# STRENGTHEN FOOD POTENTIAL OF SOYMILK BY-PRODUCT (OKARA) THROUGH FORTIFICATION OF TAPIOCA GRITS: NUTRITIONAL VALUES AND SENSORY QUALITIES OF MEAL

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## Abstract

*The increased rate at which wastes are generated by food processing industries is alarming because of the effects on the environment. Researchers are making considerable efforts by reincorporating food wastes and by-products into the food systems. For instance, soymilk residue (okara), a by-product of soymilk processing, is gaining the attention of researchers because of the residual nutritional content. The effects of incorporating okara at 10% to 40% in cassava starch to develop tapioca grit samples were evaluated. Cassava starch and okara powder were prepared and formulated: 100:0, 90:10, 80:20. 70:30, and 60:40 blends. Proximate composition of tapioca grits was determined and sensory properties of the meals were evaluated through consumer (n=45) acceptability testing and compared to a control (okara-free meal). Okara powder in tapioca grits increased protein, ash, fibre contents and energy values. Contrarily, carbohydrate content decreased steadily. Sensory results showed that the addition of okara powder to cassava starch significantly and positively affected the colour, taste, viscosity, flavour and residual particle of tapioca meals. Tapioca appeared more yellowish than control which remained white at a higher concentration of okara. The results indicated a relationship between perceived consumer effectiveness and willingness-to-buy okara-based samples. Fortifying cassava starch with okara powder, potentially improved the protein, fibre contents and ash contents to some level, thereby enhancing the value of okara-a food waste. Therefore, food uses of okara powder will add to its value, improve food nutritional value and its utilization will reduce the negative impact of the waste by reducing environmental pollution.*

**Keywords:** cassava starch, gluten-free, okara powder, soymilk residue

## Introduction

The food chain particularly in sub-Saharan Africa and other developing countries generates high levels of waste and by-products, such as okara causing serious environmental pollution and significant expenses leading to wasting resources (Guimarães *et al*., 2018; Kharel *et al*., 2021). Okara is reportedly rich in micronutrients and some other bioactive components but remained untapped for food uses (Guimarães *et al*., 2018; Kharel *et al*., 2021; Fang *et al*., 2021) which can be incorporated into foods for nutritional and health benefits. Food items like tapioca, a partially gelatinized cassava starch grits are deficient in protein and other micronutrients. Tapioca meal is a convenience food that is consumed as breakfast meals with sugar and/or milk with grated coconut in Nigeria and across the neighbouring Francophone countries (Adebowale & Ajibode, 2021). The low protein content of tapioca (0.31%-1.2%) is dependent on the cassava type used to process tapioca grits. Reducing food waste and nutrients deficiencies in food products such as tapioca meal will go a long way towards achieving some of the objectives of Sustainable Development Goal 12 (SDG12) campaign of the United Nations, through the Food and Agricultural Organization (FAO). Hence, could the addition of nutrient-dense okara powder to cassava starch improve the nutritional value of tapioca grit and enhance consumers' acceptability of tapioca meals?

Research interest has been directed towards food utilization of agro-industrial waste because they are perishable and could lead to environmental pollution (Costa *et al*., 2019; Makinde & Olaitan, 2020). Okara, a by-product of soymilk and tofu processing and is usually discarded as a waste material (Kharel *et al*., 2021). However, okara is rich in proteins (25%), fat (20%), dietary fibre (3.3%) and isoflavones (0.14 g/100 g dry basis) vitamins and minerals (Costa et al.,2019). Higher supplementation of okara in a food-based diet could potentially promote human health by causing a significant reduction in total body cholesterol (Momin *et al*., 2020). Also, applications of okara for food production have been documented, with the aim of value addition to food products (Costa *et al*., 2019; Makinde & Olaitan, 2020). The addition of okara powder in foods increased foods' protein and fibre contents (Chan & Ma, 2014). In this

regard, the substitution of okara powder in cassava starch, can produce food products with improved nutritional profile and at the same time reduce the problem of waste (okara) disposal encountered in the soymilk processing (Kambel & Rani, 2020). The nutrient potentials of okara can be used in food-to-food fortification in enriching tapioca meals.

Till now, information is insufficient on the partial fortification of cassava starch with okara powder for the development of tapioca. The use of okara powder to fortify tapioca meals could be another way to tap the nutrient potentials of okara and promote its value addition in tapioca grits or meals. Therefore, this study investigated the food-to-food fortification of tapioca grits with okara powder as a potential strategy to improve the nutritional and sensory quality of tapioca grits or meals.

## 1 MATERIALS AND METHODS

### Materials

Mature and freshly harvested cassava tubers (*oko iyawo* type) and soybean seeds were purchased from a retail market in Ilaro, Ogun State, Nigeria. Ilaro is an ancient town, the headquarters of Egbado-South Local Government in Nigeria. The town is positioned at a North latitude of 6.89°, East longitude of 3.02° and altitude of 68 m, ambient temperature ranges between an average of 23 °C to 34.2 °C in the town.

### Methods

### Cassava starch preparation

Starch was extracted from fresh cassava tubers according to the method described by Adebowale and Ajibode (2021). The tubers were peeled, washed with clean water and pulverised to slurry, in order aid the breakdown of cyanogen through hydrolysis. The slurry was wet-sieved using a perforated stainless-steel bowl, and the extract is collected as white filtrate. The filtrate was allowed to settle for about 6 hours, and supernatant drained-off leaving the extracted white starch. The extracted starch was mixed and washed with clean water four times, to remove fibrous or insoluble solid materials. The product obtained is pure and high-quality cassava starch. The starch was mechanically pressed to dewater the wet starch into a cake-like mass. The mass is then partially dried at room temperature by spreading in a tray to cool before packaging, and kept in the fridge at -20 °C till needed for further uses.

### Soymilk residue (okara) processing

About five (5 kg) of soybean seeds were soaked in hot water at a temperature of 60±2 ˚C for a period of 6 hours to eradicate the beany flavour attributed to soybean. At the expiration of 6 h, hydrated seeds were sieved and poured into cold water (25±2 ˚C) to aid dehulling of the seed and facilitate wet milling of dehulled seed. Dehulled seed was quickly milled into slurry using a laboratory hammer mill. The milled slurry was wet-sieved using a muslin cloth to allow the flow of extract referred to as 'soymilk' and retain the cake known as 'soymilk residue or okara'. The residue was air-dried in an electrically operated cabinet dryer at 50±5 oC for 10 hours to granule-like mass or okara. The granules were milled to okara powder of 500 mμ sieve size, which was cooled for 5 minutes at ambient temperature (27±2 ˚C), then packaged in an air-tight zip lock bags and kept in the fridge at – 20 ºC till needed for product formulation and analyses (Adebiyi, Adebowale & Agwo, 2016).

### Experimental design

Five blends of tapioca grits fortified with okara powder were prepared using a binary mixture containing cassava starch and okara powder as: 100%CS+0%KR, 90%CS+10%KR, 80%CS+20%KR, 70%CS+30%KR and 60%CS+40%KR respectively

### Product formulations

Tapioca grits fortified with okara powder was formulated using different mixing proportions for the production of tapioca-okara grits and meal, as shown below:

**Table 1Formulation of tapioca-okara grits from cassava starch and okara powder**

| Sample | Cassava starch (%) | Okara powder (%) |
|---|---|---|
| 100% CS + 0% KR | 100 | 0 |
| 90% CS + 10% KR | 90 | 10 |
| 80% CS + 20% KR | 80 | 20 |
| 70% CS + 30% KR | 70 | 30 |
| 60% CS + 40% KR | 60 | 40 |

CS = Cassava starch; KR = Okara flour.
100% CS + 0% KR = 100-portion Cassava starch without okara powder;
90% CS + 10% KR = 90- portion Cassava starch mixed with 10- portion okara powder;
80% CS + 20% KR = 80- portion Cassava starch mixed with 20- portion okara powder;
70% CS + 30% KR = 70- portion Cassava starch mixed with 30- portion okara powder;
60% CS + 40% KR = 60- portion Cassava starch mixed with 40- portion okara powder

**Production of Tapioca grits fortified with okara**

Composited samples were moistened (20% moisture content) separately and the mass was granulated using a sieve over a pre-oiled stainless-steel pan and constantly stirred. Granules were roasted (120-150 ˚C, 20 min) to form coarse granulated grits (tapioca-okara) in the form of lumps of partly gelatinized starch. The grit was allowed to cool to a temperature of 25±2 ºC and was then packaged in Ziplock bags and was kept (at -20 ºC) until analysed (Adebowale & Ajibode, 2021).

**Chemical analyses**

Proximate composition (moisture, ash, protein, fat and crude fibre contents) was analyzed in the tapioca samples using standard methods (AOAC (2012). Carbohydrate content was determined by difference [100- (% moisture + protein + fat + ash +fibre)]. Energy value was estimated from the conversion factor as: 9 kJ/100 g of lipid, 4 kJ/100 g of carbohydrate, and 4 kJ/100 g of protein (FAO, 2003).

**Sensory evaluation of tapioca meal samples**

Tapioca meal samples were evaluated by 45 semi-trained (19 males and 21 females, aged between 18 and 35 years) panellists notably students and staff of the Polytechnic, who are regular consumers of tapioca meal. Blind-coded samples were presented to the panellists for the actual evaluation. Attributes analyzed were colour, texture, taste, aroma, viscosity, flavour, aftertaste and overall acceptability. The panellists were instructed to assign the score of each attribute using a 9-point hedonic scale ranging from minimum (1= extremely dislike) to maximum (9 = extremely like) points. A 5-point score was set as a minimum level for acceptability of the food product.

**Statistical analysis**

Triplicate readings (except for the sensory evaluation, two sessions only) from the experiments were taken and analyzed with the statistical package for social sciences version 24 for windows (SPSS Inc., USA). Means were separated by one-way analysis of variance (ANOVA) using the Tukey test at a $p < 0.05$ significant level. Both $p < 0.05$ and $p < 0.01$ were regarded as statistically significant and highly significant respectively.

**3. Results**

Table 2 shows the means and standard deviation for the proximate composition and energy value contents of okara-based and the control samples. The moisture and ash contents of samples did show significant differences ($p>0.05$). Protein, fat and fibre contents of samples increased significantly ($p<0.05$) with the addition of okara powder whereas carbohydrate contents decreased significantly. The protein content of the tapioca-based samples ranged between 2.42% and 8.82%. The fat content of the samples ranged from 0.26% in the control (100% cassava starch) to 0.72% in the sample with 40% okara powder addition. The ash content of the sample ranged from 2.62% to 2.92%in 100%

cassava starch and 40% okara powder addition respectively. The carbohydrate content ranged between 77.5% in the sample with 40% okara powder addition and 84.14% in the control sample. The values obtained showed a significant ($p<0.05$) decrease in carbohydrate content with a corresponding increase in protein, fat, and ash content. The crude fibre of the samples ranged from 2.13% to 2.42% at 0% and 40% addition of okara powder respectively. Although there was a slight increase in the crude fibre of okara-based samples. A steady increase in the energy values of samples was recorded in Table 2. The energy values of okara-based samples were not significantly ($p>0.05$) different from the control. Though, the energy values of okara-based samples were higher than that of the control.

**Table 2: The mean proximate composition (%) and energy value contents of the control and okara-based meal** samples

| Parameters (%) | 100%CS+0%KR | 90%CS:10%KR | 80%CS:20%KR | 70%CS:30%KR | 60%CS:40%KR | *p*-values |
|---|---|---|---|---|---|---|
| Moisture | 8.42 ± 0.01 | 8.24±0.09 | 8.02±0.09 | 7.85±0.01 | 7.60±0.07 | 0.058 |
| Protein | 2.42±0.01$^{d}$ | 4.82±0.02$^{c}$ | 6.22±0.01$^{b}$ | 8.12±0.01$^{a}$ | 8.82±0.01$^{a}$ | 0.014 |
| Fat | 0.26±0.05$^{c}$ | 0.42±0.07$^{bc}$ | 0.56±0.03$^{b}$ | 0.64±0.09$^{ab}$ | 0.72±0.01$^{a}$ | 0.018 |
| Ash | 2.62±0.01 | 2.74±0.02 | 2.84±0.01 | 2.88±0.01 | 2.92±0.02 | 0.065 |
| Crude fibre | 2.13±0.03$^{c}$ | 2.22±0.01$^{b}$ | 2.35±0.01$^{ab}$ | 2.35±0.01$^{ab}$ | 2.42±0.01$^{a}$ | 0.024 |
| Carbohydrate* | 84.14±0.03$^{a}$ | 81.54±0.05$^{ab}$ | 80.02±0.08$^{b}$ | 78.12±0.04$^{c}$ | 77.50±-0.02$^{cd}$ | 0.012 |
| Energy value$^{\&}$ | 348.6±2.8 | 349.2±2.6 | 350.0±3.2 | 350.7±3.1 | 351.8±3.7 | 0.052 |

Values are means of replicate determinations (n=3) on fresh weight basis; means within rows have different superscript differ significantly ($p<0.05$).

*Calculated by difference.

$^{\&}$Calculated in kcal/100 g.

CS = Cassava starch; KR = Okara flour.

100% CS + 0% KR = 100-portion Cassava starch without okara powder;

90% CS + 10% KR = 90- portion Cassava starch mixed with 10- portion okara powder;

80% CS + 20% KR = 80- portion Cassava starch mixed with 20- portion okara powder;

70% CS + 30% KR = 70- portion Cassava starch mixed with 30- portion okara powder;

60% CS + 40% KR = 60- portion Cassava starch mixed with 40- portion okara powder.

Table 3 shows that four sensory attributes of the sample are significant ($p<0.05$), notable are taste, viscosity, flavour and aftertaste while colour, texture and aroma are not significantly ($p>0.05$) different. The sample with 60% cassava starch and 40% okara powder was rated highest in terms of taste (8.66), texture (8.60), aroma (8.90), and aftertaste (8.33), flavour (8.20) and overall acceptability (8.45). However, the control sample (100%CS+0%KR) was the most preferred in terms of colour (8.53) and willingness to buy (8.66) while the sample with 80% cassava starch and 20% okara powder was rated highest in terms of viscosity (8.06) while the sample with 90% cassava starch and 10% okara powder was rated highest in terms of aroma (9.91) and taste after feeling (8.20).

Table 3 Mean scores of sensory attributes of the control and okara-fortified tapioca samples

| Parameters | Sensory attributes | | | | | | | Overall acceptability | Willingness to buy |
|---|---|---|---|---|---|---|---|---|---|
| | Colour | Taste | Texture | Aroma | Viscosity | Flavour | Aftertaste | | |
| 100%CS+:0%KR | 8.53$^{a}$ | 8.00$^{c}$ | 8.33 | 8.33 | 8.00$^{a}$ | 7.93$^{c}$ | 7.46$^{d}$ | 7.80$^{bc}$ | 8.66$^{a}$ |
| 90%CS+10%KR | 7.93$^{b}$ | 8.26$^{a}$ | 8.06 | 8.40 | 7.93$^{a}$ | 8.20$^{a}$ | 7.93$^{b}$ | 7.93$^{b}$ | 8.06$^{b}$ |
| 80%CS+20%KR | 7.86$^{c}$ | 7.73$^{d}$ | 8.13 | 8.54 | 7.06$^{bc}$ | 8.13$^{b}$ | 7.66$^{c}$ | 7.66$^{c}$ | 7.93$^{bc}$ |
| 70%CS+30%KR | 8.20$^{ab}$ | 8.13$^{bc}$ | 8.46 | 8.33 | 7.86$^{b}$ | 8.13$^{b}$ | 8.00$^{a}$ | 8.40$^{a}$ | 8.46$^{ab}$ |
| 60%CS+40%KR | 8.33$^{a}$ | 8.66$^{a}$ | 8.60 | 8.90 | 7.00$^{c}$ | 8.20$^{a}$ | 8.33$^{a}$ | 8.45$^{a}$ | 8.53$^{a}$ |

Values are means of two sensory sessions using panellists (n=45). Means within same column with different superscript(s) differ significantly ($p<0.05$).

CS = Cassava starch; KR = Okara flour.
100% CS + 0% KR = 100-portion Cassava starch without okara powder;
90% CS + 10% KR = 90- portion Cassava starch mixed with 10- portion okara powder;
80% CS + 20% KR = 80- portion Cassava starch mixed with 20- portion okara powder;
70% CS + 30% KR = 70- portion Cassava starch mixed with 30- portion okara powder;
60% CS + 40% KR = 60- portion Cassava starch mixed with 40- portion okara powder

**4. Discussion**

Moisture content is an index of flour shelf-life and product stability measured. The moisture contents of tapioca grits samples in table 2 were below the 10% level which is an official recommendation by the Standard Organization of Nigeria (SON, 1988). Lower moisture contents (<10%) in all the samples suggest that the tapioca samples have the potential for a longer shelf-life. A probable explanation for the longevity is that mould infestation will not be able to thrive at this moisture level, unlike the unprocessed raw materials (cassava tubers and wet okara) whose moisture level is extremely higher. Consequently, the higher moisture content is detrimental to the stability of foods like tapioca because bio-chemical reactions such as oxidation are favoured, leading to poor food quality and consumer rejection (Bello *et al*., 2021).

The increase in protein, ash and fibre contents in tapioca samples in the present study results suggests that the addition of okara powder increases the proportion of protein, ash and fibre contents present in cassava starch. Cassava starch is known to be poor in these nutrients and implies that okara powder is higher in these nutrients compared to cassava starch. This development could be of interest to the consumers because of the increasing addition of nutrients (Kharel *et al*., 2021) from okara powder. The decrease in carbohydrate content may be that okara powder is low in starch, which caused further dilution of the main raw material (cassava starch). These results thus agree with some reports elsewhere with improvement in the nutritional values of tapioca fortified with almond (Adeboye *et al*., 2019), (Makinde & Olaitan, 2020), cookies from flour blends of cassava, mungbean and coconut pomace (Bello *et al*., 2021) and tapioca fortified with coconut residue (Adebowale & Ajibode, 2021).

Cassava starch, like other known starches, has a low lipid content of less than 0.60%. The little increase in the fat content of tapioca could be that okara powder contains some amount of fat not totally removed during soymilk extraction from soybean slurry. Some lipid bodies were not extracted along with the extract of soymilk (in section 2.2.2 above), perhaps the lipids are bound with the residue. This could be a likely explanation for the little increase in fat content of okara-based samples containing. Ash is the inorganic elements in food left after incineration in an oven. The increasing content of ash in tapioca samples due to the addition of okara powder in cassava starch for tapioca production could be because of the presence of inorganic or mineral elements in okara powder. Increasing amount of ash found in the present study agrees with the findings on tapioca-based reports (Adeboye *et al*., 2019; Adebowale & Ajibode, 2021).

Okara is rich in dietary fibre which is higher than that in wheat bran. Increase in fibre found in the current study agrees respectively with the findings on cookies developed from flour blends containing cassava, mungbean and coconut pomace (Bello et al., 2021), and tapioca processed from cassava starch and coconut residue mixes (Adebowale & Ajibode (2021). Furthermore, the increase in the crude fibre content of okara-based tapioca in the present study has the potential to promote human health if incorporated in diets, because of the roles play by fibre in the alimentary canal during digestion of food. Food material with dietary content exceeding 3 g/100 g is a 'source of fibre' going by the nutritional claim elsewhere (Matsumoto *et al.*, 2007). So, sample 60%CS+40%KR with a higher percentage of okara powder has nearly 3 g fibre/100 g (Table 2), maybe a potential" source of dietary fibre" to some extent going by the above assumption.

Okara naturally has a very low digestible carbohydrates but no gluten and this assertion could mean that, okara has the potential to promote health in the human diet. The much reduction in carbohydrate content of the samples due to the substitution of okara powder to cassava starch dilutes the blends more, thereby causing a reduction in the content of starch and carbohydrate. Principally, cassava root contains more starch than okara powder. Again, the present finding further agrees with some previous reports citing a reduction in the contents of carbohydrates in tapioca due to fortification with defatted almond (Adeboye *et al*., 2019), coconut residue (Adebowale & Ajibode, 2021) and biscuits made from cassava starch and okara flour (Makinde & Olaitan, 2020). The energy values increase with increasing levels of okara powder to cassava starch for the production of tapioca grits indicating that okara powder contributes little to the calorific or energy contents of the fortified samples. Thus, okara is not a good source of carbohydrates.

A higher score for colour in the control over okara-based tapioca could be that consumers are primarily familiar with the creamy or off-white appearance which is peculiar to the convectional tapioca (100% cassava starch), the control. The addition of okara powder to cassava starch has a noticeable colour change (creamy yellow) on the tapioca fortified with okara powder when compared with the control which is white. Similarly, the addition of okara powder influences the taste, aroma and flavour of tapioca meal, unlike 100%CS+0%KR tapioca which has a bland taste. The reduction in the viscosity of tapioca meal suggests that okara powder dilutes the tapioca which principally is rich in starch. The particular component is okara that could be responsible for the reduction in the viscosity of the meal is dietary fibre. The much noticed of aftertaste in okara-based tapioca could be due to the residual beany flavour of the

soybean, from which okara is a by-product. The intensity of the aftertaste increased with the increasing concentration of okara powder in cassava starch. However, despite the existence of a significant difference in overall acceptability, all the samples were rated high and they were found to be acceptable to a greater extent. This is because the rating scores by the panellists were above average (5) set for the acceptability in the present study. Panellists are showing a willingness to buy the product (okara-based tapioca), especially those samples containing a higher concentration of okara. This assertion is based on the panel's score of okara-based tapioca, which was not significantly different from the control. A possible explanation for this assumption could be that the products containing a high concentration of okara powder have good colour (golden-yellow) appeal unlike the control (dirt or off-white).

## 5. Conclusion

The addition of nutrient-dense okara powder to cassava starch improves the nutritional value of tapioca grit and enhances consumers' acceptability of tapioca meals. Fortifying cassava starch with okara powder could be a way to improve the nutritional (protein, ash and crude fibre contents) and sensory qualities of tapioca meal. Looking at the score of the overall acceptability, one could imply that, consumers prefer tapioca with 30% okara powder over the other samples. With the improvement in the nutritional quality, okara powder at 30% inclusion has the tendency to solve protein deficiency in tapioca meals. Food utilization of okara could reduce food waste from the soymilk or tofu processing industry and thus, prevent environmental pollution. Thereby, fulfilling the campaign by the FAO of the UN on the SDG12; reducing okara-a food waste and solving nutritional deficiencies by taking the nutritional advantage of okara.

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