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ORIGINAL ARTICLE

# Quality evaluation of stiff porridges prepared from Irish potato (*Solanum tuberosum*) and pigeon pea (*Cajanus cajan*) starch blends

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**Abstract** Quality attributes of stiff porridges prepared from Irish potato and pigeon pea starch blends were studied. Starches were extracted from Irish potato and pigeon pea using a wet extraction method. Various ratios of the starches were mixed and analyzed for chemical, functional and pasting properties. The starch blends were then prepared into stiff porridges for sensory evaluation using a 20-man sensory panel. Substitution of Irish potato starch with pigeon pea starch led to increases in protein (0.15 to 1.2%), fat (0.26 to 0.56%) and ash (0.30 to 0.69%) while the amylose content of the starch blends decreased (from 23.8 to 18.4%) respectively. Functional properties such as bulk density (0.75 to 0.60 g/cm$^3$), water absorption capacity (3.1 to 2.6 g water/ g sample) and dispersibility (58.6 to 42.7%) decreased significantly ($P<0.05$) at the highest concentration (50%) of pigeon pea starch respectively. Pasting properties such as peak, breakdown, final and setback viscosities increased with increasing levels of pigeon pea starch while peak time and pasting temperature decreased. The sensory attributes of stiff porridges were not adversely affected by pigeon pea starch inclusion. Therefore it should be possible to incorporate up to 50% of low digestible pigeon pea starch into Irish potato starch from legumes such as pigeon pea as alternatives to cassava starch in the preparation of stiff porridges. Such porridges made from Irish potato and legume starches could provide additional incentive for individuals requiring decreased and or slow starch digestibility such as diabetics.

**Keywords** Potato · Pigeon pea · Starch · Stiff porridge · Chemical · Functional · Pasting and sensory properties

## Introduction

Starch is a principal constituent of many foods, a major source of energy and an essential factor in the gross structure, texture or consistency of most foods. Commercial starches are obtained from grains such as maize, wheat and rice, and from roots and tubers such as Irish potato, sweet potato and cassava. In Nigeria, especially in the Southern parts, cassava starch in particular, is used in the preparation of staple stiff porridges which are consumed with stews and vegetable soups. In these parts of Nigeria as with most of sub-Saharan Africa, malnutrition is still prevalent notwithstanding the targets of the United Nations' Millennium Development Goal number one to eradicate hunger (visible and hidden) by 2015. This may be due in part to the frequent consumption of starchy foods that are often low in protein and micronutrients. Cassava, being the main starch source in the preparation of stiff porridges in most Nigerian homes, may be over-exploited especially with the crop being targeted most recently as a principal source of biofuels in Nigeria. There may be the need therefore, for alternative starch sources for the preparation of stiff porridges.

The Irish potato crop grows very well all through the year in Nigeria especially around the Jos, Mambilla, and Obudu plateaus (Anochili 1984). Irish potato (*Solanum tuberosum*) starch typically contains 0.30% ash, 0.88%

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protein, 0.70% fat, 10.80% moisture, 0.45% chloride and 0.15% phosphate and the crop is classified as a protective vegetable owing to its high vitamin C contents (Ukpabi and Umeh 1990). Pigeon pea (*Cajanus cajan*) is a legume that is also widely cultivated in Nigeria and in other tropical countries (Onwuka 2006). The whole seeds contain 20-22% proteins, 1.2% fat, 65% carbohydrate and 3.8% ash (FAO 1982) and the mineral content and amino acid profile of pigeon pea compares closely with those of soybean (Apata and Ologhobo 1994, Osagie 1998).

Regardless of source, the suitability of starches in foods such as porridges would depend not only on their pasting and functional properties but also on the sensory acceptability of the products made from them. Pasting properties of starch have been associated with cooking characteristics (Chinma et al. 2009). Pasting is the result of a combination of processes that follows gelatinization from granule rupture to subsequent polymer alignment, due to mechanical shear during the heating and cooling of starches (Otegbayo et al. 2006).

Given the low digestibility of legume starches compared to cereal starches (Sandhu and Lim 2008), the exploitation of lesser known legume starch sources such as pigeon pea could be a useful alternative in the preparation of high demand foods such as stiff porridges especially in situations requiring restricted intake of highly digestible starch-based foods by diabetic patients. In addition to the benefit of serving as a low digestible starch source, such efforts could lead to a reduction in the over-dependence on cassava starch for stiff porridge preparation, reduce post-harvest losses and increase the utilization and potential of these largely underutilized crops in Nigeria and most parts of sub-Saharan Africa. The objectives of the study were to characterize the physicochemical, functional and pasting properties of Irish potato and pigeon pea starch blends and to evaluate the sensory properties of stiff porridges prepared from the starch blends.

## Materials and methods

### Source of raw materials

Approximately 5 kg each of fresh Irish potato tubers and pigeon pea seeds were purchased from a local market in Minna, Niger state, Nigeria. Cassava starch was obtained from a supermarket in Abuja, Nigeria.

### Starch isolation

The wet extraction method described by Ihekoronye and Ngoddy (1985) was adopted. Seven kilograms each of Irish potato tuber and pigeon pea seeds were separately sorted, washed with clean tap water and milled into slurries. The slurries were separately suspended in cold deionized water and sieved to remove the fibrous material leaving the starch in solution. The starch layer was suspended in deionized water and centrifuged at 3000 rpm for 10 min until the settled starch gave a firm, dense deposit at the bottom. The final sediment was suspended in cold deionized water and sieved through 150 μm screen to remove cell wall particles. Then the residues from the starch sources were amassed separately and allowed to settle for 6 h. The starch suspensions obtained were dried in a convection oven at 50 °C until 10% moisture content was achieved. The dried materials were then pulverized using an attrition mill (Globe P 44, China) and sieved using a 75 μm screen to obtain the starch samples.

### Mixing of the starch blends

Irish potato and pigeon pea starches were mixed using the following proportions 100: 0%; 90: 10%; 80:20%; 70:30%; 60:40% and 50:50% respectively. Cassava starch served as control. A Binatone blender (Model no. BLG-450, China) was used for mixing samples at speed 2 for 3 min.

## Determination of functional properties

### Bulk density

The bulk density was determined by the method of Okezie and Bello (1988). Two grammes of sample was added into a 10 ml graduated cylinder and tapped 10 times. The ratio of the mass of the samples to their volumes was recorded as the bulk density. Average values of triplicate determinations were recorded.

### Water absorption capacity

Water absorption capacity was determined by the method of Okezie and Bello (1988). One gram of each sample was mixed at high speed in a flask shaker with 20 ml distilled water for 5 min. After resting at room temperature for 30 min, the contents was centrifuged at 500 rpm for 1 h. The volume of free water was read directly from the graduated tubes. The amount of water (total minus free) was multiplied by its density for conversion to grammes. Water was assumed to have a density of 1.0 g/ml. Water absorption capacity was expressed as grammes of water absorbed per gram of sample.

### Dispersibility

Dispersibility was determined by the method of Kulkarni et al. (1991). Ten gram sample was placed in a stopper measuring cylinder and distilled water was added to reach a volume of 100 ml. The mixture was stirred vigorously and allowed to settle for 3 h. The volume of settled particles was expressed as a percentage to obtain the dispersibility value (%).

### Swelling and solubility

The method of Sathe and Salunkhe (1981) was adopted to determine the swelling power and solubility. One gramme of starch was weighed into a 50 ml centrifuge tube and forty millilitres of 1% starch suspension (*w*/*v*) was added. The slurry was heated in a water bath at 60, 70, 80 and 90 °C, respectively for 15 min with occasional stirring to prevent clumps from forming. After 15 min, the tubes containing the slurry were centrifuged at 3000 rpm for 10 min. The supernatant was decanted and the weight of the residue was noted. A 10 ml sample was from the supernatant was dried in an air convention oven at 120 °C for 4 h to constant weight. Percentage solubility and swelling power was calculated as follows;

$$\text{Percentage solubility} = \text{dry weight at } 120^\circ\text{C} \times 400/\text{sample weight}$$
$$\text{Sweeling power} = \text{weight of swollen granules} \times 100/\text{sample weight} \times (100 - \%\ \text{solubility})$$

### Chemical analyses

Moisture, fat, protein and ash contents were analyzed using the methods described in AOAC (1995). The amylose content of starch was determined using the method of Williams et al. (1970). A 0.1 g of starch was weighed into a 100 mL volumetric flask, then 1 mL of 99.7–100% (*v*/*v*) ethanol and 9 mL 1 N sodium hydroxide were carefully added. The mouth of the flask was then covered with parafilm and the contents were properly mixed. The samples were heated for 10 min in a boiling water bath to gelatinize the starch (the timing was started when boiling began). The samples were removed from the water bath and allowed to cool, and the flasks made up to the mark with distilled water and shaken thoroughly. About 5 mL of the contents of the flask was pipetted into another 100 mL volumetric flask and 1.0 mL of 1 N acetic acid and 2.0 mL of iodine solution added. The flask was made up to the flask mark with distilled water. Absorbance (A) was read using a spectrophotometer at 620 nm wavelength. The blank contained 1 mL of ethanol and 9 mL of sodium hydroxide, boiled and made up to the mark with distilled water following the steps described for the sample. The amylose content was calculated as; $\text{Amylose content}\ (\%) = 3.06 \times \text{absorbance} \times 20$.

### Determination of pasting properties

Pasting parameters were determined using a rapid visco analyzer (Newport Scientific Pty Ltd., Warrie-wood NSW 2102, Australia). A 2.5 g of starch sample was weighed into a previously dried empty canister; then 25 ml of distilled water was dispensed into the canister containing the sample. The starch suspension was thoroughly mixed and the canister was fitted into the rapid visco analyzer. Each suspension was maintained at 50 °C for 1 min and then heated up to 95 °C at a heating rate of 12.2 °C /min and held for 2.5 min at 95 °C. It was then cooled to 50 °C at 11.8 °C /min and kept for 2 min at 50 °C.

### Preparation of stiff porridge and sensory evaluation

Fifty grammes of starch blends were separately reconstituted into paste using approximately 150 ml of boiling water over a low gas flame with continuous stirring for 5 min. A twenty-member panel consisting of students and Staff of Food Science option, Department of Animal Production Federal University of Technology, Minna Nigeria were enrolled based on their familiarity with stiff porridges for the sensory evaluation. Stiff porridge samples from the various blends were provided in coded white plastic plates and cassava starch served as standard. The order of presentation of samples to the panel was randomized. The samples were evaluated for appearance, colour, stickiness, 'mouldability', texture and overall acceptability. Each sensory attribute was rated on a 9-point Hedonic scale (1= disliked extremely while 9=liked extremely).

### Statistical analysis

Data were analyzed by analysis of variance (Steel and Torrie 1980). The differences between mean values were determined using the least significant difference (LSD) test at 5% probability level (Ihekoronye and Ngoddy 1985).

## Results and discussion

### Chemical composition of starch blends

The result of the chemical composition of starch blends (Table 1) shows that the substitution of Irish potato with

**Table 1** Chemical composition of Irish potato and pigeon pea starch blends

| Starch blend Irish potato: pigeon pea | Moisture (%) | Protein (%) | Fat (%) | Ash (%) | Amylose (%) |
|---|---|---|---|---|---|
| 100:0 | $8.0^{b}$±0.13 | $0.15^{bc}$±0.01 | $0.26^{b}$±0.01 | $0.30^{ab}$±0.03 | $23.76^{a}$±0.74 |
| 0:100 | $8.5^{ab}$±0.29 | $1.22^{a}$±0.11 | $0.43^{a}$±0.03 | $0.75^{a}$±0.01 | $21.02^{c}$±1.03 |
| 90:10 | $8.4^{ab}$±0.53 | $0.31^{b}$±0.01 | $0.31^{b}$±0.19 | $0.38^{ab}$±0.12 | $22.15^{b}$±0.92 |
| 80:20 | $8.8^{a}$±0.14 | $0.39^{b}$±0.00 | $0.38^{ab}$±0.01 | $0.46^{a}$±0.25 | $21.80^{d}$±0.80 |
| 70:30 | $9.0^{a}$±0.07 | $0.42^{b}$±0.01 | $0.45^{a}$±0.11 | $0.59^{a}$±0.01 | $20.97^{e}$±0.61 |
| 60:40 | $8.9^{a}$±0.46 | $0.50^{b}$±0.05 | $0.44^{a}$±0.02 | $0.62^{a}$±0.01 | $19.16^{f}$±0.94 |
| 50:50 | $9.2^{a}$±0.05 | $0.61^{b}$±0.00 | $0.56^{a}$±0.02 | $0.69^{a}$±0.13 | $18.39^{g}$±0.22 |

Values are means and standard deviations of three determinations

Values not followed by the same superscript in the same column are significantly different from each other

pigeon pea starch led to increases in the moisture (from 8.0 to 9.2%), protein (from 0.15 to 1.2%), fat (from 0.26 to 0.56%) and ash (from 0.30 to 0.69%) contents while the amylose content of the starch blends decreased (from 23.8 to 18.4%) respectively. Increased moisture, protein, fat and ash contents of the blends with increasing level of pigeon pea starch substitution was due to the addition effect of pigeon pea starch with higher moisture, protein, fat and ash contents than the 100% Irish potato starch. The decrease in amylose content following the addition of pigeon pea starch was unexpected since legumes are known to be generally higher in amylose contents than roots and tubers. However, the observed decreases in amylose contents with pigeon pea starch may be useful in conferring high swelling to the starch blends since low amylose content has been linked to high swelling power owing to low reinforcement of internal network by amylose molecules (Hoover 2001). This finding may be of some economic advantage to processors as well as consumers of starch-based stiff porridges.

## Functional properties of starch blends

The functional properties of starch blends (Table 2) show that the substitution of Irish potato with pigeon pea starch in the blends led to decreased bulk density (from 0.75 to 0.60 g/cm$^3$), water absorption capacity (from 3.1 to 2.6 g water/ g sample) and dispersibility (from 58.6 to 42.9%) respectively. The bulk density reducing value of pigeon pea starch although not statistically significant, could be of advantage during packaging and distribution of the starch blends. Only slight decreases in water absorption capacity of starch blends were observed with increasing level of pigeon pea starch suggesting that both potato and pigeon pea starches possessed somewhat similar water absorbing properties. Water absorption capacity depends on several often interrelated factors such as the nature of the molecules, presence of lipids, hydrophilic and hydrophobic balance in the molecule, thermodynamic properties of the system (such as bond energy and interfacial tension) as well as the physicochemical environment such as pH, ion concentration, temperature and pressure. The dispersibility values obtained in this study were generally higher than the values of 40.66% reported for breadfruit starch (Akanbi et al. 2009). However, the decreases in the dispersiblity of the starch blends with increasing level of pigeon pea starch may be due in part to the higher quantity of dry matter contained in our Irish potato starch samples as compared to that contained in the pigeon pea starches as well as to differences in the nature of the individual starches.

## Effect of temperature on the swelling power and solubility of the starch blends

The swelling and solubility of Irish potato and pigeon pea starch blends under different temperature conditions are shown in Table 3. The swelling power and solubility of the

**Table 2** Bulk density, water absorption capacity and dispersability of Irish potato and Pigeon pea starch blends

| Starch blends Irish potato: pigeon pea | Bulk density (g/cm$^3$) | Water absorption capacity (g water/ g sample) | Dispersability (%) |
|---|---|---|---|
| 100:0 | $0.75^{a}$±0.01 | $3.1^{a}$±0.26 | $58.6^{a}$±1.73 |
| 0:100 | $0.63^{a}$±0.03 | $3.0^{a}$±0.05 | $42.0^{f}$±0.55 |
| 90:10 | $0.71^{a}$±0.05 | $2.9^{a}$±0.17 | $54.8^{b}$±1.30 |
| 80:20 | $0.69^{a}$±0.01 | $2.8^{a}$±0.01 | $51.2^{c}$±0.67 |
| 70:30 | $0.66^{a}$±0.00 | $2.7^{ab}$±0.13 | $49.0^{d}$±0.53 |
| 60:40 | $0.61^{a}$±0.01 | $2.7^{b}$±0.00 | $46.4^{e}$±0.18 |
| 50:50 | $0.60^{a}$±0.00 | $2.6^{b}$±0.05 | $42.9^{f}$±1.10 |

Values are means and standard deviations of three determinations

Values not followed by the same superscript in the same column are significantly different from each other

**Table 3** Effect of temperature on the swelling power and solubility of Irish potato and Pigeon pea starch blends

| Starch blend | Swelling power (g water/ g starch) | | | Solubility (%) | | | | |
|---|---|---|---|---|---|---|---|---|
| | Temperature (°C) | | | | | | | |
| Irish potato: pigeon pea | 60 | 70 | 80 | 90 | 60 | 70 | 80 | 90 |
| 100:0 | 6.0$^{a}$±0.19 | 6.5$^{c}$±0.01 | 8.6$^{c}$±0.23 | 10.1$^{e}$±0.03 | 2.5$^{c}$±0.01 | 2.8$^{c}$±0.00 | 3.7$^{d}$±0.03 | 5.9$^{c}$±0.10 |
| 0:100 | 4.2$^{c}$±0.01 | 7.3$^{b}$±0.34 | 8.9$^{c}$±0.01 | 13.0$^{c}$±0.01 | 2.4$^{c}$±0.00 | 3.6$^{b}$±0.10 | 4.3$^{c}$±0.01 | 6.2$^{c}$±0.24 |
| 90:10 | 4.7$^{bc}$±0.00 | 5.4$^{cd}$±0.05 | 7.7$^{d}$±0.01 | 9.1$^{f}$±0.17 | 2.4$^{c}$±0.11 | 2.9$^{bc}$±0.07 | 4.0$^{c}$±0.50 | 5.0$^{cd}$±0.01 |
| 80:20 | 4.4$^{c}$±0.02 | 5.8$^{d}$±0.01 | 9.3$^{c}$±0.00 | 11.5$^{d}$±0.04 | 3.0$^{b}$±0.03 | 3.7$^{b}$±0.01 | 4.5$^{c}$±0.19 | 5.7$^{c}$±0.07 |
| 70:30 | 4.9$^{bc}$±0.01 | 7.7$^{b}$±0.01 | 10.1$^{b}$±0.10 | 13.2$^{c}$±0.29 | 3.1$^{b}$±0.05 | 3.8$^{b}$±0.01 | 4.8$^{c}$±0.03 | 6.1$^{c}$±0.00 |
| 60:40 | 5.0$^{b}$±0.01 | 8.8$^{a}$±0.03 | 12.1$^{a}$±0.01 | 15.0$^{b}$±0.07 | 3.4$^{b}$±0.01 | 3.7$^{b}$±0.13 | 5.6$^{b}$±0.11 | 6.8$^{b}$±0.24 |
| 50:50 | 5.3$^{b}$±0.03 | 10.0$^{b}$±0.02 | 12.7$^{a}$±0.00 | 16.6$^{a}$±0.01 | 4.9$^{a}$±0.00 | 5.3$^{a}$±0.05 | 6.3$^{a}$±0.51 | 7.5$^{a}$±0.13 |

Values are means and standard deviations of three determinations

Values not followed by the same superscript in the same column are significantly ($P \leq 0.05$) different from each other

various starch blends were as expected, temperature dependent, increasing with increase in temperature. When starch dispersions are heated in water, the granules acquire thermal energy; the resulting thermal agitations weaken the intra-granular bonds in proportion to the strength of the binding forces. Weaker forces relax first causing the granules to absorb water and swell and the lower molecular weight amylose solubilizes and leaches out of the granule into the surrounding medium. Increased thermal agitation causes significant swelling of the granules and the internal bonds become fragile. At a critical stress point, the swollen envelope ruptures, releasing the majority of the internal starch molecules (Atkin et al. 1998). Previous workers have demonstrated that high swelling and solubility are due to the existence of a loose granule structure and low molecular weight amylose that leach out of the amorphous domains of the starch granules (Nwokocha et al. 2009). The swelling power of the starch blends showed a rapid increase from 70 °C which could be due to the breaking of intermolecular hydrogen bonds in amorphous areas that allows irreversible and progressive water absorption as reported by Bello-Pérez et al. (1999). There was an increase in the solubility of the starch blends with temperature with the highest solubility being recorded at 90 °C. Our swelling and solubility results are similar to those reported by Akanbi et al. (2009) for African bread fruit starch.

## Pasting properties of starch blends

The pasting properties of Irish potato and pigeon pea starch blends are presented in Table 4. The results of pasting properties obtained in this study are somewhat similar to those obtained by Zaidul et al. (2007). The RVA properties of Irish potato and pigeon starch blend showed that there were significant ($P \leq 0.05$) increases in peak viscosity (from 180.1 to 397.6RVU), trough (from 79.0 to 240.1RVU),

**Table 4** Pasting properties of Irish potato and pigeon pea starch blends

| Starch blend Irish potato: pigeon pea | Peak viscosity (RVU) | Trough (RVU) | Breakdown (RVU) | Final viscosity (RVU) | Setback viscosity (RVU) | Peak time (RVU) | Pasting temperature (°C) |
|---|---|---|---|---|---|---|---|
| 100:0 | 180.1$^{a}$±1.03 | 79.0$^{a}$±0.50 | 101.8$^{a}$±0.13 | 143.2$^{a}$±0.71 | 64.2$^{a}$±0.54 | 5.5$^{a}$±0.10 | 84.5$^{b}$±0.71 |
| 0:100 | 267.9$^{f}$±0.77 | 152.6$^{f}$±1.19 | 115.4$^{e}$±0.88 | 228.6$^{f}$±1.50 | 76.2$^{f}$±0.92 | 5.2$^{b}$±1.03 | 85.0$^{a}$±0.05 |
| 90:10 | 280.1$^{e}$±1.45 | 169.3$^{e}$±0.40 | 110.7$^{f}$±0.95 | 249.8$^{e}$±0.66 | 80.5$^{e}$±0.50 | 5.4$^{a}$±1.20 | 83.0$^{c}$±0.00 |
| 80:20 | 298.4$^{d}$±0.91 | 174.5$^{d}$±1.07 | 123.9$^{d}$±0.43 | 269.6$^{d}$±1.41 | 95.1$^{d}$±1.26 | 5.4$^{a}$±0.24 | 82.6$^{d}$±0.19 |
| 70:30 | 326.8$^{c}$±1.48 | 201.0$^{c}$±1.86 | 125.8$^{c}$±1.01 | 303.4$^{c}$±0.54 | 102.3$^{c}$±0.97 | 5.3$^{ab}$±0.05 | 82.1$^{d}$±0.70 |
| 60:40 | 365.0$^{b}$±0.71 | 214.3$^{b}$±0.54 | 150.7$^{b}$±0.97 | 330.8$^{b}$±1.46 | 116.5$^{b}$±0.13 | 5.3$^{a}$±0.12 | 81.8$^{de}$±0.33 |
| 50:50 | 397.6$^{a}$±1.23 | 240.1$^{a}$±0.18 | 157.4$^{a}$±1.38 | 317.2$^{a}$±0.95 | 131.0$^{a}$±0.89 | 5.2$^{ab}$±0.60 | 81.4$^{e}$±0.26 |

Values are means and standard deviations of three determinations.

Values not followed by the same superscript in the same column are significantly ($P \leq 0.05$) different from each other breakdown (from 101.8 to 157.4RVU), final viscosity (from 143.2 to 330.8RVU) and setback (from 64.2 to 131.0RVU) with increasing level of pigeon pea starch while peak time and pasting temperature decreased from (5.5 to 5.2 min) and (85.0 to 81.4 °C) respectively. Peak viscosity gives an indication of the ability of starch to swell freely before their physical break down. The increase in peak viscosity of starch blends with increasing level of pigeon pea starch may be attributed to differences in their amylose content with increasing level of pigeon pea starch. Low amylose content has been reported to be associated with a higher peak viscosity and a lower pasting temperature (Zaidul et al. 2007). High peak viscosity is an important attribute of textural quality in foods. According to Otegbayo et al. (2006), high peak viscosity of starch paste contributes to good textural qualities of stiff porridge products. In this study, it was observed that starch blends with high peak viscosities produced stiff porridges with good textural properties (Table 5). Trough value is the maximum viscosity value in the constant temperature phase of the RVA profile and measures the ability to withstand breakdown during cooling. Trough viscosity increased with increase in pigeon pea starch level which implies increased ability of the blends to withstand breakdown during cooling. The slight increases recorded in protein and fat contents with increasing levels of pigeon pea starch substitutions may also contribute to the differences observed in trough, breakdown, final viscosity and setback value with pigeon pea starch level. Set back value of starch paste is an index of 'moudability' in stiff porridges. It has been reported that there is a positive correlation between setback values and 'moulability in stiff porridge foods such as pounded yam (Otegbayo et al. 2006). This study seem to re-affirm the earlier established relationship between set-back value and mouldability as starch blends with low set back values yielded products that scored low in 'mouldability' (Table 5). The pasting temperature provides an indication of the minimum temperature required to cook starch. Pasting temperature decreased with increase in pigeon pea starch level and this may be technologically important.

## Sensory properties of stiff porridges

The result of sensory properties of stiff porridge prepared from Irish potato and pigeon pea starch blends is shown in Table 5. The colour ratings of porridge samples ranged from 6.30 to 7.34. The colour of stiff porridges decreased with increasing level of pigeon pea starch while stickiness, mouldability and texture values of stiff porridge samples increased with increasing level of pigeon pea starch. The mouldability and texture attributes of the Irish potato (90% *w*/*w*) and pigeon pea starch (10% *w*/*w*) blend was very similar in the sensory ratings to the conventional cassava stiff porridges. The overall acceptability rating tended to increase with increasing levels of pigeon pea starch due possibly to the improved texture of the starch blends.

## Conclusions

The functional, pasting and physicochemical properties of Irish potato and pigeon pea starch blends indicate that they may be useful as alternatives to cassava starch for the preparation of stiff porridges. The sensory results show that acceptable stiff porridges could be prepared by using up to 50:50 Irish potato and pigeon pea starches respectively. Porridges prepared in this way, may have the added benefit of being valuable for individuals such as diabetic patients requiring low digestible carbohydrates. However, further studies may be required to ascertain the digestibility of Irish potato and pigeon pea starch blends in comparison with local starch sources such as cassava with a view to making appropriate recommendations.

**Table 5** Sensory properties of stiff porridge prepared from Irish potato and pigeon pea starch blends in comparison with cassava starch

| Starch blend Irish potato: pigeon pea | Colour | Stickiness | Mouldability | Texture | Overall acceptability |
|---|---|---|---|---|---|
| 100:0 | 7.3$^{a}$ | 7.1$^{a}$ | 6.9$^{ab}$ | 6.5$^{b}$ | 7.3$^{a}$ |
| 0:100 | 6.3$^{b}$ | 5.9$^{c}$ | 6.6$^{b}$ | 6.8$^{b}$ | 6.2$^{b}$ |
| 90:10 | 6.8$^{a}$ | 6.0$^{bc}$ | 7.0$^{a}$ | 7.4$^{a}$ | 6.6$^{b}$ |
| 80:20 | 7.1$^{a}$ | 6.4$^{b}$ | 7.3$^{a}$ | 7.3$^{a}$ | 7.1$^{a}$ |
| 70:30 | 6.7$^{a}$ | 6.9$^{a}$ | 7.2$^{a}$ | 7.5$^{a}$ | 7.1$^{a}$ |
| 60:40 | 7.0$^{a}$ | 7.2$^{a}$ | 7.2$^{a}$ | 7.4$^{a}$ | 7.1$^{a}$ |
| 50:50 | 7.1$^{a}$ | 6.7$^{b}$ | 7.2$^{a}$ | 7.7$^{a}$ | 7.3$^{a}$ |
| Cassava starch | 7.0$^{a}$ | 7.2$^{a}$ | 7.3$^{a}$ | 7.6$^{a}$ | 7.5$^{a}$ |

Mean values of a twenty-member sensory panel

Values not followed by the same superscript in the same column are significantly different from each other

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