Steamed Maize Pudding Formulated From Maize and African Yam Bean Flour

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Abstract

Studies were conducted on the chemical, functional, pasting and sensory properties of flour blends with ukpo oka formulated from maize- African yam bean flour (AYBF) in order to improve the nutritional content of maize and encourage a wider utilization of the legume, AYB. Supplementation of maize and African yam flour was done in the ratio of 100:0, 50:50, 60:40 and 20:80 for maize: African yam bean flour, respectively. Proximate composition, functional properties, pasting properties of the flour blends was determined and sensory attributes of the products were also evaluated. The result showed that supplementation of maize with African yam bean flour significantly increased the protein, ash and fiber content of the flour blends with values ranging from 3.91 – 11.08%, 2.90 - 6.60% and 0.67 - 1.82% for protein, ash and fiber contents, respectively. The protein, ash and fiber contents increased with addition of African yam bean flour while carbohydrate content of maize- African yam bean blends decreased with increase in the level of African yam bean. The values for functional properties ranged from 0.72 – 0.82g/ml, 99.33 – 323.33%, 9.01 – 19.65%, 690.00 - 978.33%, 0.67 – 1.13%, and 0.484 – 1.038% for bulk density, foaming capacity, emulsion capacity, swelling capacity, water absorption capacity and oil absorption capacity, respectively. Values for pasting properties of the flour blends expressed in rapid visco unit (RVU) ranged from 129.25 – 209.40, 22.55 – 67.93, 60.21 – 124.62 , 145.25 – 247.67 , 83.37 – 84.56 , 5.47 – 5.97 and 87.19 – 141.35 for peak viscosity, break down viscosity, set back viscosity, final viscosity, pasting temperature, peak time and trough, respectively. Set back viscosity and final viscosity increased with increase in the levels of African yam bean while break down viscosity decreased with the increase in the levels of African yam bean. The products were highly rated in all sensory attributes evaluated, however, aroma decreased with increase in the levels of AYBF. Product made from flour blend 50:50 was the most preferred in terms of general acceptability.

Key words: African yam bean flour, Functional properties, Maize flour, Pasting properties, Ukpo oka.

Introduction

Maize (Zea mays) is one of the most popular cereal crop cultivated in the tropical and sub-tropical regions of the world. It is grown for its rich carbohydrate content. Maize is processed and used in food preparations such as breakfast cereal, weaning foods and other snacks such as maize pudding, maize cake, etc. Maize like other cereals is low in protein content and deficient in lysine, an essential amino acid useful in biological process for growth of tissues and absorption of calcium from the intestinal mucosa (Onimisi et al., 2009), Sule et al. (2014) reported a low protein content (4.5 to 9.87%) for maize and products obtained from selected markets in Kaduna State, Nigeria.

However African yam bean (Sphenostylis stenocarpa) is reported to be rich in protein, vitamins and minerals than other legumes like cowpea and pigeon pea. It is a good supplement for cereal-legume based diet (Idowu, 2015). African yam bean (AYB) however is poorly utilized and classified as neglected underutilized species (Amoatey et al., 2000; Idowu, 2015). Its poor utilization is as result of rigorous steps during processing, long cooking time, hard seed coat, near extinction of the seed and poor research interest. African yam bean has the ability to provide the daily requirement of protein for people whose diet is deficient in protein when fully utilized as supplements in cereal based diets. Its protein content is reported to range from between 20.2 and 21.2 percent. Amino acid profile indicates that lysine and methionine levels in the protein are equal to or greater than those of soybeans. Most of the essential amino
acid corresponds to WHO/FAO recommendations (Evans and Boulter, 1974).

Ukpo oka (steamed maize pudding) is a cereal based food product similar to moi-moi. It is made from maize, pepper, salt, onions with addition of palm oil. Ukpo oka is low in protein and often consumed without any protein supplement. Cereal-legume supplementation is well documented and researched. Agu and Aluyah, (2004) studied the production and chemical analysis of weaning food from maize, soy bean and fluted pumpkin seed flour. Alabi and Anuonye, (2007) reported the nutritional and sensory attributes of soy supplemented cereal meals while Akpapunam and Darbe, (1994) studied the composition and functional properties of blends of maize and bambara groundnut flours for cookies production. In their works, supplementation of cereal with legume significantly improved the nutritional content of the cereal-legume based diet; however no work has been done to enrich ukpo oka, a popular maize pudding in the South East Nigeria. Ukpo oka is consumed as breakfast or lunch among the low income earners. It is eaten by children, adults and the elderly. Supplementing ukpo oka with African yam bean would likely improve the protein diet of the people where it is mostly consumed, solve the problem of protein-energy malnutrition (PEM) and encourage wider utilization of the legume. This study determined the effect of supplementing maize with African yam bean on the physicochemical, pasting properties and sensory properties of flour blends with ukpo oka.

MATERIALS AND METHODS

Collection of Sample

The yellow variety of maize (Zea mays) and African yam bean (Sphenostylis stenocarpa) were purchased from Nkwo Inyi market, Oji River, Enugu State Nigeria. Palm oil and other ingredients were purchased from Abakpa meat market, Abakaliki Ebonyi State Nigeria. All analyses were carried out in the laboratory of the Department of Food Science and Technology, Ebonyi State University. A questionnaire describing the quality was given to each panelist. The panelist assigned scores for each parameter as against the maximum score of 9. Each sensory attribute was rated on 9 point hedonic scale (1= dislike extremely and 9 like extremely) as described by Ihekoronye and Ngoddy, (1985). The products were coded and served to the panelists. Water and unsalted crackers were provided for the panelist to cleanse their palate between samples. After palate cleaning, a pause of 15seconds was imposed before the panelists could assess the next sample.

Preparation of Maize Flour

Maize flour was prepared by the method described by Idowu, (2015).

Preparation of African Yam Bean

African yam bean (AYBF) was prepared according to the method of Eke, (2002).

Production of Ukpo Oka

Maize and African yam bean were prepared by mixing the flour in the ratios; 100:0, 50:50, 80:20, 60:40, 20:80 of maize: African yam bean flour, respectively. The ingredients used include, 2 big onions, 2 table spoons of grounded crayfish, 20 cl of red oil, 2 cubes of maggi, 3 red bell pepper, 1 table spoon of salt and 250mL of water. The blends were thoroughly mixed in a laboratory Hobart mixer at medium speed for 5mins, packaged with plantain (Musa paradisiaca) leaves and cooked for 45 minutes.

Proximate Composition

The moisture, ash, fat and fiber contents of the flour blends were determined according to AOAC (2000) methods. The crude protein was obtained by determining the nitrogen content of the sample using micro kjeldahl method and multiplying the nitrogen by a conversion factor of 6.25. Carbohydrate content (CHO) of the samples were determined by difference method as CHO = (% moisture + %protein +%ash + % fat + % fiber). Food energy value (K/cal /100g) was determined according to the method of Marero et al., (1998) using the factor [(4 x % protein) + (4 x % carbohydrate) + (9 x % fat)]

Functional Properties

Foaming capacity, water absorption capacity (WAO), oil absorption capacity (OAC) and emulsion capacity of the flour blends were determined by the method described by Okezie and Bello (1988). Swelling index and bulk density were determined by the method described by Onwuka (2005).

Pasting Properties

Pasting properties of the flour blends were determined according to the method described by walker et al., (1988) using the Rapid Visco Analyzer New Port Scientific Australia model RVA 3D + Newport scientific Australia.

Organoleptic Evaluation

The product (ukpo oka) was assessed for organoleptic quality attributes of colour, texture, appearance, taste, mouth feel, aroma and general acceptability by 32 panelist familiar with the taste of ukpo oka. The panelists were made up of students and staff of the Department of Food Science and Technology, Ebonyi State University. A questionnaire was used to evaluate the quality was given to each panelist. The panelist assigned scores for each parameter as against the maximum score of 9. Each sensory attribute was rated on 9 point hedonic scale (1= dislike extremely and 9 like extremely) as described by Ihekoronye and Ngoddy, (1985). The products were coded and served to the panelists. Water and unsalted crackers were provided for the panelist to cleanse their palate between samples. After palate cleaning, a pause of 15seconds was imposed before the panelists could assess the next sample.

Statistical analysis

Data obtained were subjected to statistical analysis (ANOVA) using a statistical package for social science (SPSS) version 20 to detect significant difference among sample mean. Turkeys test was used to separate means. Significance difference was accepted at 5% confidence level.

RESULTS AND DISCUSSION

Proximate Composition

The result of the proximate composition of Maize-African yam bean (AYBF) flour blends is presented in Table 1. Moisture content can affect the physicochemical properties of food which directly corresponds to the freshness and
stability of food products for consumers. The result from this work showed that the moisture content ranged from 5.50% to 10.00%. The values obtained in this study were within the range (8.26-10.04%) reported by Jipara et al., (2001) for powdered weaning food fortified with germinated cowpea flour. Flour blend, 60:40 had the highest value of moisture content while the flour blend, 80:20 had the least. The moisture content obtained in this work is desirable since high moisture content might affect the storability and quality of the product (Agu and Aluyah, 2004). Low moisture content would extend the storage stability of complementary foods and other flour based food products (Nkama et al., 2001).

The protein content of the flour blend increased significantly with the addition of African yam bean. Increase in protein content may be attributed to the complementary role of African yam bean flour (Idowu, 2015). Olaoye et al., (2006) also observed an increase in protein content with corresponding increase in the proportion of soy flour supplementation in bread produced from composite flour of wheat plantain and soybean. The findings also agree with the report of Adebowale et al., (2012) who observed an increased trend in the protein content (7.06 – 11.84%) of cookies made from sorghum – wheat flour blends. Protein content in this work ranged from 3.91% to 11.08%. Flour blend, 20:80 had the highest protein content while flour blend, 100:0 had the least protein content.

Ash content of the blends ranging from 2.90% to 6.60% gives an indication of the mineral composition of the blends. The values were higher than those reported by Agu and Aluyah (2004) for weaning food from maize, soybean and fluted pumpkin seed flour (0.6 -2.0%). Significant increase was obtained in ash content of the flour blends with increasing quantity of AYBF. Ash helps in the breakdown of other compounds such as fat, protein and carbohydrate (Okaka and Ene, 2015). High ash content indicates high levels of minerals in the flour that will provide more mineral nutrient to the consumers.

Fat content of the blends ranged from 1.62% to 3.67%. The values reduced with increasing quantity of AYF flour. This may be attributed to low fat content of AYF flour (Amoatey et al., 2000). The fat content obtained from the flour blends is lower than the recommended value (FAO, 1966). The decrease in fat content is of interest to consumers interested in consumption of low fat food products. This is also beneficial because a number of health organizations including the World Health Organization (WHO) have made recommendation to reduce daily fat intake for improved health (WHO, 1990). The shelf life of the blends may however be increased due to low fat content since all fats containing foods have some unsaturated fatty acids and hence are potentially susceptible to oxidative rancidity.

The fiber content decreased with increased in maize flour. This could be due low fiber content in maize (Idowu, 2015). High fiber content in African yam bean is desirable since it may contribute to bulkiness in food and aid bowel movement and prevention of many gastrointestinal diseases in man (Satinder, et al., 2011). Fiber content ranged from 0.67% to 1.82%.

The carbohydrate content ranged from 70.92% to 80.33%. Flour blend, 80:20 had the highest carbohydrate content while flour blend, 20: 80 had the least. The carbohydrate content of maize- African yam bean blends decreased with increase in the level of African yam bean. This is due to the fact that maize being a cereal is rich in carbohydrate content. Statistical analysis showed significant difference (p<0.05) between flour blend, 80:20 and 20: 80 and no significant difference (p>0.05) between flour blend, 100: 0 and 80:20. Flour blend 100:0 had the highest energy value while flour blend 20:80 had the least. This is due to the fact that maize being a cereal product is rich in carbohydrate content. Food energy measured the amount of energy expanded. The protein, fat and carbohydrate constituents of the blends could contribute to the energy value of *ukpo oka*.

**Functional Properties**

The results of the functional properties of maize- African yam bean flour blend is shown in Table 2. Flour blend, 80:20 had the highest bulk density while the flour blend, 50:50 had the least bulk density. The bulk density decreased significantly with increasing levels of African yam bean. The values were higher than those for African bread fruit- wheat flour blends (0.71 -0.80g/cm^3) reported by Akubor et al., (2000) and bambara groundnut (0.60 - 0.75 g/cm^3) as reported by Onimawo et al., (1998). Bulk density (BD) gives an indication of relative volume of packaging materials

| Samples | Moisture (%) | Protein (%) | Ash (%) | Fat (%) | Carbohydrate (%) | Fiber (%) | Energy Kcal/100g |
|---------|--------------|-------------|---------|---------|------------------|-----------|-----------------|
| A       | 9.00^a       | 3.91^a      | 2.90^a  | 3.67^a  | 78.93^a          | 1.59^a    | 360.33^a        |
| B       | 6.17^b       | 7.40^b      | 4.70^bc | 3.17^b  | 77.49^bc         | 1.07^b    | 322.14^b        |
| C       | 5.50^b       | 5.30^b      | 5.23^b  | 2.97^b  | 80.33^b          | 0.67^bc   | 334.52^bc       |
| D       | 10.00^c      | 5.90^c      | 6.60^c  | 3.37^c  | 72.31^bc         | 1.82^c    | 308.45^c        |
| E       | 9.00^a       | 11.08^a     | 6.50^a  | 1.62^a  | 70.92^a          | 0.88^b    | 291.84^a        |
| LSD     | 1.25         | 2.15        | 1.35    | 0.49    | 9.21             | 0.44      | 9.27            |

*Means in the same column with different superscripts are significant different (P<0.05), A = 100% maize flour, B = 50% maize flour: 50% AYBF, C = 80% maize flour: 20% AYBF, D = 60% maize flour: 40% AYBF, E = 20% maize flour: 80% AYBF.*
required. High bulk density may indicate greater compactness of the particles because particle size is inversely proportional to bulk density (Falade and Olugbuyi, 2010). Foaming capacity (FC) increased significantly (p<0.05) with increasing level of African yam bean. The value ranged from 99.33 to 323.33%. The increased foaming in the blends may be attributed to the increasing protein content due to addition effect (Yasumatsu et al., 1972). The emulsion capacity value ranged from 9.01 to 19.65%. Emulsion capacity (EC) has been reported to vary with type, concentration and solubility of proteins flour (Yasumatsu et al. 1972). The results showed that these variations were related to the concentration of African yam bean flour proteins in the blends. Achi (1999) reported similar result for soy supplemented yam flour.

Swelling capacity (SC) increased significantly with increasing levels of African yam bean. The value ranged from 690.00 to 978.33%. Increase in swelling capacity may be attributed to increase in protein concentration of the flour blends. Water absorption capacity (WAC) is the ability of a product to associate with water under condition where water is limiting (Omuet et al., 2009). Higher water absorption capacity may be attributed to the proportion of the hydrophilic and hydrophobic amino acids in the protein and relative amounts of carbohydrate. The high water absorption capacity of the flour blend, 20:80 may be attributed to the addition of African yam bean, however, water absorption capacity ranged from 0.67 to 1.13%. Oil absorption capacity (OAC) is the ability of a product to associate with oil under condition where oil is limiting. Oil absorption capacity ranged from 0.484 to 1.038%.

Pasting Properties

The results of the pasting properties of Maize- African yam bean flour blend is shown in Table 3. The peak viscosity (PV) is the ability of starch to swell freely before their physical breakdown. It ranged from 129.25 to 209.40RVU. Flour blend, 80:20 had the highest peak viscosity of 209.40 RVU while flour blend, 60:40 had the lowest peak viscosity of 129.25RVU. Statistical analysis showed significant difference (p<0.05) among the flour blends. The break down viscosity (BDV) value is an index of the stability of starch during cooking (Zaidhul et al., 2006). Flour blend, 80:20 had the highest value of 67.93 RVU while the flour blend, 60: 40 had the least of 22.55 RVU. Ikegwu et al., (2010) reported that the lower the breakdown viscosity, the higher the ability of the flour to withstand heating and shear stress during processing. High holding strength exhibited by the flour blend, 80:20 showed that the flour could withstand heating and shear stress during processing without significant change in consistency. The breakdown viscosity reported in this work is higher than that reported by Okorie et al., (2016) for water yam and cowpea composite flour of 12.42 - 27.58 RVU.

The set-back viscosity (SBV) ranged from 0.67 to 124.62 RVU. Flour blend, 20:80 had the highest value while flour blend, 50:50 had the least. Statistical analysis showed significant difference (p<0.05) among the flour blends. It has been reported that low set-back value is an indication that the starch has a low tendency to retrograde or undergo syneresis during freezing or thawing (Ikegwu et al., 2010). This means that the flour blend, 50:50 might be stored at low temperature with low tendency to retrograde.

### Table 2: Functional properties of maize- African yam bean flour blends.

| Sample | BD (g/ml) | FC (%) | EC (%) | SC (mL) | WAC (%) | OAC (%) |
|--------|-----------|--------|--------|---------|---------|---------|
| A      | 0.75<sup>a</sup> | 99.33<sup>a</sup> | 16.43<sup>ab</sup> | 978.33<sup>a</sup> | 0.67<sup>ab</sup> | 1.038<sup>a</sup> |
| B      | 0.72<sup>b</sup> | 276.67<sup>a</sup> | 13.45<sup>ab</sup> | 773.33<sup>b</sup> | 0.85<sup>b</sup> | 0.484<sup>b</sup> |
| C      | 0.82<sup>c</sup> | 150.00<sup>c</sup> | 10.41<sup>ab</sup> | 775.00<sup>c</sup> | 0.76<sup>b</sup> | 0.717<sup>c</sup> |
| D      | 0.80<sup>c</sup> | 173.33<sup>c</sup> | 9.01<sup>b</sup> | 786.67<sup>c</sup> | 0.81<sup>b</sup> | 0.550<sup>c</sup> |
| E      | 0.78<sup>c</sup> | 323.33<sup>c</sup> | 19.65<sup>b</sup> | 978.33<sup>c</sup> | 1.13<sup>bc</sup> | 0.629<sup>bc</sup> |
| LSD    | 0.073    | 79.83  | 8.29   | 69.9    | 0.22    | 0.20    |

Means in the same column with different superscripts are significant different (P<0.05). A = 100% maize flour, B = 50% maize flour: 50% AYBF, C = 80% maize flour: 20% AYBF, D = 60% maize flour: 40% AYBF, E = 20% maize flour: 80% AYBF.

### Table 3: Pasting properties of maize and African yam bean blends.

| Samples | PV | BDV | SBV | FV | PT | Peak time | Trough |
|---------|----|-----|-----|----|----|-----------|--------|
| A       | 163.91<sup>b</sup> | 28.21<sup>c</sup> | 108.61<sup>b</sup> | 243.59<sup>a</sup> | 84.23<sup>a</sup> | 5.67<sup>a</sup> | 137.41<sup>a</sup> |
| B       | 133.90<sup>c</sup> | 48.46<sup>a</sup> | 60.21<sup>d</sup> | 145.25<sup>d</sup> | 83.37<sup>d</sup> | 5.65<sup>ab</sup> | 87.19<sup>d</sup> |
| C       | 209.40<sup>a</sup> | 67.93<sup>c</sup> | 85.83<sup>c</sup> | 226.67<sup>d</sup> | 84.18<sup>d</sup> | 5.80<sup>a</sup> | 141.35<sup>c</sup> |
| D       | 129.25<sup>d</sup> | 22.55<sup>c</sup> | 122.93<sup>a</sup> | 229.37<sup>d</sup> | 83.68<sup>d</sup> | 5.97<sup>c</sup> | 106.64<sup>c</sup> |
| E       | 161.85<sup>b</sup> | 37.92<sup>c</sup> | 124.62<sup>a</sup> | 247.67<sup>c</sup> | 84.56<sup>c</sup> | 5.47<sup>ab</sup> | 123.95<sup>c</sup> |
| LSD     | 3.78 | 1.19 | 1.85 | 1.69 | 0.14 | 0.31 | 3.99 |

Means in the same column with different superscripts are significant different (P<0.05). A = 100% maize flour, B = 50% maize flour: 50% AYBF, C = 80% maize flour: 20% AYBF, D = 60% maize flour: 40% AYBF, E = 20% maize flour: 80% AYBF.
Final viscosity (FV) ranged from 145.25 to 247.67 RVU. Final viscosity is used to define the quality of a particular starch based sample. It indicates the ability of the material to form a viscous paste or gel after cooking and cooling as well as the resistance of the paste to shear force during stirring. The flour blend, 20:80 had the highest value of 247.67 RVU while the flour blend, 50:50 had the least value of 145.25 RVU.

The pasting temperature (PT) is the temperature above the gelatinization temperature at which the viscosity begins to rise. It provides the minimum temperature required to cook a sample. It is the temperature at which the first detectable increase in viscosity is measured and is an index characterized by initial change due to the swelling of starch. Higher pasting temperature implies higher gelatinization, higher water binding capacity and lower swelling property of starch due to a high degree of association between starch granules. Pasting temperature ranged from 83.37 to 84.56 RVU. Peak time obtained from the flour blend ranged from 5.47 to 5.97 min. Statistical analysis showed no significant difference (p>0.05) among the flour sample. Peak time is a measure of the cooking time (Adebowale et al., 2005). It is the time at which the peak viscosity occurs.

Trough value ranged from 87.19 to 141.35 RVU. Flour blend, 80:20 had the highest value of 141.35 RVU. Trough value of flour blend, 50:50 had the least value. Statistical analysis showed significant difference (p<0.05) among the flour sample. Trough value of flour blend, 50:50 was the most preferred, followed by 80:20 while the product made from flour blend, 20:80 was least preferred.

**Sensory Properties**

The result of the sensory properties of ukpo-oka is shown in Table 4. The products were highly rated in all attributes evaluated. Aroma decreased with increase in levels of African yam bean. Product made from flour blend, 80:20 was the most preferred in terms of aroma while product made from flour blend, 20:80 was least preferred. Product with flour blend, 80:20 had the highest colour value while the product with flour blend, 20:80 had the least. Texture was found to increase with increase in levels of African yam bean. Statistical analysis showed no significant difference (p>0.05) on texture of ukpo-oka at different flour blends except flour blend, 100:0. The product made from flour blend, 80:20 was most preferred in terms of taste while the product made from flour blend, 20:80 was least preferred. Mouth feel was found to be high in product made from flour blend, 50:50 and least in product made from flour blend, 100:0. In general acceptability, the product made from flour blend 50:50 was the most preferred, followed by 80:20 while the product made from flour blend, 20:80 was least preferred.

**CONCLUSION**

The study showed that poor nutritional quality of ukpo-oka (a steamed maize pudding) can be improved through supplementation with African yam bean. This is reflected in the improved protein (3.91 -11.08%), ash (2.90 – 6.60%) and fiber (0.67 -1.82%) contents of the samples. It can serve as a nutritious household food and help address the problem of protein – energy malnutrition. The supplementation of maize- African yam bean in processing of ukpo-oka also improves the functional and pasting properties of the flour blends. The products were highly rated in all sensory attributes evaluated, however, the product made from flour blend, 50:50 was the most preferred in terms of general acceptability.

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**Table 4: Sensory properties of ukpo-oka made from blends of maize and African yam bean flour.**

| Sample | Aroma | Colour | Texture | Taste | Mouth feel | General acceptability |
|--------|-------|--------|---------|-------|------------|----------------------|
| A      | 6.41* | 6.75*  | 4.31b   | 5.69b | 4.66b      | 5.69b                |
| B      | 6.34* | 5.66b  | 6.16a   | 6.69a | 6.47a      | 6.75*                |
| C      | 6.7*  | 6.72a  | 6.19a   | 6.69a | 6.34a      | 6.73*                |
| D      | 6.19* | 6.16ab | 5.94a   | 6.03ab| 6.03ab     | 6.5ab                |
| E      | 5.8*  | 4.25c  | 5.75a   | 5.31b | 5.16a      | 4.94*                |
| LSD    | 0.90  | 0.98   | 0.98    | 0.98  | 0.98       | 0.90                 |

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