Adeyeye et al., *Cogent Food & Agriculture* (2017), 3 1278827
http://dx.doi.org/10.1080/23311932.2017.1278827

cogent food & agriculture

FOOD SCIENCE & TECHNOLOGY | RESEARCH ARTICLE

Quality and sensory properties of maize flour cookies enriched with soy protein isolate

S.A.O. Adeyeye[1*], A.O. Adebayo-Oyetoro[2] and S.A. Omoniyi[3]

Received: 18 October 2016
Accepted: 27 December 2016
First Published: 06 January 2017

*Corresponding author: S.A.O. Adeyeye, Department of Food Science and Technology, Mountain Top University, Prayer City, Ibafo, Ogun State, Nigeria
E-mail: saadeyeye@yahoo.com

Reviewing editor:
Fatih Yildiz, Middle East Technical University, Turkey

Additional information is available at the end of the article

Abstract: This study was carried out to assess the quality and sensory properties of maize flour cookies enriched with soy protein isolate with the aim of encouraging the use of soy beans in producing value-added products. Soy protein isolate was produced from soy beans and then incorporated at 5, 10, 15, 20, 25 and 30% levels in maize flour. The results revealed that substitution of maize flour with soy protein isolate significantly ($p \leq 0.05$) increased the protein from 8.69 ± 0.19 to 29.11 ± 0.34 while the moisture, crude fibre, fat and sugar contents of the cookies from the composite flour decreased as the percentage of soy protein isolate in the blends increased from 8.76 ± 0.22 to 6.96 ± 0.13, 3.81 ± 0.07 to 2.87 ± 0.02, 2.63 ± 0.06 to 1.69 ± 0.01, 9.41 ± 0.24 to 8.45 ± 0.13 and 6.21 ± 0.20 to 4.98 ± 0.11 respectively. The calorific value of the cookies decreased from 468 ± 1.59 to 383 ± 1.01 cal/100 g as the percentage of soy protein isolate increased in the cookies. Sensory evaluation results showed that the colour, texture, taste and overall acceptability changed significantly ($p \leq 0.05$) with increase in soy protein isolate in the composite flour. The optimum substitution level with soy protein isolate was 20%. Above this, the product consumer acceptability decreases.

Subjects: Environment & Agriculture; Bioscience; Food Science & Technology

Keywords: maize flour; cookies; soy protein isolates; quality; sensory properties

1. Introduction

Malnutrition is estimated to contribute to more than one third of all child deaths, although it is rarely listed as the direct cause (World Food Programme [WFP], 2000). Malnutrition as a state in which the physical function of an individual is impaired to the point where he or she can no longer maintain adequate bodily performance process such as growth, pregnancy, lactation, physical work and resisting and recovering from disease (WFP, 2000). Contributing to more than half of deaths in children worldwide; child malnutrition was associated with 54% of deaths in children in developing countries in 2001 (Monika & Mercedes, 2005; World Health Organization, 2013). Protein-energy malnutrition

ABOUT THE AUTHOR

S.A.O. Adeyeye is a researcher in the Department of Food Science and Technology, Federal University of Agriculture, Abeokuta, Nigeria. He completed his MSc degree in Food Technology from University of Ibadan, Nigeria in 1997 and PhD degree in Food Processing and Storage Technology from Department of Food Science and Technology in 2016. He has carried out extensive research work on Food Processing, Food Quality Control, Food Microbiology, Food Safety and their related aspects.

PUBLIC INTEREST STATEMENT

This study revealed that maize flour cookies enriched with soy protein isolate could be produced from maize and soy beans. This would help in encouraging the use of soy beans in producing value-added products.

cogent • food & agriculture

(PEM), first described in the 1920s, is observed most frequently in developing countries but has been described with increasing frequency in hospitalized and chronically ill children in the United States (Hendricks, Duggan, & Gallagher, 1995).

Cookies are small, flat, sweet, baked goods, usually containing flour, eggs, sugar, and either butter, cooking oil or another oil or fat (Abayomi, Oresanya, Opeifa, & Rasheed, 2013; Adeyeye & Akingbala, 2015). It may include other ingredients such as raisins, oats, chocolate chips or nuts. In most English-speaking countries except for the US and Canada, crisp cookies are called biscuits (Abayomi et al., 2013; Adeyeye & Akingbala, 2015). Cookies are made from unleavened dough (Adeleke & Odedeji, 2010; Adeyeye & Akingbala, 2015; Fayemi, 1981).

The consumption of cereal snacks foods, such as biscuits, cookies, wafers and short bread, has become very popular in Nigeria, especially among children (Abayomi et al., 2013). They are ready-to-eat, convenient and inexpensive food products, containing digestiveand dietary principle of vital importance. In Nigeria, the consumption of ready-to-eat baked products is continually growing, and there has been an increase in reliance on imported wheat (Abayomi et al., 2013; Adeyeye & Akingbala, 2015; Akpapunam & Darbe, 1999).

Moreover, Nigeria grows staple crops other than wheat such as sweet potato, cassava or yam and cereals that can be used for baked foods. It would therefore be of economic advantage if wheat flour can be replaced with flour from tubers, legumes and cereals, hence reducing the reliance on its importation and thus enhance the industrial utilization of local crops (Abayomi et al., 2013; Adeyeye & Akingbala, 2015; Onabanjo & Ighere, 2014).

Maize (*Zea mays*) has the highest world-wide production of all grain crops, yielding 875 million tonnes in 2012 (http://faostat.fao.org/). Maize is a major source of starch. Maize flour is a major ingredient in home cooking and in many industrialized food products. Maize is also a major source of cooking oil (corn oil) and of maize gluten (Food and Agriculture Organization of the United Nations, Statistics Division [FAO Statistics Division], 2009; Thompson, Manore, & Vaughan, 2010). Maize starch can be hydrolyzed and enzymatically treated to produce syrups, particularly high fructose corn syrup, and a sweetener; and also fermented and distilled to produce grain alcohol. Grain alcohol from maize is traditionally the source of Bourbon whiskey.

Maize meal is made into a thick porridge in many cultures: from the polenta of Italy, the *angu* of Brazil, the *mămăligă* of Romania, to cornmeal mush in the US (and *hominy grits* in the South) or the food called *mealie pap* in South Africa and *sadza*, *nshima* and *ugali or ogi* in other parts of Africa. Maize meal is also used as a replacement for wheat flour, to make cornbread and other baked products. Masa (cornmeal treated with limewater) is the main ingredient for tortillas, atole and many other dishes of Central American food (FAO Statistics Division, 2009; Vallabhaneni & Wurtzel, 2009; Winkel-Shirley, 2001).

Soybean (*Glycine max*) is a leguminous vegetable of the pea family that grows in tropical, subtropical, and temperate climates. Soybean was domesticated in the 11th century BC around northeast of China (Food and Agriculture Organization of the United Nations [FAO], 2005; Gibson & Benson, 2005). It is believed that it might have been introduced to Africa in the 19th century by Chinese traders along the east coast of Africa. It consists of more than 36% protein, 30% carbohydrates, and excellent amounts of dietary fiber, vitamins, and minerals. It also consists of 20% oil, which makes it the most important crop for producing edible oil (Edema, Sanni, & Sanni, 2005; FAO, 2005; Gibson & Benson, 2005).

Malnutrition, particularly protein deficiency, is prevalent in many parts of Africa as animal protein is too expensive for most people in Africa. Many leguminous crops provide some protein, but soybean is the only available crop that provides an inexpensive and high quality source of protein comparable to meat, poultry and eggs (Edema et al., 2005; FAO, 2005).

More than 216 million tons of soybeans were produced worldwide in 2007, of which 1.5 million were in Africa. Africa imports nearly as much soybean as it produces. Africa exports about 20,000 tons annually. Nigeria is the largest producer of soybean in sub-Saharan Africa (SSA), followed by South Africa.

The key benefits of soya are its high protein content, vitamins, minerals and insoluble fibre. The high fibre content makes soya beans and other soya containing foods valuable in cases of constipation, high cholesterol and type-2 diabetes (Edema et al., 2005; FAO, 2005; Gibson & Benson, 2005).

Protein energy malnutrition (PEM) is one of the major nutritional dilemmas in developing countries (Edema et al., 2005; FAO, Statistics Division, 2009; Kadam, Salve, Mehrajfatema, & More, 2012). As cereals are the staple diet of these nations and they mostly rely on plant-based food sources, so the utilization of pulses to supplement maize flour can be an effectual approach to combat PEM. Soy bean is rich in protein with well-balanced amino acid profile, so in search for nutritious food products, it provides an opportunity to be used in baked products such as cookies, bread, pasta, soups and snack foods (Edema et al., 2005; Kadam et al., 2012).

The aim of this study, therefore, was to assess quality and sensory properties of maize flour cookies enriched with soy protein isolate with the aim of encouraging the use of these under- utilized food crops in producing value-added products with nutraceutical potential.

2. Materials and methods

2.1. Procurement of raw materials
Yellow maize and yellow soy beans varieties were procured from Bodija market in Ibadan, Oyo State, Nigeria. All chemicals and reagents used were of food and analytical grade.

2.2. Sample preparation

2.2.1. Preparation of maize flour
The maize flour was prepared by the method reported by Houssou and Ayemor (2002). Maize grains were sorted, conditioned by spray 35 cl of water into the grains and allowed to stay for 15 min. This is done for easy de-hulling and de-germing. The de-germed and de-hulled maize was milled in a disc attrition mill and allowed to pass through 250 μm opening. The flour was packaged in cellophane bag until used.

2.2.2. Preparation of defatted soy flour
Defatted soy flour was produced as described by Meyer (1971) with modification. One kilogram of cleaned and sorted soybean was cracked in a rice sheller into 4 or 5 cracks. The cracked beans were then winnowed to remove the hulls. One part of the dehulled soybeans was then milled with a moulinex blender and the other part with a hammer mill (Christy and Norris Ltd., England) with speed of 8,000 rpm. The flour was then defatted in a soxhlet extractor for 6 h using n hexane with boiling point of 50–55°C. The defatted flour was desolventised by leaving to dry at room temperature for about 24 h. The flour from the moulinex blender was autoclaved at 6.9 kpa pressure at 121°C for 20 min.

2.2.3. Processing of soy protein isolate
Soy protein isolate was processed by using the method of How and Morr (1982) with modification. Twenty grams of the autoclaved, moulinex blended defatted soy flour was extracted in 200 ml water at pH 8.9. The pH of the distilled water was adjusted using 1 N NaOH. The slurry was stirred continuously for 30 min. The mixture was then centrifuged using Eppendorf 30,000 ×g system comprising of Safe-Lock Tubes and Centrifuge 5430 R with high-speed rotor for 30 min.

The extract was decanted and the residue re-extracted with 100 ml of distilled water for 30 min. The extract was mixed with the first extract while the residue was discarded. The pH of the combined extracts was then adjusted to pH 4.5, the isoelectric point of the major soybean globulins. The extract was centrifuged using Eppendorf 30,000 ×g system comprising of Safe-Lock Tubes and Centrifuge 5430 R with high-speed rotor for 30 min. The supernatant wasdiscarded while the residue, that is, the precipitate was given two 50 ml washes with distilled water and re-centrifuged. The precipitate (ASPI) was then neutralized to pH 7 using 1 N NaOH and then spread thinly in a crucible and dried in an air-draught oven at 40°C for 12 h.

2.2.4. Composite flour
Soy protein isolate was incorporated at different levels into maize flour for the development of composite flour as shown in Table 1.

2.2.5. Preparation of cookies
Cookies were prepared by the method reported by Mohamed (2000) and Abayomi et al. (2013) with modification. Two hundred grams of flour from each sample of different flour blends was used for the experiment. Eighty grams of sugar was creamed with one hundred grams of margarine until light and fluffy constituency was obtained using Kenwood chef with initial minimum speed, and the speed increased stepwise until the mark of 6 on the chef indicator was attained. Whole egg (60 g) was added, followed by flour (200 g), powdered milk (20 g), baking powder (0.1 g) and salt (1 g) were added and mixed until a stiff paste (batter) was obtained. The batter was rolled on a floured board using rolling pin to a thickness of 0.2–0.3 cm. The rolled batter was cut into circular shapes with a cutter and arranged on a greased tray and baked at 150°C for 20 min. The cookies were brought out, cooked and packaged in cellophane bag until used for laboratory analysis.

2.3. Chemical analysis of samples

2.3.1. Moisture content of the flour and cookies samples
Moisture content of maize grains, maize flour, their blends and cookies samples were determined by oven method described in by Association of Official Analytical Chemists (AOAC, 1990) method.

2.3.2. Protein content of the flour and cookies samples
Crude protein was determined by the Kjeldahl nitrogen method (AOAC, 1990) where:

$$\% \text{ Crude protein} = \% \text{ Total nitrogen} \times 6.25$$

2.3.3. Fat content of the flour and cookies samples
Fat content was determined by the Soxhlet extraction method described by AOAC (1990) and Adeyeye and Akingbala (2015). About 2 g of each sample was extracted with 240 ml of petroleum ether in a Soxhlet extraction apparatus for 8 h. The ether was distilled off and the flask dried:

$$\% \text{ Fat} = \frac{W3 - W2 \times 100}{W1}$$

where, $W3$ is the weight of the flash with the extracted oil; $W2$ is the weight of the empty flash; and $W1$ is the weight of the sample.

2.3.4. Ash content of the flour and cookies samples
Ash was determined by AOAC (1990) method. About 2 g of each sample was ignited at 600°C in a muffle furnace for 6 h. The residue was cooled in a desiccator and weighed.

$$\% \text{ Ash (dry basis)} = \frac{M_{\text{ASH}}}{M_{\text{DRY}}} \times 100$$

Table 1. The proximate compositions of maize flour, soy protein isolate and composite flour at different soy protein isolate substitution

	Moisture (%)	Ash (%)	Crude fibre (%)	Fat (%)	Crude protein (%)	Starch (%)	Carbohydrate (%)	Sugar (%)
SPI	5.68 ± 0.11^{a}	2.92 ± 0.08^{h}	0.46 ± 0.01^{a}	1.63 ± 0.08^{h}	89.31 ± 0.46^{h}	ND	ND	ND
MF (100%)	10.09 ± 0.17^{b}	1.36 ± 0.07^{g}	1.33 ± 0.08^{h}	1.58 ± 0.07^{g}	8.06 ± 0.10^{a}	ND	72.31 ± 0.23^{g}	2.46 ± 0.14^{g}
95:5 MF/SPI	13.89 ± 0.29^{h}	1.22 ± 0.06^{f}	1.05 ± 0.07^{g}	1.29 ± 0.06^{f}	10.73 ± 0.13^{b}	ND	67.69 ± 0.20^{f}	2.13 ± 0.12^{f}
90:10 MF/SPI	13.61 ± 0.27^{g}	1.09 ± 0.05^{e}	0.98 ± 0.06^{f}	1.03 ± 0.05^{e}	13.46 ± 0.17^{c}	ND	65.92 ± 0.19^{e}	1.91 ± 0.10^{e}
85:15 MF/SPI	12.85 ± 0.25^{f}	0.96 ± 0.04^{d}	0.89 ± 0.05^{e}	0.82 ± 0.04^{d}	17.92 ± 0.19^{d}	ND	62.83 ± 0.17^{d}	1.73 ± 0.08^{d}
80:20 MF/SPI	12.69 ± 0.22^{e}	0.81 ± 0.03^{c}	0.76 ± 0.04^{d}	0.79 ± 0.03^{c}	22.17 ± 0.22^{e}	ND	59.26 ± 0.15^{c}	1.52 ± 0.06^{c}
75:25 MF/SPI	12.34 ± 0.20^{d}	0.76 ± 0.03^{b}	0.68 ± 0.03^{c}	0.63 ± 0.02^{b}	26.83 ± 0.24^{f}	ND	55.47 ± 0.13^{b}	1.29 ± 0.05^{b}
70:30 MF/SPI	11.89 ± 0.18^{c}	0.69 ± 0.02^{a}	0.54 ± 0.02^{b}	0.59 ± 0.01^{a}	31.36 ± 0.28^{g}	ND	51.96 ± 0.12^{a}	0.97 ± 0.03^{a}

Key: MF = maize flour; SPI = soy protein isolate.

Notes: ND = Not determined; all data are means of three replicates expressed on dry weight basis; means with the same superscripts are not significantly difference at $p \leq 0.05$; 95:5 = maize flour: soy protein isolate ratio.

2.3.5. Crude fibre content of the flour and cookies samples
Crude fibre was determined by AOAC (1990) method. About 1 g of each sample was weighed into 600 ml of Erlenmeyer flask; 100 ml of trichloroacetic acid digestion reagent was added. The solution was brought to boil and reflux for exactly 40 min at 50–60°C counting from the time boiling started. The flask was removed from the heater, cooled a little bit and was filtered through a 15.0 cm, Whatman filter paper of 1.0 g, the residue was washed six times with hot water and once with methylated spirit. Residue was removed by spatula from the opened-out filter paper, and the fibre was transferred into a porcelain dish and was dried overnight at 500°C. The sample was transferred to a desiccator and weighed when cool; it was ashed in a muffle furnace at 600°C for 6 h. This was cooled again and reweighed:

$$\%\ \text{Crude fibre} = \frac{\text{Weight after drying} - \text{Weight after Washing}}{\text{Sample weight}} \times 100$$

2.4. Physico-chemical analysis of samples

2.4.1. Bulk density of the flour samples
The bulk density of the flour samples was determined by method of Beuchat (1977) and Olapade and Ogunade (2014).

2.4.2. Water binding capacity of flour samples
Water binding capacity was determined by method described by Beuchat (1977) and Olapade and Ogunade (2014).

2.4.3. Dispersability of flour samples
The method described by Padmashree, Vijayalakshmi, and Puttaraj (1987) was used.

2.4.4. Swelling power for samples
The swelling power of starches of the maize flour and their blends was determined by the method described by Beuchat (1977).

2.4.5. Sieve analysis of the sample
Particle size distribution of the flour samples was determined by the method reported by Okaka and Isieh (1990).

2.4.6. Cookie flow and break strength
Cookie flow was determined by method described by Okaka and Isieh (1990).

2.4.7. Starch content determination
Starch was described by the method by Hassid and Newfield (1964). Each of the flour sample was refluxed with boiling ethanol at 80°C for 6 h in a Soxhlet extractor. The ethanol insoluble residue was refluxed with 10% HCl for 4 h in a Soxhlet extractor. The resulting hydrolysates were neutralized with NaOH and quantitatively estimated by the anthrone–sulphuric acid method (Carroll, Longley, & Roe, 1956). The value of glucose was multiplied by 0.9 to obtain the starch value (Hassid & Newfield, 1964).

2.4.8. Sugar content determination
This was determined by a refractometry method with the ABBE 60 Refractometer (Bellingham-Stanley Limited, Kent, England) (Van Hal, 2000).

2.4.9. Calorific value determination
Calorific values of the cookie samples were determined by using Gallenkamp Ballistic Bomb Calorimeter (Coded CBB 330). One gram of each sample of the cookies was ignited and burnt in excess oxygen in the bomb. The maximum temperature rise of the bomb was measured with the thermocouple and galvanometer system (Van Hal, 2000). By noting the change in the temperature of the water, one can calculate the energy value of the food by applying the definition for a calorie.

The unit of energy in the International System of Units (SI) is the joule (J). The conversion factors for joules and calories are: 1 kJ = 0.239 kcal; and 1 kcal = 4.184 kJ.

2.5. Sensory evaluation
Cookies prepared from maize flour and maize flour with various level of soy protein isolate substitution were compared to cookies from 100% maize flour sample (R) as control. Two different groups of (10 members; 5 men and 5 women) consumer type untrained sensory panellists were selected from undergraduate students of University of Agriculture, Abeokuta, who eat cookies regularly. Each panellist was provided with separate sensory booth. Water was provided to rinse the palate between two tasting sessions. Also, quality attributes, colour, texture, taste, appearance, crispiness and overall acceptability were evaluated on a nine-point Hedonic scale where 9 = Like extremely and 1 = Dislike extremely.

2.6. Statistical analysis
The data were collected in triplicates and means were compared statistically with IBM SPSS (Version 21.0) using Duncan's Multiple Range Test. One-way ANOVA was done on colour, texture, taste, appearance, crispiness and overall acceptability using Duncan's Multiple Range Test ($p \leq 0.05$) to study the difference between means.

3. Results and discussion

3.1. The proximate composition of maize grain and soy beans isolate
The proximate composition of the maize grains and soy protein isolate used for the production of cookies agreed with the previous works of David and Dickerson (1991), Adedeji, Oyinloye, and Ocheme (2014) and Adeyeye and Akingbala (2015). The values of 5.68 ± 0.11, 2.92 ± 0.08, 0.46 ± 0.01, 1.63 ± 0.08 and 89.31 ± 0.46 respectively for moisture, crude fibre, ash, fat and crude protein contents of soy protein isolate were also consistent with the range of those components reported in the literature (Mizrani, Zimmermann, Beak, & Cogan, 1967; Urbanski, Wei, Nelson, & Steinberg, 1982). The carbohydrate contents of the maize grains and soy protein isolate were obtained by difference. The carbohydrate and soy protein isolate values of 72.31 ± 0.23 and 51.96 ± 0.12 for 10% maize flour and 70% maize flour respectively agreed with the values of 70.1–83.9% reported by Adedeji et al. (2014); Abayomi et al. (2013); and Onabanjo and Ighere (2014) for maize flour and soy protein isolate respectively.

3.2. The proximate chemical composition of maize flour, soy protein isolate and their blends
The proximate composition of maize flour, soy protein isolate and their blends are presented in Table 1. The moisture, crude fibre, ash, fat and crude protein contents of the maize flour were 10.09 ± 0.17, 1.36 ± 0.07, 1.33 ± 0.08, 1.58 ± 0.07 and 8.06 ± 0.10 respectively while that of the soy protein isolate were 5.68 ± 0.11, 2.92 ± 0.08, 0.46 ± 0.01, 1.63 ± 0.08 and 89.31 ± 0.46 respectively. These values agreed with 9.6–13.5, 9.6–10.7, 1.4–9.4 and 5.0% reported by Oboh, Ologhobo, and Tewe (1989), Adedeji et al. (2014), Abayomi et al. (2013) and Onabanjo and Ighere (2014) respectively. The moisture, crude fibre, ash, fat, starch and sugar contents of the mixture decreased as the percentage substitution of soy protein isolate increased. While the protein content increased as the soy protein isolate substitution increased. This might be due to high protein content of soy protein isolate.

3.3. Effect of soy protein isolate substitution on the proximate composition of maize flour cookies
The effects of soy protein isolate substitution on the proximate composition of maize flour cookies are presented in Table 2. The moisture, crude fibre, fat and sugar contents of the cookies from different flour blends decreased as the percentage of soy protein isolate in the blends increased from 8.76 ± 0.22 to 6.96 ± 0.13, 3.81 ± 0.07 to 2.87 ± 0.02, 2.63 ± 0.06 to 1.69 ± 0.01, 9.41 ± 0.24 to 8.45 ± 0.13 and 6.21 ± 0.20 to 4.98 ± 0.11 respectively. The protein content, however, increased from 8.69 ± 0.19 to 29.11 ± 0.34%, respectively, as the percentage of soy protein isolate in the blends

Table 2. The proximate compositions of cookies from different soy protein isolate substitution

Samples (%)	Moisture (%)	Ash (%)	Crude fibre (%)	Fat (%)	Crude protein (%)	Sugar (%)
MF (100%)	6.41 ± 0.12[a]	3.98 ± 0.08[g]	2.87 ± 0.07[g]	9.63 ± 0.26[g]	6.21 ± 0.14[a]	6.33 ± 0.22[g]
95:5 MF/SPI	8.76 ± 0.22[g]	3.81 ± 0.07[f]	2.63 ± 0.06[f]	9.41 ± 0.24[f]	8.69 ± 0.19[b]	6.21 ± 0.20[f]
90:10 MF/SPI	8.59 ± 0.20[f]	3.74 ± 0.06[e]	2.31 ± 0.05[e]	9.22 ± 0.22[e]	11.62 ± 0.23[c]	5.98 ± 0.19[e]
85:15 MF/SPI	7.92 ± 0.19[e]	3.56 ± 0.05[d]	2.19 ± 0.04[d]	8.89 ± 0.20[d]	15.74 ± 0.25[d]	5.67 ± 0.17[d]
80:20 MF/SPI	7.63 ± 0.17[d]	3.31 ± 0.04[c]	1.98 ± 0.03[c]	8.63 ± 0.16[c]	20.33 ± 0.28[e]	5.53 ± 0.15[c]
75:25 MF/SPI	7.28 ± 0.15[c]	2.98 ± 0.03[b]	1.74 ± 0.02[b]	8.57 ± 0.15[b]	24.64 ± 0.31[f]	5.31 ± 0.13[b]
70:30 MF/SPI	6.96 ± 0.13[b]	2.87 ± 0.02[a]	1.69 ± 0.01[a]	8.45 ± 0.13[a]	29.11 ± 0.34[g]	4.98 ± 0.11[a]

Key: MF = maize flour; SPI = soy protein isolate.

Notes: All data are means of three replicates expressed on dry weight basis; means with the same superscripts are not significantly difference at $p \leq 0.05$; 95:5 = maize flour: soy protein isolate ratio.

Table 3. Physico-chemical properties of the flour samples

Ratio of maize flour: soya protein isolate	Bulk density	Dispersability	Water binding capacity	Swelling power at 950°C
MF (100%)	4.8 ± 1.76[a]	49.4 ± 2.78[a]	0.8 ± 0.06[g]	12.0 ± 1.58[a]
95:5 MF/SPI	4.6 ± 1.59[b]	43.3 ± 2.59[b]	1.1 ± 0.12[f]	10.2 ± 1.41[b]
90:10 MF/SPI	4.2 ± 1.52[c]	38.1 ± 2.38[c]	1.3 ± 0.14[e]	9.8 ± 1.33[c]
85:15 MF/SPI	4.0 ± 1.50[d]	32.9 ± 2.21[d]	1.5 ± 0.15[d]	8.4 ± 1.29[c]
80:20 MF/SPI	3.6 ± 1.45[e]	28.6 ± 2.13[e]	1.7 ± 0.14[c]	7.1 ± 1.23[d]
75:25 MF/SPI	3.3 ± 1.39[f]	24.7 ± 2.02[f]	1.9 ± 0.16[b]	6.3 ± 1.18[e]
70:30 MF/SPI	3.1 ± 1.32[g]	18.1 ± 1.91[g]	2.0 ± 0.19[a]	5.8 ± 1.14[f]

Key: MF = maize flour; SPI = soy protein isolate.

Notes: All data are means of three replicates expressed on dry weight basis; means with the same superscripts are not significantly difference at $p \leq 0.05$; 95:5 = maize flour: soy protein isolate ratio.

increased. This might be due to dilution of soy protein isolate and the fact that soy protein isolate has high protein content.

3.4. Effect of soy protein isolate substitution on the functional properties of the maize flour

The effects of soy protein isolate substitution on the functional properties of maize flour are presented in Table 3. The bulk density, dispersability and swelling power capacities of maize flour decreases as the level of soy protein isolate in the composite flour increases. These ranged from 4.6 ± 1.59 to 3.1 ± 1.32, 43.3 ± 2.59 to 18.1 ± 1.91 and 10.2 ± 1.41 to 5.8 ± 1.14 respectively. While the water holding capacity increases from 1.1 ± 0.12 to 2.0 ± 0.19. The incorporation of soy protein isolate increased water holding capacity and decreased bulk density, dispersability and swelling power capacities of maize flour.

3.5. Cookie flow and break strength properties

Data on cookie flow after baking and the break strength of the cookie samples are presented in Table 4. The cookies from 100% maize flour had the highest increase in volume of 57.6 ± 1.58%. Substitution of maize flour with soy protein isolate reduced cookie flow. Addo, Akinola and Yusuff (1987) and Okaka and Isieh (1990) reported similarly findings.

Cookies from 70% maize flour and 30% soy protein isolate had the highest break strength of 2.9 ± 0.23. Substitution of maize flour with soy protein isolate increased the break strength of maize

Table 4. Calorific values, cookie flow and break strength properties

Ratio of maize flour: soya protein isolates	Cookie flow (%)	Cookie break strength (kg)	Energy (Cal/100 g)
MF (100%)	57.6 ± 1.58[a]	1.5 ± 0.07[g]	468 ± 1.59[a]
95:5 MF/SPI	52.9 ± 1.49[b]	1.7 ± 0.09[f]	451 ± 1.33[b]
90:10 MF/SPI	50.0 ± 1.33[c]	1.9 ± 0.11[e]	439 ± 1.26[c]
85:15 MF/SPI	45.9 ± 1.28[d]	2.0 ± 0.13[d]	425 ± 1.18[d]
80:20 MF/SPI	42.6 ± 1.17[e]	2.2 ± 0.16[c]	419 ± 1.12[e]
75:25 MF/SPI	39.8 ± 1.11[f]	2.5 ± 0.19[b]	408 ± 1.06[f]
70:30 MF/SPI	34.4 ± 1.04[g]	2.9 ± 0.23[a]	383 ± 1.01[g]

Key: MF = maize flour; SPI = soy protein isolate.

Notes: All data are means of three replicates expressed on dry weight basis; means with the same superscripts are not significantly difference at $p \leq 0.05$; 95:5 = maize flour: soy protein isolate ratio.

Table 5. Mean sensory evaluation of cookie samples (hedonic scale)

Ratio of maize flour: soya protein isolate	Colour	Taste	Texture	Crispiness	Overall acceptability
MF (100%)	7.4 ± 0.17[a]	4.8 ± 0.12[b]	6.0 ± 0.14[ab]	6.8 ± 0.16[a]	7.0 ± 0.17[a]
90:5 MF/SP	6.8 ± 0.16[b]	5.8 ± 0.16[b]	6.2 ± 0.16[a]	6.4 ± 0.14[ab]	5.8 ± 0.13[e]
95:10 MF/SPI	6.3 ± 0.14[b]	6.8 ± 0.17[ab]	6.0 ± 0.14[ab]	7.0 ± 0.16[a]	6.5 ± 0.14[d]
85:15 MF/SPI	6.1 ± 0.14[b]	7.0 ± 0.18[a]	5.0 ± 0.10[c]	7.0 ± 0.16[a]	6.8 ± 0.15[c]
80:20 MF/SPI	5.6 ± 0.12[c]	6.7 ± 0.17[ab]	6.2 ± 0.16[a]	6.5 ± 0.15[ab]	7.0 ± 0.16[b]
75:25 MF/SPI	5.0 ± 0.1[d]	5.2 ± 0.12[c]	5.7 ± 0.13[b]	5.8 ± 0.13[b]	5.6 ± 0.11[e]
70:30 MF/SPI	4.0 ± 0.10[e]	5.3 ± 0.13[c]	5.2 ± 0.11[bc]	6.0 ± 0.14[ab]	5.3 ± 0.12[f]

Key: MF = maize flour; SPI = soy protein isolate.

Notes: All data are means of three replicates expressed on dry weight basis; means with the same superscripts are not significantly difference at $p \leq 0.05$; 95:5 = maize flour: soy protein isolate ratio.

flour cookies while soy protein isolate substitution reduced the energy level. This may be due the fact that soy protein isolate has low carbohydrate content and high protein content.

3.6. Calorific value of soy protein isolate substituted maize flour cookies

The calorific values of samples from soy protein isolate substituted maize flour cookies are presented in Table 4. Cookies made from maize flour (control) had the highest energy (468 ± 1.59 cal/100 g). This value agreed with the value of 493 Cal/100 g reported by McCance and Widdowson (1991) for digestive biscuits. The calorific value of maize flour cookies decreased with increase in concentration of soy protein isolate substitution (Table 2). The calorific values of the cookies from maize flour and soy protein isolate substituted maize flour showed that they are comparable with similar products from wheat, barley and sorghum (McCance & Widdowson, 1991). The lower calorific values and increase in protein content of the cookies may be due to the soy protein isolate.

3.7. Sensory evaluation of cookies (hedonic scale)

For the hedonic scale shown in Table 5, all the samples were not significantly different ($p < 0.05$). The 100% maize flour cookies (control) with the value of 7.2 ± 0.17 rated the highest in terms of overall acceptability. About 25% level of soy protein isolate substitution reduced overall acceptability to 5.6 ± 0.11. The results showed that increase in the level of soy protein isolate in the maize flour was detected at 25% and became less acceptable as the percentage of substitution increases above 25%. About 30% soy protein isolate cookies had least acceptability level of 5.3 ± 0.10. For the organoleptic test 5, 10, 15, 20, 25 and 30% levels of substitution were not significantly different from each other in terms of their comparison with the control from maize flour. However, they were significantly different from each other for texture and crispiness. A change in colour was detected at 20% level of substitution and became less acceptable as the percentage of substitution increases above 30%.

4. Conclusion

This study concluded that production of maize flour cookies enriched with soy protein isolate improved the protein content of the product. The maximum level of enrichment of maize flour with soy protein isolate for cookie making was 20%; above this, the acceptability of the cookies to the consumers decreases. The results showed that the enrichment of maize flour cookies with soy protein isolate would ensure increase utilization of soy beans as an underutilize crop in Nigeria leading to wealth creation among farmers.

Funding
The authors received no direct funding for this research.

Competing Interest
The authors declare no competing interests.

Author details
S.A.O. Adeyeye[1]
E-mail: saadeyeye@yahoo.com
ORCID ID: http://orcid.org/0000-0001-7519-4231
A.O. Adebayo-Oyetoro[2]
E-mail: wonunext@gmail.com
ORCID ID: http://orcid.org/0000-0002-3604-1440
S.A. Omoniyi[3]
E-mail: omoniyidewale@yahoo.com
[1] Department of Food Science and Technology, Mountain Top University, Prayer City, Ibafo, Ogun State, Nigeria.
[2] Department of Food Technology, Yaba College, Yaba, Lagos State, Nigeria.
[3] Department of Home Science and Management, Federal University, Gashua, Yobe State, Nigeria.

Citation information
Cite this article as: Quality and sensory properties of maize flour cookies enriched with soy protein isolate, S.A.O. Adeyeye, A.O. Adebayo-Oyetoro & S.A. Omoniyi, *Cogent Food & Agriculture* (2017), 3: 1278827.

References

Abayomi, H. T., Oresanya, T. O., Opeifa, A. O., & Rasheed, T. R. (2013). Quality evaluation of cookies produced from blends of sweet potato and fermented soybean flour, World Academy of Science, Engineering and Technology. *International Journal of Biological, Food, Veterinary and Agricultural Engineering, 7*, 350–355.

Addo, A. A., Akinola, J. O., & Yusuff, B. (1987). Chemical composition and organoleptic. *Nigerian Food Journal, 1*, 24–29.

Adedeji, O. E., Oyinloye, O. D., & Ocheme, O. B. (2014). Effects of germination time on the functional properties of maize flour and the degree of gelatinization of its cookies. *African Journal of Food Science, 8*, 42–47. doi:10.5897/AJFS2013.1106

Adeleke, R. O., & Odedeji, J. O. (2010). Functional properties of wheat and sweet potato flour blends. *Pakistan Journal of Nutrition, 9*, 535–538.

Adeyeye, S. A., & Akingbala, J. O. (2015). Quality characteristics and acceptability of cookies from sweet potato–maize flour blends. *Nutrition & Food Science, 45*, 703–715. doi:10.1108/NFS-03-2015-0020

Akpapunam, M. A., & Darbe, J. W. (1999). Chemical composition and functional properties of blend of maize barbara groundnuts flours for cookie production. *Plants Food for Human Nutrition, 46*, 147–155.

Association of Official Analytical Chemists. (1990). *Official methods of analysis* (16th ed.). Washington, DC: Author.

Beuchat, L. R. (1977). Functional and electrophoretic characteristics of succinylated peanut flour protein. *Journal of Agricultural and Food Chemistry, 25*, 258–261. http://dx.doi.org/10.1021/jf60210a044

Carroll, N. V., Longley, R. W., & Roe, J. H. (1956). The determination of glycogen in liver and muscle by use of anthrone reagent. *Journal of Biological Chemistry, 220*, 583–593.

David, J., & Dickerson, J. (1991). *Nutrient content of food portions* (p. 50). Cambridge: Royal Society of Chemistry.

Edema, M. O., Sanni, L. A., & Sanni, A. I. (2005). Evaluation of maize-soybean flour blends for sour maize bread production in Nigeria. *African Journal of Biotechnology, 4*, 911–918.

Fayemi, P. O. (1981). *Home economics teacher guide*. Ibadan: Macmillan Nigerian Publishers.

Food and Agriculture Organization of the United Nations (FAO). (2005). *The cassava transformation in Africa*. Rome: Author.

Food and Agriculture Organization of the United Nations, Statistics Division. (2009). *Maize, rice and wheat: Area harvested, production quantity, yield*. Rome: Author.

Gibson, L., & Benson, G. (2005, March). *Origin, history, and uses of soybean (Glycine max)*. Ames, IA: Department of Agronomy, Iowa State University.

Hassid, W. Z., & Newfield, E. F. (1964). Qualitative determination of starch in plant tissue. In Webster (Ed.), *Methods in carbohydrate chemistry* (Vol. 2, pp. 33–36). New York, NY: Wolform Academic Press.

Hendricks, K. M., Duggan, C., & Gallagher, L. (1995, October). Malnutrition in hospitalized pediatric patients. *Archives of Pediatrics & Adolescent Medicine, 149*, 1118–1122. http://dx.doi.org/10.1001/archpedi.1995.02170230072010

Houssou, P., & Ayemor, G. S. (2002). Appropriate processing and food functional property of maize flour. *African Journal of Science and Technology, 3*, 126–131. doi:10.4314/ajst.v3i1.15297.

How, J. S. L., & Morr, C. V. (1982). Removal of phenolic compounds from soy protein extracts using activated carbon. *Journal of Food Science, 47*, 933–940. http://dx.doi.org/10.1111/jfds.1982.47.issue-3

Kadam, M. L., Salve, R. V., Mehrajfatema, Z. M., & More, S. G. (2012). Development and evaluation of composite flour for missi roti/chapatti. *Journal of Food Processing and Technology, 3*, 134. doi:10.4172/2157-7110.1000134

McCance, R. A., & Widdowson, E. M. (1991). *The composition of foods* (5th revised and extended ed., pp. 257–258). London: Royal Society of Chemistry.

Meyer, E. W. (1971). Oilseed protein concentrates and isolates. *Journal of the American Oil Chemists' Society, 48*, 484–488. http://dx.doi.org/10.1007/BF02544666
Mizrani, S., Zimmermann, G., Beak, Z., & Cogan, U. (1967). The use of isolated soybeans protein in bread. *Cereal Chemistry, 44*, 193–203.
Mohamed, R. I. (2000). *Comparative studies about using some plant proteins in food processing* (PhD Thesis). Department of Food Science and Technology, Faculty of Agriculture, Al-Azhar University, Cairo.
Monika, B., & Mercedes, O. (2005). *Malnutrition: Quantifying the health impact at national and local levels* (Environmental burden of disease series). Geneva: WHO.
Oboh, S. O., Ologhobo, A. O., & Tewe, O. O. (1989). Some aspects of the biochemistry and nutritional value of the sweet potato (*Ipomea batatas*). *Food Chemistry, 31*, 9–18. http://dx.doi.org/10.1016/0308-8146(89)90146-5
Okaka, J. C., & Isieh, M. I. (1990). Development and quality evaluation of cowpea-biscuits. *Nigerian Food Journal, 8*, 56–62.
Olapade, A., & Ogunade, O. (2014). Production and evaluation of flours and crunchy snacks from sweet potato (*Ipomea batatas*) and maize flours. *International Food Research Journal, 21*, 203–208.
Onabanjo, O. O., & Ighere, D. A. (2014). Nutritional, functional and sensory properties of bread biscuit produced from wheat-sweet potato composite. *Journal of Food Technology Research, 1*, 111–121.
Padmashree, T. S., Vijayalakshmi, L., & Puttaraj, S. (1987). Effect of traditional processing on the functional properties of cowpea (*Vigna catjang*) flour. *Journal of Food Science and Technology, 24*, 221–224.
Thompson, J. L., Manore, M. M., & Vaughan, L. A. (2010). Nutrients involved in energy metabolism. In *The science of nutrition* (2nd ed., pp. 292–321). San Francisco, CA: Pearson Education. ISBN 978-0-321-64316-2.
Urbanski, G. E., Wei, L. S., Nelson, A. I., & Steinberg, M. P. (1982). Effect of solutes on rheology of soy four and its components. *Journal of Food Science, 47*, 792–795. http://dx.doi.org/10.1111/jfds.1982.47.issue-3
Vallabhaneni, R., & Wurtzel, E. T. (2009). Timing and biosynthetic potential for carotenoid accumulation in genetically diverse germplasm of maize. *Plant Physiology, 150*, 562–572. PMC 2689957. PMID 19346441. doi:10.1104/pp.109.137042
Van Hal, M. (2000). Quality of sweetpotato flour during processing and storage. *Food Reviews International, 16*(1), 1–37. http://dx.doi.org/10.1081/FRI-100100280
Winkel-Shirley, B. (2001). Flavonoid biosynthesis. a colorful model for genetics, biochemistry, cell biology, and biotechnology. *Plant Physiology, 126*, 485–493. PMC 1540115. PMID 11402179. doi:10.1104/pp.126.2.485
World Food Programme. (2000). *Food and nutrition handbook*. Rome: Author.
World Health Organization. (2013). *Malnutrition-The global picture*. Author. Retrieved January 1, 2013, from http://www.who.int/home-page/