

Nutritional properties of indigenous fermented condiment (ogiri) produced from partial substitution of castor oil bean (*Ricinus communis*) with soybean (*Glycine max*) seeds

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Abstract

Recently, in Nigeria, there has been a series of controversial publications and debates over the use of seasoning cubes and monosodium glutamate as cancer inducing agents. With this, the use of local condiments like *Ogiri* has become an option. *Ogiri* is traditionally produced from castor oil beans which is scarce in some communities. This study therefore explored the possibility of substituting castor oil bean with soybean to obtain an acceptable *Ogiri*. Proximate, mineral and vitamin composition and sensory characteristics of the substituted *Ogiri* samples produced were evaluated using standard methods. With increase in soybean substitution levels, proximate analysis showed an increase in crude protein (17.33%-31.68%), crude fibre (0.47-1.71%) and fat (13.76-20.23%) contents while ash (3.63-3.21%) and carbohydrate (48.13%-23.55%) contents decreased. Mineral contents increased from 46.11 - 80.21, 60.25 - 73.83, 80.33 - 99.42, 118.10 - 794.38, 1.63 - 6.32 and 0.49 - 1.48 mg/100g for calcium, magnesium, phosphorous, potassium, iron and zinc, respectively. Potassium was the most abundant mineral in the samples. Also, retinol (11.63-16.26 mg/100g), vitamin B₁ (0.10-0.21 mg/100g), vitamin B₂ (10.37-14.79 mg/100g), vitamin B₃ (9.21-9.91 mg/100g), vitamin C (2.43-5.85 mg/100g) and vitamin E (6.43-11.25 mg/100g) increased significantly. Sensory analysis revealed that the *Ogiri* sample with 50% soybean inclusion and the control had the best organoleptic properties. Therefore, soybean substitution of up to 50% gave a better acceptable *Ogiri* with improved nutrient contents.

Keywords: "ogiri", castor oil bean, soybean.

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Introduction

Condiments constitute an essential part of the human diet in various cultures from different parts of the world. They are mostly of two types : fermented and non-fermented food condiments. They are particularly produced from leguminous plants and oilseeds. However, in Asian continent, particularly in places like Japan, Thailand, Vietnam, Indonesia, Malaysia as well as in Northern Europe like France, fermented condiments are made from fish sauce (Okafor, 2007). Common fermented Nigerian condiments include *Ogiri* from castor oil bean (*Ricinus communis*) or melon seed (*Citrullus vulgaris*), 'iru' or 'daddawa' from

African locust bean (*Parkia biglobosa*), 'okpei' from mesquite seed (*Prosopis africana*) and 'ugba' from African oil bean (*Pentaclethra macrophylla*). *Ogiri* is mostly used in soup preparation to impart unique aroma and taste. It is prepared by subjecting castor oil beans to a traditional method of uncontrolled solid-state fermentation. Fermentation has been reported to increase variety in the diet, improve nutritional value, and reduce anti-nutritional compounds (Achi, 2005). Microorganisms of the genus *Bacillus* and *Staphylococcus* have been reported to be involved in the fermentation process of 'ogiri', 'ugba', 'ogiri-igbo', 'dawadawa' and 'iru' (Ezekiel *et al.*, 2015).

Castor oil bean seed is obtained from castor bean plant (*Ricinus communis*) which belongs to the class of *Euphorbiaceae* and family *Angiosperm*. The castor oil plant is indigenous to the South-eastern Mediterranean region and parts of east Africa but it is today widespread throughout the tropical regions of the world (Ibe and Orabuike, 2009) with several varieties. It contains toxic protein, ricinine and ricinoleic acid, and therefore not consumed directly without processing like fermentation that normally removes these toxic constituents (Daeschel, 1989). Castor oil bean seeds constitute about 15 to 25% fat, 25% protein, 10-20% carbohydrates, 2.2% ash content, 5.1-6.5% moisture content (Verscht *et al.*, 2006) and about 40-53% of oil comprising glycosides of ricinoleic, isoricinoleic, stearic and dihydroxy stearic acids (Lin and Areinas, 2007).

Soybean (*Glycine max*) belongs to the family of *leguminosae* and sub-family *papillionideae*. It is an important source of high quality plant protein (Kure *et al.*, 1998) due to the presence of about 35-45% protein (Dandago and Igwe, 2006). It is rich in lysine which is deficient in most cereals. In addition, it contains an appreciable quantity of vitamins and minerals.

It is an antioxidant, lowers cholesterol level, and prevents cancer (Wada *et al.*, 2013), lowers cardiovascular disease, regulates menopause and combat oxidative degradation for the extension of product storability. The presence of anti-nutrients like trypsin inhibitors, tannins and phytic acid that inhibit bioavailability of desired nutrients have previously limited the utilization of soybean in food production. However, fermentation and boiling have been employed to reduce them (Enujiugha, 2009). However, the use of soybean as a raw material for "ogiri" production has been poorly investigated. The aim of this study is therefore to ascertain the acceptability and nutritional properties of "ogiri" produced from partial substitution of castor oil bean with soybean seeds.

Materials and Methods

Sample acquisition

The castor oil bean (Plate 1) and soybean seeds (Plates 2) used in this research were purchased without authentication from Nsukka market, in Enugu State, Nigeria.

Table 1: Sample codes and formulation ratios for "ogiri" production.

Sample codes	CBS (%)	SBS (%)
CBS100: SBS0	100	0
CBS90: SBS10	90	10
CBS95: SBS5	95	5
CBS50: SBS50	50	50

CBS = Castor oil bean seed. SBS = Soybean seed.

Preparation of "ogiri" samples from castor oil bean seeds.

The method described by Ibe and Orabuike (2009) was used in the preparation of all the "ogiri" samples as shown in Figure 1. The seed pods are decorticated to release the seeds for dehulling. Dehulled castor oil bean seeds (1 kg) were boiled for 2 hours, strained and boiled

again for 6 hours. The seeds were pounded in a clean mortar with pestle into paste, wrapped into smaller sizes with banana leaves and allowed to ferment for 5 days at room temperature (25°C). The wraps were placed over the cooking pot heat source in the kitchen for 48 hours after which maximum fermentation and flavour development must have been achieved. The wraps were used for the analysis.

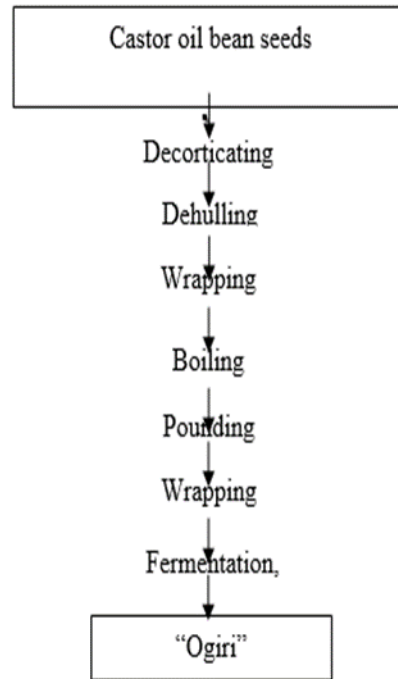


Figure 1: Flow chart for the production of “ogiri” from castor oil bean seeds.

Preparation of "ogiri" samples from soybean substituted castor oil bean seeds

Same method was used here, but castor oil bean seeds were partially substituted with soybean seeds. Castor oil bean seeds were first decorticated and dehulled to obtain the dehulled white seeds. Soybean seeds were steeped in water for 12 hours at room temperature (25°C), boiled for twenty minutes (20 min) to soften the cotyledons and facilitate dehulling, hand-dehulled and the hulls were removed by water floatation to obtain the

cotyledons. Dehulled castor oil bean seeds and soybean cotyledons were weighed and blended (Table 1). Each blend was wrapped and boiled separately and pounded together thereafter. The paste obtained was wrapped into smaller sizes with banana leaves and allowed to ferment for 5 days at room temperature (25°C). The fermented wraps were placed over a heat source (a cooking pot in the kitchen) for 48 hours to achieve maximum fermentation and flavour development (Figure 2). The fermented wraps were used for analysis.

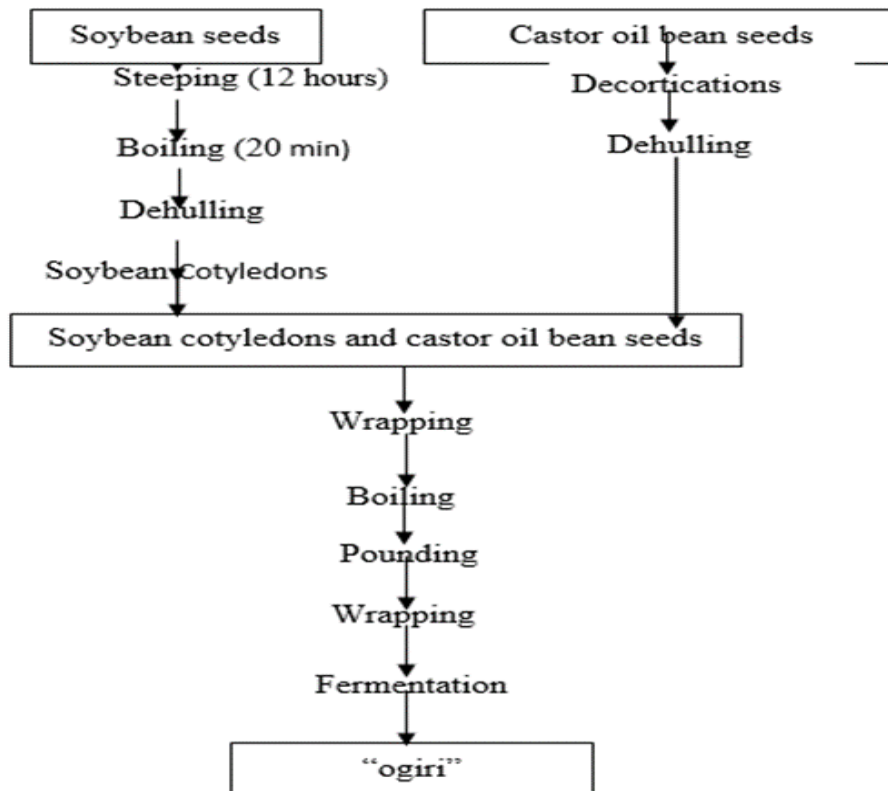


Figure 2: Flow chart for the production of “ogiri” from soybean substituted castor oil bean seeds.

Proximate analysis

The method described by AOAC (2010) was used in evaluating the moisture, crude fibre, protein, fat, and ash content, while the carbohydrate content was determined by difference.

Minerals analysis

The method described by Carpenter and Hendricks (2003) was used in determining the calcium, magnesium, potassium, sodium and phosphorus contents of the “ogiri” samples.

Vitamins analysis

Retinol, vitamin B₁, vitamin B₂, vitamin B₃, and ascorbic acid were determined by the method described by Rutkowski (2010).

Dietary energy content

This was calculated with the Atwater factor using the energy substrates (Mullan; 2006).

Sensory evaluation

Sensory evaluation was carried out according to the method described by Iwe (2010) on each sample using 20 semi-trained panellists. Panellists were selected randomly among the students within the University community, mainly those who are used to eating “ogiri”. Attributes evaluated were appearance, aroma, texture, and overall acceptability of the “ogiri” samples. They were instructed on how to taste and score the samples according to a 9- point Hedonic scale. The samples were presented separately, coded to each panellist in identical plates along with a bottle of water to rinse their mouths after testing each sample. The 9- point Hedonic scale includes: 1 = disliked extremely, 2 = dislike very much, 3 = dislike moderately, 4 = dislike slightly, 5 = neither like nor dislike, 6 = like slightly, 7 = like moderately, 8 = like very much, 9 = like extremely.

Statistical analysis

The data obtained from all the analyses were subjected to analysis of variance (ANOVA) of a completely Randomized design (CRD) using the SPSS version 2.0. Treatment means were separated using Duncan Multiple range test at 95% confidence level ($p < 0.05$).

Results and Discussion

Proximate composition

The results are presented in Table 2.

Moisture content (MC)

The MC of the substituted "ogiri" samples increased (17.63-19.62%) with increasing soybean substitution levels with the CBS50:SBS50 sample having the highest value while SBS100:SBS0 (control) had the least (16.84%). The significant ($p < 0.05$) variations between the "ogiri" samples could be attributed to soybean steeping which reflects a significant ($p < 0.05$) MC variation at low soybean substitution level of 5%. The MC values obtained were lower than 43.53 to 50.84% as reported by Ukaegbu (2016) and 27.00 to 31.00% by Ishiwu and Tope (2015). These discrepancies may be attributed to preparatory methods used, soybean steeping, and extent of fermentation. As the relatively high MC of the "ogiri" may likely soften the paste with enhanced freshness, quickens dissolution in soups, boosts taste and acceptability, blended samples may be better preferred to control. Blended samples may also be more shelf stable than control.

Crude protein

The crude protein content of the samples increased linearly with increase in soybean inclusion levels. Soybean substitution at 5%, 10% and 50% resulted in respective higher protein content increase of 21.74%, 22.41% and 31.68% than the control (17.33%). Significantly ($p < 0.05$) higher protein content of all the blended samples (21.74-31.68%) than control (17.35%) could be traced to higher protein content of soybean than castor oil bean. This is evident in the significant ($p < 0.05$) protein contribution by as low as 5% soybean substitution. Iwe (2003) reported that soybean contains a reasonable amount of protein which

ranks highest among all the food crops. Ishiwu and Tope (2015) also reported that crude protein content increases during the fermentation process. Therefore, increased protein content of the samples could be related to the fermentation process as a result of the activities of predominant proteolytic microorganisms that hydrolyse the protein to free amino acids (Enujiugha, 2009). High protein content of the product is noteworthy since it could contribute to dietary protein in addition to its flavouring roles. Protein helps to build and maintain healthy muscle mass, while also supporting tendon, ligaments and other body tissue. It also helps to prevent spikes in blood glucose which is especially important for preventing type 2 diabetes, balancing energy levels, while keeping appetite and mood in check (Voet *et al.*, 2008).

Crude fibre

There was a significant ($p < 0.05$) increase in the crude fibre content of the blended samples from 1.02 in sample CBS95: SBS5 to 1.71% in CBS50:SBS50, more than the control (0.47%). Similar to crude protein content, the crude fibre content increased with increase in soybean substitution; probably, soybean crude fibre content is higher than that of castor oil bean. Fibre has been reported to offer a variety of health benefits and is essential in reducing the risk of diseases such as diabetes, obesity, cardiovascular disease and diverticulitis. It lowers the concentration of low density lipoprotein cholesterol in the blood, possibly by binding with bile acids (Ishiwu and Tope, 2015). The results obtained in this study implied that the crude fibre content of "ogiri" can be increased with the addition of soybean (as from 5%) with the intent of improving the beneficial effect of fibre. The results were at variance with that obtained by Ukaegbu (2016) who reported fibre range of 2.59 to 7.50%.

Fat content

The fat contents of the blended samples increased linearly (15.37 to 20.23%) with increasing levels of soybean substitution (5, 19 and 50%) more than the control (13.76%). Increase in fat content could be due to the fact that soybean has higher oil content (Iwe, 2003) than castor oil bean. The improved fat content of the "ogiri" samples is of nutritional significance considering its high calorific value and source of fat soluble vitamins. Besides, the fat will prevent the "ogiri" from sticking to the wrapping leaves, boost the flavour and extend

the shelf life by reducing the rate of moisture loss. The blended samples could possibly serve as a source of essential fatty acids.

Ash content

The ash contents of the blended samples decreased (3.63 to 3.21%) significantly ($p > 0.05$) with increase in the quantity of soybean in the blends. This may mean that castor oil bean seed contained more minerals than soybean which inclusion at 5, 10 and 50% levels used in this study reduced the mineral contents significantly ($p < 0.05$) as reflected in the decreasing ash content. At higher substitution level of soybean (CBS50:SBS50), the ash content was 3.21% while at the lowest substitution of CBS95:SBS5 the ash content was highest (3.63%). Results obtained in this study are higher than 2.98 to 3.47% reported by Ishiwu and Tope (2015) probably due to blending, processing technique and the variety of castor oil bean used. Ash content represents total minerals content in foods and thus, serves as a viable tool for nutritional evaluation of minerals (Lienel, 2002).

Carbohydrate content

The carbohydrate content of the "ogiri" samples was found to decrease significantly ($p < 0.05$) from 48.13% in the control to 23.55% in CBS50:SBS50 with increasing level of soybean substitution. This may mean that there is lower carbohydrate content in soybean than castor oil bean seeds. Also sprouting may have contributed as well. These results are in agreement with those obtained by Sanful and Darko (2010) and Ishiwu and Tope (2015). They established that complementation with legumes such as soybean at different levels led to a decrease in carbohydrate content. *Mineral composition*

The results are as shown in Table 3.

Calcium content

There was a significant ($p < 0.05$) increase in the level of calcium from 62.31 mg/100g (5% substitution) to 80.21 mg/100g (50% substitution) among all the blended samples, more than the control (46.11 mg/100g), with increasing soybean substitution. This may signify that soybean contained higher calcium than castor oil bean since as low as 5% soybean substitution could increase the calcium content significantly ($p < 0.05$) from 46.11 to

63.13mg/100g. The calcium content recorded in this study was lower than that reported by Ukaegbu (2016) probably due to the variety of castor oil used and the processing technique adopted. Considering the calcium recommended daily intake (RDI) of 800-1200 mg/day for adults (WhereinCity, 2009), the entire "ogiri" samples were not good calcium sources. Calcium is important in the body as it helps in the building and maintenance of strong bones and teeth. It is vital for nerve transmission, muscle function, blood clotting and aids conversion of food into energy (Fallon and Enig, 2007; WhereinCity, 2009).

Sodium

For sodium content, a significant ($p < 0.05$) increase was recorded in the "ogiri" sample of 5% soybean substitution level (200.02 mg/100g), 10% (200.36 mg/100g) and 50% (362.42 mg/100g) compared to the control sample (147.22 mg/100g). Considering the adult RDI of 2400 mg/d (LENNTECH, 2018) for sodium, all the blended "ogiri" samples were good sodium sources, better than the control. Thus, increasing soybean substitution levels would possibly provide more sodium which has a variety of functions such as improving the functioning of the nervous system, muscular contraction and the nerves sending signals. Sodium also helps to maintain fluid balance in the body (Flack, 2018).

Magnesium

The magnesium content of the samples increased significantly ($p < 0.05$) with increasing soybean substitution levels from 67.32 (5% substitution) to 73.83mg/100g (50% substitution) higher than the control (60.25 mg/100g). Soybean magnesium content may have been responsible for the linear increase. All samples were good magnesium sources better than the control considering the RDI of 310 to 420 mg/day (Wyn, 2004). This increasing effect is beneficial since magnesium is a cofactor in more than 300 enzyme systems that regulate diverse biochemical reactions in the body, including protein synthesis, muscle and nerve function, blood glucose control, and blood pressure regulation (Aydin *et al.*, 2010). It is required for energy production, oxidative phosphorylation and glycolysis. Magnesium is also needed for healthy bones, blood vessels, and essential in nerve and muscle activities (Soetan *et al.*, 2010).

Table 2: Proximate composition of 'ogiri' produced from castor oil bean and soybean seeds blends (%).

Samples	Moisture	Crude Protein	Crude Fibre	Fat	Ash	Carbohydrate
CBS100: SBS0	16.84 ^d ±0.03	17.33 ^d ±0.01	0.47 ^d ±0.01	13.76 ^d ±0.01	3.48 ^c ±0.01	48.13 ^a ±0.00
CBS95: SBS5	17.62 ^c ±0.02	21.74 ^c ±0.01	1.02 ^c ±0.01	15.37 ^c ±0.01	3.63 ^a ±0.01	40.02 ^b ±0.01
CBS90: SBS10	18.23 ^b ±0.01	22.41 ^b ±0.01	1.21 ^b ±0.01	16.01 ^b ±0.01	3.52 ^b ±0.01	39.26 ^c ±0.01
CBS50: SBS50	19.62 ^a ±0.03	31.68 ^a ±0.01	1.71 ^a ±0.01	20.23 ^a ±0.01	3.21 ^d ±0.01	23.55 ^d ±0.00

Values are means of triplicate determinations ± standard deviation. Mean values in the same column with different superscript (a-d) are significantly different ($p < 0.05$) while those with the same superscript within the same column are not significantly different ($P > 0.05$). CBS100 is control sample with 100% castor oil bean seeds, CBS95-SBS5 is sample with 95% castor oil bean seeds and 5% soybeans seed blend, CBS90-SBS10 is sample with 90% castor oil bean seeds and 10% soybeans seed blend and CBS50-SBS50 is sample with 50% castor oil bean seeds and 50% soybean seeds blend.

Phosphorous

The phosphorous values obtained from the blended samples in this study increased (84.31 to 99.42 mg/100g) significantly ($p < 0.05$) more than the control (80.33 mg/100g) with increase in soybean substitution levels. Soybean may have been the major source and may have contained more phosphorous than castor oil bean. Considering the adult phosphorous RDI of 700 mg/d (Healthline, 2018), substituted samples were better sources than the control. Phosphorus works in synergy with calcium to build strong bones and teeth. These two minerals combine to form calcium-phosphate, the predominant mineral in the bones (Ebeledike *et al.*, 2010).

Potassium

Potassium is the most abundant mineral present in the entire "ogiri" samples (118.10 to 794.38 mg/100g) with CBS50: SBS50 having the lowest value, lower than that of the control sample (641.02 mg/100g), while CBS95: SBS5 had the highest value (794.38 mg/100g). The results obtained in this study showed higher potassium content at low levels of soybean substitution not exceeding 10%. Potassium RDI of 3500 mg/d (LENNTECH, 2018) implied that all the samples were poor sources. Potassium is a very important mineral for proper functioning of cells, tissues, and organs in the body. Potassium is also an electrolyte, a substance that conducts electricity in the body, along with sodium, calcium and magnesium (Flack, 2018). It plays a key role in skeletal and smooth muscle contraction, therefore important for normal digestive and muscular function (OrganicFact, 2018).

Iron

Though second to the least abundant minerals, iron content increased with significant ($p < 0.05$) variations from 1.63 to 6.32 mg/100g as soybean substitution levels increased. The increase could stem majorly from soybean which may have higher iron content than castor oil bean. This is substantiated by the least iron value of the control (1.63 mg/100g) and highest

(6.32 mg/100g) in sample CBS50:SBS50. With iron RDI of 10 to 18mg/d (ODS, 2007), the entire samples were good sources. Soybean substitution in 'ogiri' production is therefore an iron improvement which helps the red blood cells to transport oxygen to all parts of the body. Iron also plays an important role in specific processes within the cell that produce energy for our body (Fallon and Enig, 2007).

Zinc

The zinc content of the entire samples (which ranged from 0.49 to 1.48 mg/100g) was the least mineral content of "ogiri". Increasing the level of soybean substitution from 5% to 50% increased the zinc (0.61 to 1.48 mg/100g) contents. With zinc RDI of 15 mg/d (LENNTECH, 2018), the entire samples were poor sources except 50:50% substituted sample which is a good source. Zinc is needed for the body's defensive (immune) system to work properly. It plays a role in cell division, cell growth, wound healing and breakdown of carbohydrates (Singh *et al.*, 2011).

Vitamins composition

The results are presented in Table 4.

Retinol

Retinol, a precursor of vitamin A, is the most abundant vitamin (11.63 to 16.26 mg/100g) in the "ogiri" may be because castor oil bean and soybean seeds are oil seeds and retinol is fat-soluble. Retinol content of the blended samples increased with significant ($p < 0.05$) variations from 13.01 (CBS95: SBS5) to 16.26 mg/100g (CBS50:SBS50) with increasing level of soybean substitution. Soybean probably contains a more reasonable amount of vitamin A (Omafuvbe *et al.*, 2003) than castor oil bean. The substituted samples are better sources of retinol than the control considering 700 µg/d retinol RDI (Olson, 1987). Retinol, a powerful antioxidant, plays a critical role in maintaining healthy vision, neurological function, healthy skin and supports immune function. It is involved in reducing inflammation through fighting free radical damage (Onyeka, 2008).

Table 3: Mineral composition of 'ogiri' produced from castor oil bean seed and soybean seeds (mg/100 g).

Sample	Calcium	Sodium	Magnesium	Phosphorus	Potassium	Iron	Zinc
CBS100: SBS0	46.11 ^d ±0.01	147.22 ^d ±0.01	60.25 ^d ±0.01	80.33 ^d ±0.01	641.02 ^c ±0.01	1.63 ^d ±0.01	0.49 ^d ±0.01
CBS95: SBS5	62.31 ^c ±0.01	200.02 ^c ±0.01	67.32 ^c ±0.01	84.31 ^c ±0.01	794.38 ^a ±0.33	1.90 ^c ±0.00	0.61 ^c ±0.01
CBS90: SBS10	63.13 ^b ±0.01	200.36 ^c ±0.01	68.23 ^b ±0.01	86.83 ^b ±0.02	782.12 ^b ±0.01	1.94 ^b ±0.01	0.65 ^b ±0.01
CBS50: SBS50	80.21 ^a ±0.01	362.42 ^a ±0.01	73.83 ^a ±0.02	99.42 ^a ±0.01	118.10 ^d ±0.03	6.32 ^a ±0.01	1.48 ^a ±0.01

Values are means of triplicate determinations ± standard deviation. Mean values in the same column with different superscript (a-d) are significantly different ($p < 0.05$) while those with the same superscript within the same column are not significantly different ($P > 0.05$). CBS100 is control sample with 100% castor oil bean seeds, CBS95-SBS5 is sample with 95% castor oil bean seeds and 5% soybeans seed blend, CBS90-SBS10 is sample with 90% castor oil bean seeds and 10% soybeans seed blend and CBS50-SBS50 is sample with 50% castor oil bean seeds and 50% soybean seeds blend.

Vitamin B-complex

Vitamin B₁ complex increased from 0.17 to 0.21 mg/100g, B₂ from 10.37 to 14.79 mg/100g and B₃ from 9.21 to 9.91 mg/100g. The increase was significant ($p < 0.05$) in all the substituted samples with increase in soybean substitution levels with the sample CDS50:SBS50 having the highest values. Only B₁ at 5% and 10% substitution levels had lower value than the control sample (0.17mg/100g) but higher (0.21mg/100g) at 50% substitution level. Higher levels of B-complex vitamins in CBS50:SBS50 could be attributed to the increase in soybean inclusion which is a good source of B-complex vitamin (Iwe, 2003). However, the soybean substitution levels 5%, 10% and 50% used improved that the samples are good vitamins sources considering the respective RDIs of 1.4, 1.6 and 18 mg/d (LENNTECH, 2018) for B¹, B² and B³, respectively. Vitamin B₁ 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 serves as an anti-stress (ProHealth, 2018).

Vitamin C

The vitamin C content of the blended samples increased significantly ($p < 0.05$) from 3.62 (CBS95: SBS5) to 5.85 mg/100g (CBS50:SBS50) more than the control (3.41 mg/100g) with increasing soybean substitution levels. Notably, the inclusion of soybean which had been reported to contain 2.92 mg/100g vitamin C (Enujiugha, 2009) may have been the major source. Also, soybean vitamin C may be higher than that of castor oil bean. Vitamin C contents of the substituted samples are good sources more than the control considering the RDI of 45 mg/d (MedicineNet, 2011). Vitamin C helps to purify the blood as an antioxidant (Cohen *et al.*, 2000), maintains healthy immune systems, fights infections and is required for the synthesis of collagens. It also maintains healthy muscle, vascular tissue, tendons,

ligaments, teeth, bones, gum, cartilage, joints, lining, skin and blood vessels (MedicineNet, 2011).

Vitamin E

The Vitamin E content of the blended samples increased significantly ($p < 0.05$) from 7.52 mg/100g to 11.25 mg/100ml which is lower than the content observed in the control (6.43 mg/100g) with increasing soybean levels of the substitution. Due to the improvement, the substituted samples are better sources of vitamin E than the control when compared to the RDI of 20 mg/d (NIH, 2018). Vitamin E is a strong antioxidant that potentially prevents damages caused by free radicals that can modify cell components like proteins, DNA and lipids. Vitamin E had been reported to prevent oxidation of low-density lipoprotein cholesterol in vascular cells (Skyrme *et al.*, 2000). Thus, vitamin E may play the role of preventing atherosclerotic cardiovascular diseases and cancer. It is also critical in maintaining cellular functionality in general, inhibits cell proliferation and enhances immune function (Meydani *et al.*, 2005).

Calorific value of the "ogiri" samples

The calorific values of the blended "ogiri" samples as presented in Table 5 increased significantly ($p < 0.05$) with increase in soybean inclusion levels thereby implicating soybean as a better energy source than castor oil bean. The CBS50: SBS50 sample had the highest energy value (378.98Kcal) while CBS95:SBS5 had the least (237.32Kcal) which is lower than the control (373.32Kcal). Dietary energy is a non-nutritive component of foods responsible for metabolic processes, physiological functions, muscular activity, heat production, growth, transport of substances round the body, synthesis of enzymes and hormones in the body (NHMRC, 2016).

Table 4: Vitamin content of "ogiri" produced from Castor oil bean seed and Soybean seed blends (mg/100 g).

Samples	Retinol	Vitamin B ₁	Vitamin B ₂	Vitamin B ₃	Vitamin C	Vitamin E
CBS100:SBS0	11.63 ^d ±0.01	0.17 ^b ±0.01	10.37 ^d ±0.01	9.21 ^d ±0.01	2.43 ^d ±0.01	6.43 ^d ±0.02
CBS95: SBS5	13.01 ^c ±0.01	0.10 ^d ±0.00	11.63 ^c ±0.01	9.28 ^c ±0.01	3.62 ^c ±0.01	7.52 ^c ±0.01
CBS90: SBS10	13.09 ^b ±0.01	0.14 ^c ±0.01	11.81 ^b ±0.01	9.49 ^b ±0.01	3.79 ^b ±0.01	8.06 ^b ±0.01
CBS50: SBS50	16.26 ^a ±0.01	0.21 ^a ±0.00	14.79 ^a ±0.01	9.91 ^a ±0.01	5.85 ^a ±0.01	11.25 ^a ±0.01

Values are means of triplicate determinations ± standard deviation. Mean values in the same column with different superscript (a-d) are significantly different ($p < 0.05$) while those with the same superscript within the same column are not significantly different ($P > 0.05$). ±

Table 5: Calculated dietary energy values of "ogiri" samples by Atwater factor

Sample	Protein (%)	Fiber (%)	Fat (%)	Carbohydrate (%)	Energy values Kj/g	Energy values Kcal/g
CBS100:SBS0	17.33	0.47	13.76	48.13	1569.48 ^c ±0.11	373.32 ^c ±0.03
CBS95:SBS5	21.74	1.02	15.37	40.02	1559.73 ^d ±0.04	237.32 ^d ±0.03
CBS90:SBS10	22.41	1.21	16.01	39.06	1582.17 ^b ±0.10	376.99 ^b ± 0.13
CBS50:SBS50	31.68	1.71	20.23	23.55	1623.55 ^a ±0,07	387.98 ^a ±0.11

Values are means of triplicate determinations ± standard deviation. Energy values in same column with same superscript have no significant difference ($P < 0.05$) while those with different superscript have significant ($P \geq 0.05$). CBS100:SBS0 is 100% castor oil bean seed "ogiri", CBS95:SBS5 is "ogiri" made from 95% castor oil bean seed and 5% soybean seed blends, CBS90:SBS10 is "ogiri" made from 90% castor oil bean seed and 10% soybean seed blend and CBS50:SBS50 is "ogiri" made from 50% castor oil bean seed and 50% soybean seed blend.

Sensory characteristics

The results for sensory characteristics of the condiments are presented in Table 6.

The appearance scores of the blended "ogiri" samples increased significantly ($p < 0.05$) from 4.70 to 7.15 with increase in soybean substitution levels. Samples CBS95: SBS5 (4.70) and CBS90: SBS10 (4.25) with respective soybean substitution levels of 5 and 10% had lower scores each than the control sample (6.20), which suggested that the improvement in the appearance of the blended samples was from the 10% soybean inclusion. However, the appearance of the "ogiri" sample with 50% soybean (7.15) was the most preferred by the panellists.

The aroma scores of the blended samples increased (4.60-6.65) significantly ($p < 0.05$) with increasing soybean substitution level, with the sample CBS50:SBS50 having the highest value (6.65). This increase could be attributed to the significant ($p < 0.05$) protein content (Table 2) of the sample, which is the major aroma source in "ogiri". Protein is the major substrate responsible for the release of aromatic substances peculiar to "ogiri" by the fermenting organisms (Ouoba *et al.*, 2005). Similar to the appearance scores, the scores for 5% (4.60) and 10% (4.15) soybean substitution were lower than the control sample (5.60).

The texture scores of the blended samples increased (5.30-6.40) with significant ($p < 0.05$) variations as soybean substitution levels increased. Only the texture score of the sample CBS50:SBS50 (6.40) was higher than the control (5.85) which implies that texture improvement of the "ogiri" samples will increase as from 50% soybean substitution level.

General acceptability test revealed that the 50% soybean substitution level was preferred (6.85) better than the 100% castor oil bean. This could be traced to the increased protein content as explained before as "ogiri" is rated for its flavour. Also, increasing fat content (Table 2) is another contributing factor since it is a flavour enhancer. Furthermore, the sample CBS50: SBS50 had the highest scores in all the organoleptic properties evaluated.

Conclusion

This study revealed that with increase in soybean substitution levels, the proximate composition of the "ogiri" samples increased proportionately, except for ash and carbohydrate contents which showed decreasing values. There were increasing mineral content at soybean substitution levels not exceeding 10%, with potassium being the most abundant. Also, the entire samples were good sources of sodium, magnesium, phosphorus and iron, but were poor sources of calcium, potassium and zinc. Furthermore, all the vitamin contents of the substituted "ogiri" samples improved to become good sources with retinol being the most abundant. Energy values also improved. The "ogiri" sample with 50% soybean inclusion had the best organoleptic properties of all the samples, substantiating all the maximum nutrient contents obtained in this study at 50% soybean inclusion. This study has therefore demonstrated the production potential, nutrition, acceptability and health benefits of soybean inclusion in "ogiri" production.

Table 6: Sensory properties of the 'ogiri' produced from castor oil bean and soybean seeds blends.

Samples	Appearance	Aroma	Texture	General acceptability
CBS100:SBS0	6.20 ^b ±1.85	5.60 ^b ±1.85	5.85 ^b ±2.08	6.00 ^b ±2.00
CBS95: SBS5	4.70 ^c ±1.75	4.60 ^c ±1.69	5.30 ^c ±1.63	5.15 ^c ±1.81
CBS90: SBS10	4.25 ^d ±2.02	4.15 ^d ±1.66	4.65 ^d ±1.79	4.35 ^d ±1.93
CBS50: SBS50	7.15 ^a ±1.87	6.65 ^a ±2.23	6.40 ^a ±1.43	6.85 ^a ±1.31

Values are means of triplicate determinations ± standard deviation. Mean values in the same column with different superscript (a-d) are significantly different ($p < 0.05$) while those with the same superscript within the same column are not significantly different ($P > 0.05$). CBS100 is control sample with 100% castor oil bean seeds, CBS95-SBS5 is sample with 95% castor oil bean seeds and 5% soybeans seed blend, CBS90-SBS10 is sample with 90% castor oil bean seeds and 10% soybeans seed blend and CBS50-SBS50 is sample with 50% castor oil bean seeds and 50% soybean seeds blend.

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