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Quality Evaluation of Custard Produced from Blends of Sweet Potato and Corn Starch Enriched with Defatted Soybean

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Authors' contributions

This work was carried out in collaboration among all authors. Author CCE designed the study and performed the statistical analysis. Author HOA and Author MCE wrote the protocol and the first draft of the manuscript. Author CSA and Author CRA managed the analyses of the study. Author KSO managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Custard is a thick, rich, creamy sweet or savory dessert, made mixtures of eggs or egg yolks, milk or cream and commonly consumed in most part of Africa especially Nigeria. This research was carried out to determine the physicochemical properties and sensory characteristics of custard produced from the blends of sweet potato and corn starch enriched with defatted soybean flour. The sweet potato was peeled, washed and diced into small cubes to aid milling while the maize grains were cleaned and soaked in water for 24 hours, and they were separately milled and filtered. The filtrates were allowed to settle for four hours, the starches were obtained and dried at 70°C and 60°C for 8 hours and 5 hours respectively. The soybean was cleaned, soaked, boiled, toasted, dehulled, milled and defatted in petroleum ether. Ten custard samples were then formulated using sweet potato starch, corn starch and defatted soybean flour respectively in the following ratios: 100:0:0; 80:10:10; 70:20:10; 60:30:10; 50:40:10; 40:50:10; 30:60:10; 20:70:10; 10:80:10; 0:100:0. The custard formulations were evaluated for their physicochemical and sensory

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characteristics, using commercial custard (Checkers custard) as control. The result of the proximate composition showed that moisture, ash, crude fibre, crude protein and carbohydrate content in % ranged from 5.40-18.08, 0.70-3.07, 1.16-6.52, 0.82-5.23, 1.31-9.91 and 68.87-85.25, respectively. The functional properties also showed that least gelation concentration (%), bulk density (g/cm), swelling power and gelatinization temperature (^{o}C) ranged from 4.00-10.00; 0.59-0.83; 6.37-8.02 and 69.2-80.1, respectively. The result showed that the swelling power differed significantly ($p<0.05$) from each other and some of the samples differed significantly in bulk density, least gelation and gelatinization temperature, respectively. Sensory evaluation carried out on different samples of the custard formulation showed that the control sample (Checkers custard) had the highest score of overall acceptability. The 100% corn starch and 100% sweet potato starch were accepted by the consumers as an alternative to the commercial custard product. The enrichment of custard with soybean contributed to an increase in the nutritional value of the custard.

Keywords: Corn starch; custard; defatted soybean; sweet potato starch; quality evaluation.

1. INTRODUCTION

Custard is a treated type of pap and it is a smooth-textured food product made from maize-starch to which salt, flavourants, colourants, as well as egg yolk solids, vitamins and minerals were added [1]. Custard powder is generally white in colour but turns yellow when reconstituted in water. Custard could be used as infant's supplement, breakfast cereal by many and serve as choice food for ill persons [2]. Custard is majorly consumed either as a breakfast cereal-based food or weaning food in many developing countries of the tropics especially amongst children [3]. Custard has a long shelf life and it is in great demand in the urban areas because of the ever busy lifestyle of most Nigerian households. It is easy to prepare and it comes handy, hence it is a common food product at home with its affordability, good taste, convenience, easy and short time of preparation [3].

Sweet potatoes (*Ipomea batatas*) are a perennial crop, which belong to the bindwind or morning glory family, *Convolulaceae* and are from the specie *batatas*. They are large, starchy, sweet-tasting, tuberous roots. Sweet potatoes are considered staple food in many parts of the world. All varieties of sweet potatoes are good sources of vitamin C and B and as well as dietary fibre, potassium, iron, calcium, and selenium. Sweet potatoes contain high levels of antioxidants; beta–carotene. Many foods that contain sweet potato are important because of their beneficial effects on health. Therefore, they are very desirable in meals and serve as a functional food [4]. Sweet potato contains about 70% carbohydrates (dry basis) of which a major fraction is starch, which can be utilized as a functional ingredient in some food preparations. During cooking for instance, controlling the rate of heating can help activate endogenous amylolytic enzymes leading to the conversion of a fraction of starch to dextrins, which as an adhesive material could serve as a binding agent in food formulations [5]. Despite the fact that it is cheaper than other crops, this abundant resource is, however, still poorly utilized.

Maize (*Zea mays L.)* is a vital annual cereal crop of the world which belongs to the family *Paceae*. Maize or corn is considered a staple food in many parts of the world. It is a third leading crop of the world after rice and wheat [6]. Maize kernel is a nutritive and edible constituent of the plant. It contains vitamin C, vitamin K, B-group of vitamins, selenium, N-p-coumaryl tryptamine and N-ferrulyl tryptamine. Potassium is the major mineral present in maize and it has an exceptional significance being that many human diets are Potassium-deficient [7].

Soybean (*Glycine max*) is a plant-based protein source, which when used partially to enrich potato starch-based custard would help tremendously in enhancing the nutritional quality of such custard. According to Iwe [8], soybean plays an important role in enriching cereals and tuber crops-based food products due to its exceptional nutritional quality and functional roles. Soybean is a legume of the pea family that strives in tropical, subtropical and temperate regions. It contains about 36% protein, 30% carbohydrates and it is an excellent source of dietary fiber, vitamins and minerals. It also consists of about 20% oil, which qualifies it as the most crucial crop for the production of edible oil [8]. Protein deficiency malnutrition is prevalent in many parts of Africa as animal protein is very expensive for most populations [9]. Many pulses provide some protein, but soybean is the only available legume that provides an inexpensive and high quality protein comparable to meat, poultry and eggs. Soybean protein products can serve as good substitutes for animal products because, unlike some other legumes, soybean offers a nearly complete amino acid profile [10]. Soybeans contain all the essential amino acids except methionine, which must be supplied in the diet because they cannot be synthesized by the body. Protein products from soybean can be used in place of animal-based foods which also have complete proteins but have the tendency of containing more saturated fats. Proteins, lipids, some vitamins and minerals are the major important nutrients in soybeans [11].

This research is set out to achieve the production of custard from sweet potatoes starch and corn starch enriched with defatted soybean.

2. MATERIALS AND METHODOLOGY

2.1 Source of Materials

White variety Maize (*Zea mays*), sweet potato (*Ipomea batatas*) and soybean (*Glycine max)* used for the study were purchased from Eke Awka Market, Awka South Local Government, Anambra Sate. The colourant (tartrazine and sunset yellow) and flavourant (vanilla) were purchased from chemical plant, Ojota, Lagos state, Nigeria. The control, which is ('Checkers custard', manufactured by Checkers Africa Limited, Km 5, Itokin road, Itamope, Ikorodu, Lagos, Nigeria, West Africa) was also purchased from Eke Awka Mrket, Awka, Anambra State, Nigeria.

2.2 Processing of Raw Materials

2.2.1 Processing of sweet potato starch powder

The sweet potato starch was prepared according to the method described by Vithu et al. [12] with some modification as shown in Fig. 1.

Fresh sweet potato roots were peeled and sliced (manual slicer, 2mm) into a bowl of water containing 1% sodium metabisulphite in order to avoid browning of the starch. The slices were then blended using Warring blender to obtain a paste which was filtered with muslin cloth, allowed to sediment for four hours and then decanted. Fresh water was added to the starch and stirred very well to allow any foreign material still in the starch to be loosened and to float. The slurry after being allowed to sediment for another four hours was decanted, dewatered and the starch gotten was dried using the hot air oven model BST/HAO-1122 (300 × 300 × 300 mm) (70°C for 8 hours). After drying, the starch was milled to obtain a finer starch which was stored properly in an airtight container prior to the custard production.

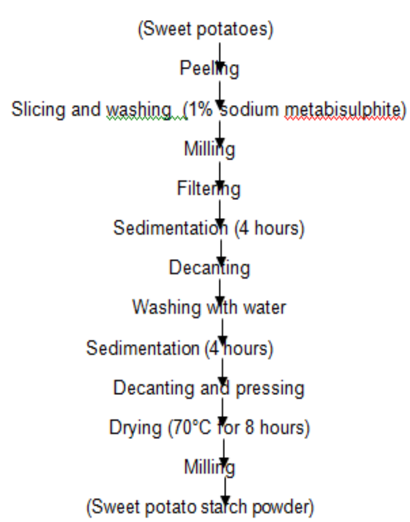

Fig. 1. Sweet potato starch production powder

2.2.2 Processing of maize starch

The corn starch was prepared according to the method described by Makanjuola and Makanjuola [13] with slight modifications as shown in Fig. 2. Maize grains were cleaned to remove dirt and other extraneous materials after which they were soaked in potable water for 24 hours with change of water at interval of 6 hours to prevent fermentation. Thereafter, the steeped grains were milled using laboratory grinder (model 400S and 400SW), filtered (muslin cloth) and allowed to sediment for 4 hours.

The water was decanted, the starch pressed and dried in a hot air dryer (60°C for 5 hours). After that, the dried starch was milled (attrition mill) to obtain fine starch. The corn starch produced was aseptically packaged and sealed in a polyethylene bags before blending and preparation of custard formulations.

2.2.3 Processing of defatted soybean

Defatted soybean flour was prepared using the method described by Khetarpaul et al. [14] with slight modification. Soybean seeds were cleaned to remove extraneous materials, boiled for 30 minutes, drained of boil-water, dried in the hot air oven (80°C for 12 hrs), coarse-milled to loosen the hull and then winnowed to remove the detached hulls. The dehulled seeds were milled (attrition mill) and defatted by soaking in petroleum ether (100g: 1,000ml) for 12 hours. Thereafter, the petroleum ether was decanted and the soy flour was dried in an oven at 65°C for 40 minutes, cooled and sieved through a 100µm mesh sieve. The fine defatted soybean flour obtained was finally packaged and sealed in polyethylene bags for blending and preparation of custard formulation.

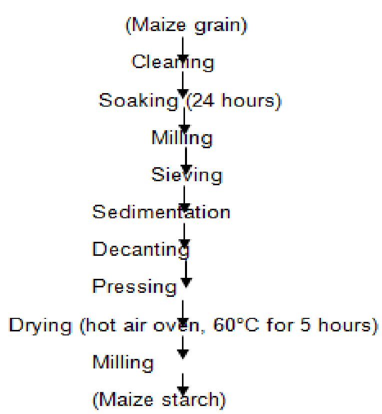

Fig. 2. Maize starch production

2.3 Experimental Design

Table 1. Experimental design

	Level of substitution (%)		
Sample runs	**Sweet potato starch (SPS)**	**Corn starch (CS)**	**Defatted soybean flour (DSF)**
1	100	0	0
2	80	10	10
3	70	20	10
4	60	30	10
5	50	40	10
6	40	50	10
7	30	60	10
8	20	70	10
9	10	80	10
10	0	100	0

2.4 Custard Formulation

The custard formulation was according to the method described by Ihekoronye [15]. The sweet potato starch (SPS) and corn starch (CS) and defatted soybean flour (DSF) were mixed at varying ratios of 0 – 100% Table 1 in a Kenwood mixer for 25 – 30 minutes to obtain various samples of sweet potato starch/corn starch/defatted soybean custard blends. Then 15% sunset yellow and tartrazine, 10% vanilla flavour and 5% salt were added to each of the flour blends and mixed thoroughly for 10 minutes to produce the enriched custard formulations. The custard formulations were individually packaged and sealed in polyethylene bags and kept at room temperature (29 ± 2^{o}C) for analysis.

2.5 Chemical Analysis of Samples

2.5.1 Proximate analysis

Proximate analysis was carried out on all the custard samples according to AOAC [16]. The percentage carbohydrate content was determined by difference; 100 - (% Moisture + % protein + % Fat + % Ash + % Crude fibre).

2.5.2 Functional properties

2.5.2.1 least Gelation Concentration

Least gelation concentration was determined by the method described by Onwuka [17]. Ten suspensions in the range of 2-20% (W/V) of the custard samples in distilled water was prepared in test tubes and heated in a boiling water bath for 1 hour. The tubes and their content were cooled rapidly under running water and then cooled further for 2 hours at 4°C. The tubes were then inverted to check if the content will fall or slip off and is determined as the concentration when the sample from the inverted test tube will not fall or slip.

2.5.2.2 Swelling power and solubility

Swelling power and solubility were determined by method described by Onwuka [17]. One percent (1%) solution of starch slurry was prepared and heated in a water bath (model D5581) maintained at 90^{o}C for 30 minutes with constant stirring and cooled. The suspension was centrifuged with Benchtop centrifuge at 3200 rpm and the supernatant was collected in a pre-weighed aluminium dish which was dried at 110^{o}C for 24 hours. The weight of the wet sediment in the centrifuge and that of the dried aluminium dish were recorded. The solubility and swelling power were thus calculated:

% Solubility = Weight of dried supernatant × 100 / Sample weight
% Swelling power = Weight of wet sediment × 100 / Sample weight × (100- % solubility).

2.5.2.3 Bulk density

The method described by Oladele and Aina [18] was used for the determination of the bulk density. The custard sample was weighed (20g) into a 50 ml graduated measuring cylinder. The cylinder was tapped gently against the palm of the hand until a constant volume was obtained. Bulk density was calculated as;

$$\frac{\text{Weight of sample}}{\text{Volume of sample after tapping}}$$

2.5.2.4 Gelatinization temperature

The gelatinization temperature was determined according to the method described by Onwuka [17]. Ten percent suspension of the flour sample was prepared in a test tube. The aqueous suspension was heated in a boiling water bath and was stirred continuously with a stirrer. Gelatinization temperature was recorded when gelatinization was visually noticed.

2.6 Sensory Analysis

Sensory analysis of the laboratory samples and the commercial sample of custard was conducted using 20 member-panelist semi-trained in the Department of Food Science and Technology, Nnamdi Azikiwe University, Awka. Twenty grams (20g) of custard sample was measured into a clean beaker, 100ml of potable water was added after which it was then stirred and 100ml of boiling water was added to form paste. The paste was served to the panellists with addition of equal amounts of sucrose. Water was provided for rinsing of mouth. Rating was done using a 9-point hedonic scale system [8] to determine the preference on appearance, taste, flavour, mouth feel and overall acceptability, where 1 denotes dislike extremely and 9 is like extremely.

2.7 Statistical Analysis

The work was designed using a completely randomized design (CRD). The data obtained was analysed using SPSS software (version 23) One-way ANOVA. Means, where significant, were separated using Duncan's multiple range test at 5% probability level.

3. RESULTS AND DISCUSSION

3.1 Proximate composition of Custard from Blends of Sweet Potato Starch, Corn Starch and Defatted Soybean flour

The proximate composition of custard obtained from blends of sweet potato starch, corn starch and defatted soybean flour are shown in Table 2. The results showed that there was significant differences ($p<0.05$) in some of the proximate composition parameters of the custard samples.

The moisture content of the custard formulations were significantly different ($p<0.05$) except for samples with the SPS:CS:DSF ratios of 40:50:10 and 30:60:10 and ranged from 5.40 to 18.08%. The significant differences ($p<0.05$) in the moisture content could be as a consequence of different moisture content contributed by the individual components that was used in the formulation of the custard powder and the differential drying rates of the individual flour samples. The primary raw materials of these flours have different chemical and physical configuration which would have affected the drying rates of the flours and thus leading to different moisture content. Furthermore, the method of production of these flours could also be one of the causative factors leading to its different moisture content. Sample with the ratio 10:80:10 (sweet potato starch: corn starch: defatted soybean flour) have the highest moisture content (18.08%) which is relatively high, followed by samples with SPS:CS:DSF ratio of 20:70:10, 30:60:10 and 40:50:10 with 14.04%, 12.20%, 12.20% moisture content respectively. This abnormality is quite explanatory, the drying temperature and time of these starches varied, the sweet potato starch was dried at the temperature of 70°C for 8 hours while the corn starch was dried at a lower temperature and time (60°C for 5hours). These starches were dried at different temperature because sweet potato is believed to have a very high moisture content than corn and this led to the corn starch not being able to dry as much as the sweet potato starch which became evident in the final product as the samples with the higher moisture content are seen to have more of corn starch than sweet potato starch. The lower moisture content in sweet potato starch suggests better microbial stability of sweet potato starch to corn starch. Low moisture content favours the inhibition of microorganism whose growth and activities cause spoilage in foods [19].

The ash content of the custard samples ranged from 0.71 to 3.07%. Four samples were observed to be statistically the same (samples with SPS:CS:DSF ratio 10:80:10; 20:70:10; 30:60:10 and 40:50:10) as the differences in their values are insignificant ($p>0.05$) but they were significantly different from the other samples. Samples with ratio 100:0:0 and 70:20:10 (SPS: CS: DSF) had no significant difference ($p<0.05$) amongst both of them. The ash content is a measure of the total amount of minerals present in a food [20]. Determination of ash content of food is important for nutritional labelling, quality, microbiological stability, and nutritional evaluation and processing of food product. Sample with 100% corn starch had the highest ash content (3.07%) followed by sample with 100% sweet potato starch which had 2.35% ash content. This could be as a result of the relatively high ash content in corn and sweet potato raw materials [19].

The crude fibre of the samples were significantly different ($p<0.05$) in five samples but there were no significant differences in Samples with ratios 70:20:10 and 40:50:10 (SPS:CS:DSF). The fibre content of the custard samples ranged from 1.16 to 6.52%. Control sample had the highest value of 6.52% followed by sample with 100% potato starch which had 4.50% This could be attributed to the fact that sweet potato is a root vegetable and most vegetables are known to have very high fibre content than cereals. Sweet potato has been identified as a significant source of dietary fibre [21]. Custard with 100% corn starch had the least fibre content and from previous researches and projects, corn starch has relatively low fibre content [22]. Sweet potatoes contain both soluble fiber (15-23%) in the form of pectin, and insoluble fiber (77-85%) in the form of cellulose and hemicellulose, and lignin [23]. Soluble fibres such as pectin may increase fullness, decrease blood sugar spikes by slowing your digestion of sugars and starches. A high intake of insoluble fibres has been associated with health benefits, such as a reduced risk of diabetics and improved gut health. Fibre content determination in food is very important for our digestive health and regular bowel movement. Fibre also helps you feel fuller for long, can improve cholesterol and blood sugar levels and can assist in preventing some diseases such as diabetes, heart disease and bowel cancer [21].

Fat content of the formulations were all significantly different (p<0.05) except for samples with SPS:CS:DSF ratio 40:50:10 and 20:70:10. The fat content of the samples ranged from 0.82 to 5.23% with the control sample having the lowest value and 100% corn starch custard having the highest fat content followed by 100% sweet potato starch custard which had 2.73% fat content. The low fat content in these custard samples are quite explanatory and it is deduced from the fact that root vegetables and cereals have low fat content. Soybean being a good source of fat should have increased its fat content but with sufficient extraction of oil from the soybean during defatting, the fat content was drastically reduced. Determination of fat content is important for formulating product for individuals with demand for products with reduced fat content and for shelf stability reasons.

The Protein content of the formulations ranged from 1.31% to 9.91% and were all significantly different (p<0.05). Sample with 40:50:10 (SPS:CS:DSF) ratio formulation had the highest protein content while the control sample had the lowest % crude protein. The samples were observed to have relatively higher protein content when compared to the control and the reason is not farfetched. The inclusion of defatted soybean to the formulation would have likely made it so. Protein determination is important due to its critical role in the diet, replacement of worn out tissues, growth and health.

Carbohydrate content of the formulations ranged from 68.87 to 85.25%. Sample with SPS:CS:DSF ratio of 10:80:10 had the lowest value (68.87%) while the control had the highest value (85.25%). All the samples differed significantly (p<0.05) from each other. Apart from the control sample with 85.25%, samples with 100% corn and 100% sweet potato starch had relatively high carbohydrate values of 76.22% and 76.90%, respectively, being that there was no defatted soybean inclusion in them. Their high carbohydrate values indicate that they will be suitable for individuals with high carbohydrate/calorie needs.

3.2 Functional Properties of Formulated Custard Powders

The functional properties of the formulated custard samples were carried out to study how the food materials behave during preparation and cooking, and how they affect the finished food product in terms of appearance, flavour and mouth feel. The functional properties of the custard samples obtained from blending of sweet potato starch, corn starch and defatted soybean flour are shown in Table 3. The samples differed significantly in some parameters (least gelation concentration, bulk density, swelling power and gelatinization temperature).

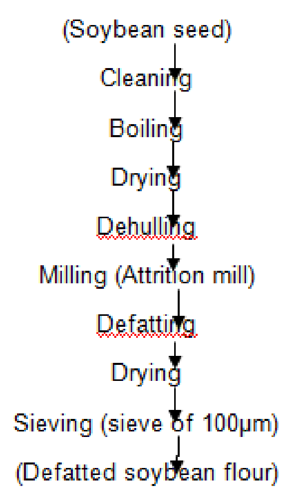

Fig. 3. Defatted soybean flour production

Table 2. Percentage (%) Proximate composition of formulated custard powder samples

Samples (SPS:CS:DSF)	Moisture (%)	Ash (%)	Crude fiber (%)	Fat (%)	Crude protein (%)	Carbohydrate (%)
100:0:0	6.77^{b}±0.25	2.35^{c}±0.48	4.50^{f}±0.20	2.73^{f}±0.03	7.47^{f}±0.03	76.22^{f}±0.63
70:20:10	10.27^{d}±0.30	2.10^{c}±0.10	4.17^{e}±0.051	2.19^{d}±0.01	6.60^{d}±0.02	74.67^{e}±0.31
40:50:10	12.20^{e}±0.10	1.09^{b}±0.12	4.08^{e}±0.21	2.03^{b}±0.06	9.91^{h}±0.01	70.69^{b}±0.31
30:60:10	12.20^{e}±0.03	1.40^{b}±0.10	3.09^{b}±0.07	2.46^{e}±0.05	9.23^{g}±0.03	71.62^{c}±1.20
20:70:10	14.04^{f}±0.04	1.13^{b}±0.06	3.31^{c}±0.07	2.03^{b}±0.06	7.30^{e}±0.26	72.19^{d}±0.34
10:80:10	18.08^{g}±0.03	1.20^{b}±0.35	3.55^{d}±0.05	2.11^{c}±0.53	6.19^{c}±0.05	68.87^{a}±0.36
0:100:0	8.58^{c}±0.09	3.07^{d}±0.03	1.16^{a}±0.02	5.23^{g}±0.26	5.06^{b}±0.06	76.90^{g}±0.07
Control	5.40^{a+}±0.20	0.70^{a}±0.06	6.52^{g}±0.02	0.82^{a}±0.02	1.31^{a}±0.03	85.25^{h}±0.23

Values are mean ± SD (n=3). Values on the same column with different superscript(s) are significantly different (p<0.05). SPS = sweet potato starch: CS = corn starch: DSF = defatted soybean flour. Control = Checkers custard

Table 3. Functional properties of formulated custard powder samples

Sample ratio (SPS:CS:DSF)	Least gelation(%)	Bulk density (g/cm^{3})	Swelling power (g/g)	Gelatinization temperature (°C)
100:0:0	10.00^{d}±0.54	0.66^{cd}±0.03	6.43^{a}±0.09	69.2^{a}±0.20
70:20:10	8.00^{c}±0.63	0.67^{d} ±0.04	6.37^{a+}±0.15	72.3^{b}±0.36
40:50:10	5.00^{ab+}±0.13	0.72^{e}±0.05	7.39^{cd+}±1.40	76.2^{c}±0.34
30:60:10	5.00^{ab}±0.01	0.60^{ab}±0.02	7.04^{b}±0.34	76.2^{c}±0.20
20:70:10	5.00^{ab}±0.21	0.63^{bc}±0.04	7.31^{c}±1.15	76.6^{d}±0.20
10:80:10	6.00^{b}±0.30	0.63^{ab}±0.04	7.51^{d}±1.04	77.1^{e}±1.73
0:100:0	5.00^{ab+}±0.79	0.59^{a}±0.03	7.79^{e}±0.96	77.2^{e}± 0.20
Control	4.00^{a}±0.13	0.83^{f}±0.10	8.02^{f}±0.25	80.1^{f}±0.17

Values are mean ± SD (n=3). Values on the same column with different superscript(s) are significantly different (p<0.05). SPS; sweet potato starch: CS; corn starch: DSF; defatted soybean flour. Control = Checkers custard

The higher the least gelation concentration, the higher the amount of starch needed to form gel [24]. The least gelation concentration value for the samples ranged from 4.00 to 10.00%. Sample with SPS:CS:DSF ratio of 100:0:0 (100% sweet potato starch) had the highest least gelation concentration of 10.00%. The commercial custard (checkers custard) had the lowest least gelation concentration(4.00%) showing that a lower amount of it will be needed to form a gel. The samples were all significantly different (p<0.05) from each other except for samples with SPS:CS:DSF ratio of 0:100:0, 20:70:10 and 30:60:10. This could be as a result of the ratio of formulation from the component raw materials and their chemical interaction which include the amylose and amylopectin present in the starch granules [24].

Bulk density of the material is the ratio of the mass to the volume (including the inter-particulate void volume) of an untapped powder sample. Bulk density for the formulated custard powder samples ranged from 0.59 to 0.83g/cm^3. All the samples differed significantly (p<0.05) except for sample ratios of 30:60:10 and 10:80:10 (SPD:CS:DSF). The slight difference noticed between the commercial custard (Checkers custard) and the laboratory custard samples would have been influenced by their particle size differences of the different custard samples. The control (commercial) sample had the highest bulk density of 0.83g/cm^3 and differed significantly from other samples while the sample with SPS:CS:DSF ratio of 0:100:0 (100% corn starch) had the lowest value of 0.59 g/cm^3 and would be more suitable for infants. The high bulk density value of the control (commercial) custard could be a consequence of its small particle size, added fortificants and other additives during formulation. Particle size is inversely proportional to bulk density and bulk density is a measure of heaviness of flour [25], so the high bulk density of the control (commercial) custard implies a lower particle size and heavier custard. The commercial sample appeared to be finer/smoother than the laboratory custard samples.

The result obtained for the swelling power of the flour samples showed that there were significant differences (p<0.05) in the swelling power of all the samples except for samples with SPS:CS:DSF ratios 100:0:0 and 70:20:10 which didn't differ significantly from each other. The swelling power ranged from 6.37 to 8.02. The sample with the ratio of 0:100:0 (100% corn starch) had the highest swelling power (7.79) apart from the control (8.02) while the sample with SPS:CS:DSF ratio of 70:20:10 had the lowest swelling power of 6.37. It appeared that the swelling power of the laboratory samples increased with increment in the ratio of corn starch. This could be as a result of the amylose content of the starches. Tester and Karkalas [26] reported that the amylose acts both as diluents and inhibitor of swelling, especially in the presence of lipids which can form insoluble complexes with some of the amylose during swelling and gelatinization. Starches that are high in amylose swell less, are resistant to digestion, gelatinize at high temperature and have low melting point [27]. The swelling power of starch-based food is an indication of hydrogen bonding between the granules [28].

Gelatinization temperature of the control is highest at 80.1°C and is significantly different from all the other samples. The gelatinization temperature showed progressive increase which corresponded with progressive increment in the ratio (20%, 50%, 60%, 70% and 80%) of corn starch added in the custard sample. It appeared that the higher the potato starch substitution with corn starch, the higher the gelatinization temperature, with 100% corn starch custard (0:100:0) having the highest value of 77.2°C among the laboratory samples while that of 100% sweet potato starch (100:0:0) is lowest at 69.2°C. This could be as a result of the variety of the starch as starches from different sources and/or regions display different behavioural pattern. The difference in gelatinization temperature may also be as a result of granule size. Gelatinization temperature decreases as granules size decreases [29].

3.3 Sensory Properties of Custard Made from the Blends of Sweet Potato Starch, Corn Starch and Defatted Soybean

The sensory evaluation of the custard samples was carried out by twenty (20) semi-trained panelists. The mean scores of the sensory evaluation of all the custard samples are presented in Table 4.

From the results obtained, it was observed that the Commercial (control) sample had the highest values and differed significantly (p<0.05) from all the other samples for colour, taste, mouth feel, aroma and overall acceptability.

Table 4. Sensory properties of the gruel of formulated custard samples

Samples codes	Ratio	Colour	Aroma	Mouth feel	Taste	Overall acceptability
SPS	100:0:0	7.70^{f}± 1.26	7.30^{b} ± 0.98	6.60^{bc} ± 1.31	6.60^{bc} ± 1.31	6.55^{b} ± 1.28
SCD	80:10:10	5.75^{cd} ± 1.68	6.35^{a} ± 1.79	5.45^{a} ± 1.85	5.45^{a} ± 1.85	4.90^{a} ± 1.92
SOS	70:20:10	6.10^{e} ± 1.21	5.95^{a} ± 1.47	5.65^{a} ± 1.73	5.65^{ab} ± 1.73	5.10^{a} ± 1.97
SRY	60:30:10	5.00^{a} ± 1.52	5.55^{a} ± 1.23	4.95^{a} ± 1.93	4.95^{a} ± 1.93	4.25^{a} ± 1.92
SNF	50:40:10	5.50^{a} ± 1.45	5.75^{a} ± 1.16	4.85^{a} ± 1.90	4.85^{a} ± 1.90	4.65^{a} ± 2.20
SCS	40:50:10	5.65^{b} ± 1.23	5.70^{a} ± 1.34	5.25^{a} ± 1.83	5.25^{a} ± 1.83	4.80^{a} ± 2.19
SSF	30:60:10	5.80^{bcd} ±1.61	5.90^{a} ± 1.29	5.65^{ab} ± 2.08	5.65^{ab} ± 2.05	5.05^{a} ± 2.16
SND	20:70:10	6.00^{cde} ±1.34	5.50 ^{a} ± 1.40	5.15^{a} ± 2.13	5.15^{a} ± 2.13	5.15^{a} ±2.00
SCY	10:80:10	6.05^{de} ± 1.32	5.60^{a} ± 1.60	5.20^{a} ± 1.88	5.20^{a} ± 1.88	4.90^{a} ± 1.74
CNS	0:100:0	8.10^{g} ± 1.21	7.85^{b} ± 0.93	7.50^{cd} ± 1.47	7.20^{cd} ±1.47	7.55^{bc} ± 1.19
Commercial product		8.10^{g} ± 0.91	8.05^{b} ± 1.00	8.00^{d} ± 1.30	8.00^{d} ± 1.30	7.90^{c} ± 1.20

Values are mean ± SD (n=3). Values on the same column with different superscripts are significantly different (p<0.05). Samples ratios = Sweet potato starch: Corn starch: Defatted soybean flour. Commercial product (control) = Checkers custard

For the colour, there were significant differences ($p<0.05$) amongst some of the samples. Samples with ratios of 60:30:10 and 50:40:10 was not significantly different ($p<0.05$) from each other, and sample with ratio 0:100:0 (SPS:CS:DSF) and the commercial product (control) also did not significantly differ ($p<0.05$) from one another.

The sample with SPS:CS:DSF ratio of 0:100:0 (100% starch) and the commercial product (control) were the most accepted followed by sample with SPS:CS:DSF ratio of 100:0:0 (100% sweet potato starch).

For Aroma, there was no significant difference ($p<0.05$) for all the samples except for samples with SPS:CS:DSF ratio 100:0:0 (100% sweet potato starch), 0:100:0 (100% corn starch) and the commercial product (control). These three samples did not significantly differ ($P<0.05$) amongst themselves.

For mouth feel, taste and overall acceptability, all the samples were significantly the same ($p<0.05$) except for samples with SPS:CS:DSF ratio of 100:0:0, 0:100:0 and the commercial product (control). Amongst these three samples that differed significantly, the commercial product (control) had the highest overall acceptability, mouth feel and taste, followed by sample with SPS:CS:DSF ratio of 0:100:0 (100% corn starch) and 100:0:0 (100% sweet potato starch).

The inclusion of defatted soybean to the custard samples had an effect on the taste, aroma, mouth feel, colour and overall acceptability as the samples containing defatted soybean had lower scores than the one without defatted soybean flour. Samples with SPS:CS:DSF ratio 100:0:0 and 0:100:0 which had no defatted soybean were clearer, more palatable, more appealing than the other samples except for the commercial control product which had the best overall acceptability.

In all sensory parameters including overall acceptability, there is no significant difference ($p>0.05$) in preference for the commercial control and 100% corn custard samples. These were followed by preference for the 100% sweet potato starch custard which differed significantly ($p<0.05$) from the corn starch and commercial control in all parameters except in aroma. Inclusion of defatted soybean flour (DSF) decreased the preference of the custard samples.

4. CONCLUSION

From the research, it is evident that the inclusion of defatted soybean in custard improved the protein content. Increase in Sweet potato starch in the custard increased the least gelation concentration and decreased the gelatinization temperature. Inclusion of defatted soybean flour (DSF) decreased the overall acceptability/preference of the custard samples. Optimization of the custard samples should be done to achieve the ratios that are very acceptable to consumers while still improving their protein intake.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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