppm) of milk produced from bambara nut, tiger nut and coconut milk blends (Okorie *et al*., 2014) and higher than the iron content (0.31ppm) of pito drink (Duodu *et al*., 2012). The high content of iron in the soy-milk drinks indicates that the milk drink could help in reducing anemic problem in children from poor and low income earners parents in developing countries.

The soy-walnut milk drinks is relatively rich in magnesium. Sample CM (50% malted soybean substitution) had the highest magnesium content (59.51 ppm) while sample A (10% soybean substitution) had the least magnesium content (22.13

ppm). The high magnesium content of the milk drinks (Sample CM) could be due to high magnesium content (19.85 ppm) of 100% walnut milk and increased proportion of malted soymilk drinks in the milk blends. The magnesium content (22.13 – 59.51 ppm) of soy-walnut milk drinks produced in this study was close to the magnesium content (51.9 – 65.4%) of kunun zaki (Abulude *et al.*, 2006). Low intake and impaired absorption of magnesium have been reported to be associated with the development of osteoporosis (Meletis, 2003). Thus, the soy-walnut milk drinks could help in reducing the development of osteoporosis in elderly people.

The soy-walnut milk drinks were rich in calcium (Table 2). Calcium is important in the development and health of bone and teeth. It is also necessary for promoting a healthier cardiovascular system and helps in maintaining the volume of water necessary for life processes (Harold and Hubert, 1970). The calcium content of the soy-walnut milk drinks (26 – 59.5 ppm) produced in this study is higher than the calcium content (4.92 ppm) of kunun produced from maize (Adebayo *et al*., 2010), the calcium content (0.012-0.018 ppm) of commercially available pito drinks sold in Ghana (Duodu *et al*., 2012) and the calcium content (2.00 -4.00 ppm) of zobo drinks (Olayemi *et al*., 2011), but lower than the calcium content (51.8 – 73.5 ppm) of fortified kunu zaki beverage (Abulude *et al.,* 2006). The high content (26.08 – 35.08 ppm) of calcium in the soy-milk drinks could be due to the high content of calcium in walnut milk and soymilk. Thus, the soy-walnut milk drinks could help in promoting a healthier cardiovascular system and bone development in consumers.

Sodium is necessary in the body to maintain the balance of the physical fluids system, it is also require for nerves and muscle functioning (Wardlaw, 2004) and in regulating water and chemical balance in the body. The higher sodium content (3.25 ppm) of sample CM (50% malted soybeans substitution) could be due to the malting process undergone by the soybean seed and the percentage composition of the malted soymilk in the milk blends. The sodium content (2.71-3.25 ppm) of soy-walnut milk drinks obtained in this study was higher than the sodium content (0.29%) of tiger nut-soymilk (Awonorin *et al.*, 2014).

The zinc content (1.38-2.14 ppm) of the soy-walnut milk drinks obtained in this study was close to the zinc content (3.58 - 3.83 ppm) of soymilk fortified by carrot powder (Madukwe and Eme, 2012), but lower than the zinc content (41.70 – 66.70%) of raw cow milk (Ajai *et al.*, 2012). Since zinc is important for normal growth and health, consumers of the soy-walnut milk will benefit from its zinc content.

Table 3. Physicochemical composition of soy-walnut milk drinks

Sample Code	pH	Total Solid (%)	Total Soluble Solid (°Brix)	Total Titratable Acidity (%)
A	4.95±0.95^a	11.72±0.08^b	4.2±0.14^a	0.42±0.01^c
AM	5.61±0.09^a	9.34±0.28^a	3.4±0.14^a	0.25±0.01^a
B	4.96±0.53^a	13.05±0.11^c	3.9±0.07^a	0.41±0.01^c
BM	5.36±0.14^a	9.55±0.47^a	3.5±0.07^a	0.27±0.01^a
C	4.98±0.13^a	13.17±0.60^c	3.9±0.35^a	0.33±0.01^b
CM	5.25±0.15^a	10.35±0.14^b	3.7±0.49^a	0.32±0.00^b
D	5.08±0.06^a	9.04±0.21^a	3.8±0.14^a	0.31±0.01^b

Values are expressed as mean ± standard deviation of triplicate determination. Means with the same letters along the same column are not significantly different (p>0.05).Nd = not detected. A: 90% Walnut milk + 10% Soymilk; AM: 90% Walnut milk + 10% Malted Soymilk; B: 70% Walnut + 30% Soymilk; BM: 70% Walnut milk + 30% Malted Soymilk; C: 50% Walnut milk+ 50% Soymilk; CM: 50% Walnut milk + 50% Malted Soymilk; D: 100% Walnut milk.

Physicochemical composition of soy-walnut milk drinks

The physicochemical content of soy-walnut milk drinks obtained in this study is presented in Table 3. The pH value of the milk drinks ranged from 4.95 – 5.61. There was no significant difference (P>0.05) between all the samples in terms of their hydrogen ion concentration (pH). The pH value of the soy-walnut milk drinks produced from malted soybeans was higher than that of the milk drinks produced from un-malted soybeans. This shows that malted soy-walnut milk drinks were less acidic, thus implying that the milk drink made from malted soybeans and walnut milk will be more acceptable to patients with ulcer and other related problems (David, 1986). The pH value of the soy-walnut milk drinks reported in this study is close to the pH value (6.07 – 6.67) of raw cow's milk (Teshome *et al.*, 2015).

The total solid content of the soy-walnut milk drinks produced from malted soybeans is lower (9.34 – 10.35%) than the total solid content of the milk drinks made from un-malted soybeans (11.72 – 13.17%). This total solid content of the milk drinks (9.34 – 13.17%) were within the range of total solid content (9.17 – 12.19%) of commercially available kunun zaki in Nigeria (Akoma et al., 2014), but higher than the total solid content (4.2%) of Pito drink and Zobo drink (6.2%) (Adeleke and Abiodun, 2010).

The total soluble solid of all the soy-walnut milk drinks were not significantly different (P>0.05). This

Table 4. Sensory attributes of soy-walnut milk drinks

Sample	Color	Taste	Flavor	Mouth Feel	Overall Acceptability
A	7.62±0.97^{b}	6.86±1.44^{b}	6.52±1.44^{b}	7.10±1.04^{c}	7.43±1.03^{d}
AM	7.14±1.35^{b}	6.48±1.60^{cd}	6.24±1.55^{b}	6.57±1.16^{bc}	6.71±1.15^{c}
B	6.90±1.04^{b}	5.38±1.53^{ab}	5.67±1.20^{ab}	5.48±2.06^{ab}	6.98±1.43^{c}
BM	7.14±1.11^{b}	5.81±1.75^{abc}	5.90±1.34^{b}	5.90±1.73^{ab}	6.33±1.56^{b}
C	6.90±1.04^{b}	6.57±1.47^{cd}	6.10±1.92^{b}	6.14±1.60^{bc}	6.95±1.66^{c}
CM	5.57±2.20^{a}	5.14±1.93^{a}	4.86±1.53^{a}	4.86±1.82^{a}	4.81±2.29^{a}
D	7.48±1.12^{b}	6.29±1.01^{bcd}	5.57±1.60^{ab}	5.90±1.73^{ab}	6.38±1.72^{b}

Values are expressed as mean ± standard deviation of triplicate determination. Means with the same letters along the same column are not significantly different (p>0.05). Nd = not detected. A: 90% Walnut milk + 10% Soymilk; AM: 90% Walnut milk + 10% Malted Soymilk; B: 70% Walnut + 30% Soymilk; BM: 70% Walnut milk + 30% Malted Soymilk; C: 50% Walnut milk+ 50% Soymilk; CM: 50% Walnut milk + 50% Malted Soymilk; D: 100% Walnut milk.

implies that the un-malted soy-walnut milk drinks (Sample: A, B, C) and the malted soy-walnut milk drinks (Sample: AM, BM and CM) were similar in terms of their sweetness. The total soluble solid contents (3.4-4.2 obrix) of the soy-walnut milk drinks produced in this study was within the range of the total soluble solid contents (0.3 – 10.7%) of local beverages commercially available in Osun state Nigeria (Adeleke and Abiodun, 2010).

The total titratable acidity (TTA) of soy-walnut milk drinks obtained in this study ranged from 0.25-0.42%. The TTA value of the soy-walnut milk drinks were significantly different (P<0.05) from one sample to the other. The total titratable acidity content (0.25 – 0.42%) of the soy-walnut milk drinks reported in this study is in agreement with the TTA value (0.16 – 0.21%) of raw cow milk (Teshome *et al*., 2015) and TTA (0.07 – 0.22%) of non-alcoholic beverage from malted roasted varieties of maize (Akonor *et al*., 2014), but lower than the TTA (0.03 – 0.08) of plain soymilk beverages (Terhaag *et al.*, 2013).

Sensory attributes

Table 4 shows the results of sensory attributes of the soy-walnut milk drinks. The results for colour showed that there was no significant difference (P>0.05) between samples A, AM, B, BM, and sample C. The colour of the milk samples were not affected by 10% and 30% soymilk incorporation in the milk blends. However, it was observed that the higher the percentage composition of malted soymilk substitution (>10%), the more the colour of the milk drinks changes from white to cream colour. However, there is variation in terms of the taste, flavor and mouth feel in the soy-walnut milk drinks.

The overall acceptability of the soy-walnut milk drinks for sample A (10% substitution) was higher (7.43%) than sample D (100% walnut milk). The difference in the overall acceptability of the milk drinks could be due to differences in the percentage ratio of malted and un-malted soymilk in the milk drinks. Thus, the lower the percentage substitution of malted soymilk, the better the acceptability of the soy-walnut milk drinks, however, as the percentage substitution of malted soymilk incorporated increases in the milk blends, the rate of rejection of the milk drinks by the panelist increases probably due to changes in the colour, flavour, taste and mouthfeel of the milk drinks as the proportion of the malted soymilk increases in the milk blends.

Conclusion

This study showed that soy-walnut milk drinks produced from 30% soymilk substitution resulted in notable increased in protein and mineral content, and was also acceptable to consumers. This indicates that soy-walnut milk drink could be nutritionally advantageous in Nigeria, where many people can hardly afford animal protein foods because of its high cost. The milk drinks can also be used to fortify local weaning foods (gruels), which are mostly produced from cereals with very little protein content. The milk drink will be an alternative source of milk for people that are lactose intolerance. Thus, soy-walnut milk drinks could help in solving the problem of protein malnutrition and micronutrient deficiency especially among children and pregnant women in developing countries, and also increase the utilization of walnut in Africa.

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