PHYSICAL, FUNCTIONAL AND SENSORY PROPERTIES OF YAM FLOUR 'ELUBO' IN GBOKO LOCAL GOVERNMENT AREA, BENUE STATE

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Abstract

Yams *(Dioscorea species.)* which are regarded as traditional foods are consumed in various ways but mostly consumed as yam flour in the South west and Middle belt region of Nigeria. This study investigated the physical, functional and sensory properties of representative samples of 70% of the yam flour sold in the Tse-Kucha-market, Gboko. They were compared with freshly produced yam flour. The particle size, colour, pH, bulk density, swelling power, dispersibility water absorption index, pasting properties and sensory evaluation were investigated. Particle size was fou
nd to have significant effect ($P<0.05$) on the functional and sensory properties of all the yam flour samples. There were significant differences ($p<0.05$) in the pH (6.25 to 6.93), bulk density (0.54 to 0.72) g/ml, swelling power (5.45 to 8.05), dispersibility (66.00 to 72.50) %, water absorption index (99.206 to 245.24) and final viscosity (158.04 to 258.50) Relative value Units (RVUs). There were significant difference ($P<0.05$) in the sensory panelists scores for the market samples and the reference sample with respect to sensory attributes of colour, taste, mouldability, texture and aroma. The study shows that the yam flour samples sold in Tse-Kucha market were significantly different ($p<0.05$) in terms of the physical, functional and sensory properties of the collected samples.

1.0 Introduction

Yam is one of the major food crops in West Africa, Asia, India and part of Brazil (Ihekoroye and Ngoddy, 1985). Yam is the common name for some species in the genus Dioscorea (family Dioscoreacea). These are perennial herbaceous vines cultivated for the consumption of their starchy tubers in Africa, Asia, Latin America and Oceania. In West Africa there are many cultivars of yam, more than 95% of the world's yam is produced in Africa with the remainder grown in the West Indies, part of Asia, South and Central America (Purseglove, 1988). Majority of yam consumed is produced in West Africa with more that 90% of the world production. Yam production has increased steadily in the last decades from 19 million metric tonnes in 2000 to a recent estimate of over 39million (FAO, 2001). Yam is among the oldest recorded food crops and ranks second after cassava in supply of starch in West Africa (Nweke, Ugwu & Asadu, 1991). Naturally, yam is rich in starch and produces energy. Yam tubers grow up to 2.5m (8.2ft) in length and weigh up to 70kg (154lb) it has a tough stem which softens after heating. Yam is an important source of carbohydrate for many people of the Sub Saharan region especially in the yam zones of West Africa. It's the second most important tuber crop in Africa, after cassava root, with production reaching above one third of the level of cassava (FAO, 1997). Yam tuber is essentially a starchy food, its principal nutritional function being the supply of calories to the body (Onwueme, 1978). This characteristic contributes to the sustaining of food supply, especially in the scarcity periods at the start of the wet season. Poorly harvesting methods also contributes to yam deterioration, yams are also exposed to pathogens, and insects and pests during storage (Coursey and Ferbe, 1979) .The flesh of yam species usually used is white, the colour of the processed flour ranges from cream-white to dark brown. This discoloration phenomenon has long been studied in fresh yam tubers and has mainly been associated with enzymatic browning due to the action of polyphenoloxidase (Alimenteros and Del-Rossatio, 1984).

Materials and Method

2.1 Materials

White yam *(Dioscorea rotundata)* tubers were purchased at Tse-Kucha market in Gboko, Benue State. Representative samples of 70% of Yam flour sold in Tse-Kucha market were purchased from different sellers in the market. Yam flour was collected randomly from the traders in Tse-Kucha market in sterile containers.

2.2 Methods of Production of yam flour (Elubo)

Yam tubers were washed with clean water to remove adhering soil and other undesirable materials. The yams were hand-peeled using kitchen knives and sliced into sizes of 2 to 3cm thickness. The slices of yam were parboiled in water at 50 ^{0}C for 2 hours after which the yam was removed. The parboiled yam was steeped for 24 hours to allow the yam attain a flabby nature. The steeped yam was drained and transferred into the cabinet dryer to dry. The dried yam slices were milled using locally fabricated hammer mill and sealed in polythene prior to analysis (Babajide *et al,* 2006).

2.3 Physical Properties Analysis

This was used to select the representative samples from the collected samples. This was carried out by visual inspection of samples which was done by checking for the desirable properties of yam flour which includesoff-colour, texture and presence of lumps. Particle size determination was carried out using standard sieves.

→Washing →Peeling →Slicing (2-3cm thickness) →Parboiling (50 °C for 2 hrs) →Steeping (24 hrs →Draining →Cabinet drying→ Dry yam chips→ Milling→ Sieving

2.4 Determination of particle size distribution

One hundred grams (100g) of dried yam flour sample was weighed and sieved through a series of selected standard test sieves of mesh sizes 710 µm, 610 µm, 425 µm,and 250 µm using a mechanical sieve shaker. The stack of sieves was mechanically shaked for five minutes and the material on each sieve was collected and weighed. The particle size distribution was recorded as percentage of yam flour sample retained on mesh 710µm, 610 µm, 425 µm, and 250 µm sieves (AOAC, 2000).

$$\text{PSD} = \frac{\text{Weight of yam flour sample retained}}{\text{Total weight of yam flour samples in all sieves}}\ x\ 100$$

2.5 Colour determination of Yam Flour

1g of each grounded sample was weighed into a 100ml beaker 25ml of Spectrophotometer cuvette. Methanol was added to extract the colour by shaking and homogenizing with glass rod for 30minutes.The mixture was allowed to stand for 10 minutes after which it was filtered through hardened whatman No 42 filter paper. The organic filtrate obtained was used to determine colour by taking absorbance or optical density at wavelength of 420nm and 520nm on a Cecil 200 colorimeter respectively Colour intensity is the sum of the absorbance for each sample at wavelength of 520nm and 420nm (Glories, 1984).

Mathematically, Colour intensity = Absorbance at 420nm + Absorbance at 520nm.

$$\% \text{ yellow/cream} = \frac{\text{Absorbance at 420nm}}{\text{Colour intensity}} \times 100$$

$$\% \text{ Red or brown} = \frac{\text{Absorbance at 520nm}}{\text{Colour intensity}} \times 100$$

2.6 Determination of pH of Yam flour

pH was determined using hand pH meter five grams of the flour sample was weighed into a beaker containing 25ml of distilled water. It is allowed to stand for 30 minutes with constant stirring. The pH was then determined using pH meter.

3.0 Functional Properties of Yam Flour

3.1 Bulk Density Determination of Yam Flour

The bulk density was determined by the method of Wang and Kinssela (1976). A known amount of the sample was weighed into 50ml graduated measuring cylinder. The samples were packed by gently tapping the cylinder on the bench top 10 times from height of 5cm. the volume of the sample was recorded.

Bulk density (g/ml or g/cm^3) = Weight of the sample
Volume of the sample after tapping**???**

3.2 Swelling Power Determination of Yam Flour

Swelling power and solubility index was determined by Takashi and Sieb (1988) method. It involves weighing 1g of flour sample into 5ml centrifuge tube; 50ml of distilled water is added and mixed gently. The slurry was heated in a water bath at temperatures (70, 80, 90, and 100) ^{0}C respectively for 15 minutes. During heating, the slurry is stirred gently to prevent clumping of the flour. On completion of 15 minutes, the tube containing the paste is centrifuged at 3000rpm for 10 minutes. The supernatant will be decanted immediately after centrifuging. The weight of the sediment is then taken and recorded. The moisture content of the sediment gel was used to determine the dry matter content of the gel.

Swelling power =Weight of wet mass sediment Weight of dry matter in gel

3.3 Dispersibility Determination of Yam Flour

Dispersibility was determined using the method described by Kulkarni *et al.*, (1991). Ten grams of the flour sample was weighed into 100ml measuring cylinder, water was added to each volume of 100ml. the set up stirred vigorously and allowed to stand for three hours. The volume of settled particles was recorded and subtracted from 100. The differences reported as percentage Dispersibility.

% Dispersibility = 100 - volume of settled particle.

3.4 Water Absorption Index Determination of Yam Flour

Water absorption index was determined using the modified method of (Ruales et al., 1993). Yam Flour sample (2.5g) was suspended in 30ml distilled water at 30^0C in a centrifuge tube, stirred for 30 minutes intermittently and then centrifuged at 300rpm for 10 minutes. The supernatant is decanted and the weight of the gel formed was recorded. The water absorption index (WAI) was calculated as gel weight per gram dry sample.

Water Absorption Index (WAI) = Bound water (g) x 100 Weight of sample

3.5 Pasting Property Determination of Yam Flour

Pasting characteristics was determined with a Rapid Visco Analyzer (RVA), (Model RVA3D+, Network Scientific, and Australia). First, flour samples (2.5g) were weighed into a dried empty canister; then 25ml of distilled water was dispensed into the canister containing the sample. The solution was thoroughly mixed and the canister was well fitted into the RVA as recommended. The slurry was heated from 50 ^oC to 95 ^oC with a holding time of two minutes flowed by cooling to 50 ^oC with 2 minutes holding time. The rate of heating and cooling was at a constant rate of 11.25 ^oC per min. Peak viscosity, trough, breakdown, final viscosity, set back, peak time, and pasting temperature were read from the pasting profile with the aid of thermocline for windows software connected to a computer (International Institute of Tropical Agriculture, 2001).

3.6 Sensory Evaluation

The processed yam flour and the samples collected from the market was subjected to sensory evaluation. Yam flour (50g) was stirred in 150ml boiling water to make paste (Amala) for each sample. Scoring difference test and hedonic scale test was used in measuring the intensity and acceptability of the Amala paste colour, taste, mould-ability, texture and aroma. A panel consisting of twenty judges who are regular consumers of reconstituted yam flour (Amala) were used for the sensory test Panelist were asked to evaluate the yam flour samples using the questionnaire provided for scoring difference test for intensity of colour as 1 = Extremely-black, 2 = black, 3 = Dark-Brown, 4 = brown, 5 = Slightly brown, 6 = Cream. Taste were evaluated as 1= extremely bitter, 2 = Bitter, 3 = slightly bitter, 4 = Bland, 5 = slightly sweet, 6 = Not Bitter. Mouldability was evaluated as 1 = Extremely-mouldable, 2 = very mouldable 3 = mouldable, 4 = moderately mouldable, 5 = slightly mouldable, 6 = Not mouldable. Texture was evaluated as 1 = extremely smooth, 2 = very smooth, 3 = smooth, 4 = moderately smooth, 5= slightly smooth, 6 = Not smooth. Aroma was evaluated as 1 = Like extremely, 2 = Like very much, 3 = Moderate, 4 = Neither like or dislike, 5 = Dislike Slightly, 6 = Dislike extremely. A 9-point hedonic scale was used to determine the overall acceptability of yam paste. Amala with 1 = dislike extremely, 2 = dislike very much, 3 = dislike moderately, 4 = dislike slightly, 5 = neither like or dislike, 6 = like slightly; 7 = like moderately, 8 = like very much and 9 = like extremely as described by Ihekoronye and Ngoddy, (1985).

3.7 Statistical Analysis

All data were subjected to Analysis of Variance (ANOVA) using SPSSversion 16.00 and means were separated using Duncan's Multiple Range Test (DMRT).

4.0 Results and Discussion

4.1 Screening of Collected Yam Flour Samples

The collected samples were reduced prior to analysis by visual inspection of the appearance and checking for presence of lumps and texture. Samples were eliminated due to presence of foreign matter such as sand and other impurities yam flour samples with lumps and grainy texture as this indicates presence of tiny particles which could be as a result of contaminants such as sand, dirt, cassava shaft and yam peels which are the main food constituent used for adulteration of yam flour. The remaining samples were subjected to sieve analysis.

4.2 Particle Size of Yam Flour Samples

The results of particle size determination which is presented Table 1, It was observed that all the values obtained for each sieve after sieve analysis are significantly different (P<0.05). It can be deduced that the sieve 710μm retained a low percentage of yam flour particles (0.81 to 6.51) % from the total amount of flour used for the sieve analysis. The particle retained consist of white cassava shafts, dirt and small yam peels which indicates adulteration. However, the shelf life of yam flour depends on the additional measures taking at the time of packaging and the storage condition (Brownsell *et al.*, 1989). The samples retained in Sieve 610μm (0.39 to 2.58) % are significantly different (P<0.05). The samples retained were minimal. Large amount of particles were retained as the samples passed through sieves 425μm. Sieve 250μm has the highest percentage (95.40 to 70.76) % of yam flour. Particle size determines the swelling power of the yam flour. The variation in the particle size distribution is due to the milling procedure, and the extent of steeping of the yam slices during processing (Oduro *et al.,* 2000). The market samples with high percentages (80.07 to 95.40) % for the 250^m sieve were chosen randomly as the representative samples because fine yam flour particles is desired in producing smooth Amala paste. The selected representative samples (Tse-Kucha2, Tse-Kucha4, Tse-Kucha6, Tse-Kucha10, Tse-Kucha11, And Tse-Kucha14) were subjected to further analysis.

4.3 Colour of Yam Flour sold in Tse-Kucha Market

The results of colour is shown in table 2, It was observed that there is significant difference (p< 0.05) in the colour of the yam flour browness index (69.82 to 78.46)% and lightness (21.53 to 30.15)% comparison with the reference sample whose colour percentage is 68.42% and lightness 31.58% . The colour absorbance at 420nm and 520nm were significantly different (p<0.05) from each other. The colour absorbance at 420nm ranged from 0.060% to 0.240%. The values for the samples were significantly different from each other (p<0.05) except for samples Tse-Kucha2 (0.017)%, Tse-Kucha6 (0.014)% and Tse-Kucha11 (0.015)%. The colour absorbance at 520nm which ranged from 0.013% to 0.067%.The absorbance at 520nm are significantly different (p<0.05) from each other except for Tse-Kucha 11 which is not significantly different (p>0.05) from the other samples. The level of lightness in yam flour samples: Tse-Kucha2, Tse-Kucha4 and Tse-Kucha14 were not significantly different (p> 0.05) from each other but were significantly different (p< 0.05) from Tse-Kucha10 and reference sample. Tse-Kucha4 has the highest light colour of 30.17%. The extremely dark colour in some of the samples could be attributed to the presence of yam peels in the flour which imparts a darker colour. The percentage browness in the market samples were significantly different (p<0.05) from each other and from the reference sample. Tse-Kucha6 has the highest brown colour of 78.46%, while Market sample Tse-Kucha2, had the lowest browness index value of 69.82% next to the Reference sample.

Table 1: Particle Size Determination of Yam Flour sold in Tse-Kucha Market

COLLLECTED SAMPLES	FRA (%)	FRB (%)	FRC (%)	FRD (%)
Tse-Kucha1	6.51^{a}	0.39^{i}	19.02^{b}	74.04^{i}
Tse-Kucha2	2.04^{d}	2.52^{ab}	0.86^{i}	95.40^{a}
Tse-Kucha3	0.67^{g}	2.09^{cd}	17.15^{e}	80.29^{h}
Tse-Kucha4	0.89^{g}	1.18^{g}	13.21^{g}	84.75^{d}
Tse-Kucha5	0.81^{g}	0.39^{i}	18.64^{e}	80.18^{g}
Tse-Kucha6	5.49^{b}	2.09^{cd}	7.12^{k}	85.08^{c}
Tse-Kucha7	3.66^{c}	1.63^{f}	7.59^{j}	87.09^{b}
Tse-Kucha8	1.82^{de}	1.76^{ef}	9.18^{gh}	87.22^{b}
Tse-Kucha9	6.49^{a}	0.48^{i}	22.24^{a}	70.76^{j}
Tse-Kucha10	1.08^{fg}	0.96^{gh}	17.30^{d}	80.9^{g}
Tse-Kucha11	1.11^{fg}	2.29^{bc}	15.63^{f}	80.07^{g}
Tse-Kucha12	1.32^{efg}	0.53^{i}	0.62^{i}	77.32^{h}
Tse-Kucha13	1.61^{def}	2.58^{a}	15.63^{f}	81.21^{e}
Tse-Kucha14	1.06^{fg}	0.89^{h}	18.64^{c}	87.07^{b}

Means values of two replicates

Sample means followed by same superscript in a column are not significantly different ($p>0.05$)

FRA% -percentage of yam flour retained on sieve size 710 µm

FRB% - percentage of yam flour retained on sieve size 610µm

FRC% - percentage of yam flour retained on sieve size 425 µm

FRD% - percentage of yam flour retained on sieve size 250 µm

Tse-Kucha1 - Tse-Kucha14 represents the collected market samples.

Sample	Cream %	Colour absorbance at 420 nm	Colour absorbance at 520 nm	Brown %
Tse-Kucha2	27.33^{abc}	0.017^{bc}	0.056^{b}	72.65^{abc}
Tse-Kucha4	30.17^{ab}	0.013^{d}	0.035^{e}	69.82^{cd}
Tse-Kucha6	21.53^{d}	0.014^{cd}	0.051^{c}	78.46^{a}
Tse-Kucha10	26.37^{bc}	0.240^{a}	0.067^{a}	73.62^{bc}
Tse-Kucha11	23.80^{cd}	0.015^{cd}	0.48^{cd}	76.19^{ab}
Tse-Kucha14	29.68^{ab}	0.019^{b}	0.045^{d}	70.31^{ab}
Reference	31.58^{a}	0.060^{e}	0.013^{f}	68.42^{d}

Table 2: Colour of Yam Flour sold in Tse-Kucha Market

4.4 Means values of two replicates

Samples of means followed by same superscript in a column are not significantly different ($p>0.05$)

Tse-Kucha2, Tse-Kucha4, Tse-Kucha6, Tse-Kucha10, Tse-Kucha11, and Tse-Kucha14 - representative samples of the yam flour collected in Tse-kucha market.

Reference- yam flour sample produced in the laboratory.

4.5 pH and Functional Properties of Yam Flour

Table 3, shows the pH and functional properties of yam flour sold in Tse-Kucha market. The pH ranges from 6.25 to 6.93. There were significant differences ($p<0.05$)in the pH of all the samples. Tse-Kucha2 had the highest pH of 6.93 whileTse-Kucha4 had the lowest pH (6.25). This indicates a low level of acidity in the market samples. The bulk density of the samples ranges from 0.54g/ml to 0.62g/ml. There were significant differences ($p<0.05$) in the bulk densities of the Market yam flour samples. The bulk density of the yam flour is considerably low in comparison to the bulk density of the Reference sample which has the highest value of 0.70g/ml. Plaami (1997) reported that bulk density is influenced by the structure of the starch polymers and loose structure of the starch polymers could result in low bulk density. The swelling power of the samples is significantly different ($p<0.05$) from each other. The swelling power of the representative samples is considerably low compared with the Reference sample having the highest value of 8.05. The swelling power is an indication of presence of amylase which influences the quantity of amylose and amylopectin present in the yam flour. Therefore, the higher the swelling power, the higher the associate forces (Ruales *et al,* 1993). The variation in the swelling power indicates the degree of exposure of the internal structure of the starch present in the flour to the action of water (Ruales *et al,* 1993).The dispersibility of the yam flour (66.00 to 72.50) % were significantly different ($p<0.05$) from each other with Tse-Kucha2 having the highest dispersibility (72.50 %) and Tse-Kucha11 having the lowest value (66.00 %).The water absorption index of the yam flour ranges from 99.20% to 245.25%. They are significantly different ($p<0.05$) from each other. Tse-Kucha6 has the highest water absorption.

Table 3: pH and Functional Properties of Yam Flour sold in Tse-Kucha Market

Samples	pH	Bulk density (g/ml)	Swelling power	Dispersibility %	Water absorption index
Tse-Kucha1	6.93^{a}	0.54^{d}	6.15^{c}	72.50^{a}	99.20^{e}
Tse-Kucha4	6.25^{f}	0.58^{c}	6.75^{b}	71.00^{ab}	199.7^{d}
Tse-Kucha6	6.57^{d}	0.62^{b}	6.10^{cd}	68.00^{cd}	242.61^{a}
Tse-Kucha10	6.33^{e}	0.55^{d}	5.45^{e}	72.00^{ab}	245.24^{a}
Tse-Kucha11	6.70^{b}	0.56^{d}	6.30^{c}	66.00^{d}	220.90^{b}
Tse-Kucha14	6.64^{c}	0.62^{b}	5.90^{d}	70.00^{bc}	218.96^{b}
Reference	6.64^{c}	0.70^{a}	8.05^{a}	72.00^{ab}	214.13^{c}

Means value of two replicates

Sample means followed by the same superscript in a column are not significantly Different ($p>0.05$) Tse-Kucha2, Tse-Kucha4, Tse-Kucha6, Tse-Kucha10, Tse-Kucha11, Tse-Kucha14-Representative yam flour samples References –Yam flour sample produced in the laboratory.

Samples	Peak (RVU)	Through (RVU)	Break down	Final viscosity (RVU)	Setback	Peak Time (mins)	Pasting Temp (^{0}C)
Tse-Kucha2	215.96^{c}	122.50	93.46^{a}	162.42^{c}	39.91^{de}	4.68^{d}	61.87^{a}
Tse-Kucha4	250.58^{b}	214.38^{b}	36.12^{d}	260.79^{b}	46.41^{b}	5.41^{b}	61.95^{a}
Tse-Kucha6	240.71^{b}	214.33^{b}	26.37^{e}	258.50^{b}	44.17^{bc}	5.49^{b}	61.90^{a}
Tse-Kucha10	150.83^{e}	138.08^{c}	12.75^{f}	161.33^{c}	23.25^{f}	6.37^{a}	61.62^{a}
Tse-Kucha11	191.79^{d}	120.62^{d}	71.16^{c}	158.04^{c}	37.42^{e}	4.93^{c}	62.05^{a}
Tse-Kucha 14	250.58^{b}	213.92^{b}	36.66^{d}	255.50^{b}	41.58^{cd}	5.44^{b}	61.87^{a}
References	317.20^{a}	235.62^{a}	81.58^{b}	374.83^{a}	139.21^{a}	4.76^{d}	61.92^{a}

Table 4: Pasting Properties of Yam Flour sold in Tse-Kucha Market.

4.6 Means value of two replicate

Sample means followed by the same superscript in a column are not significantly different ($p>0.05$) Tse-Kucha2, Tse-Kucha4, Tse-Kucha6, Tse-Kucha10, Tse-Kucha11, Tse-Kucha14-Representative Yam flour samples References-yam flour sample produced in the laboratoryindex (245.24%) which is higher than the value of the Reference sample (214.13) %. The water absorption index measures the extent of water retention in yam flour this affects the ability of the yam flour to form paste.

4.7 Pasting Properties of the Yam Flour sold in Tse-Kucha Market

In table 5, variations were observed in the pasting properties of the representative market sample. The peak viscosities (150.83 to 250.58) RVU were significantly different ($p<0.05$) from each other. The peak values of the samples are considerably low compared to the reference sample (317.20) RVU. Trough of the yam flour samples (120.62 to 214.38) RVU were significantly different ($p<0.05$) from each other except samples Tse-Kucha4 (214.38), Tse-Kucha6 (214.33) and Tse-Kucha10 (213.92). Breakdown of the yam flour which ranged from 12.75RVU to 93.46RVU were significantly different ($p<0.05$). Tse-Kucha2 had the highest breakdown (93.46) RVU. The higher the break down in viscosity, the lower the ability of the sample to withstand heating and the shear stress during cooking (Adebowale *et* al.,2005) The breakdown of yam flour samples is thedifference in the peak viscosity and trough viscosity (IITA. 2001).

The final viscosities (158.04 to 374.8) RVU of the yam flours were significantly different ($p<0.05$) with exception of Tse-Kucha4 (260.79) RVU, Tse-Kucha6 (258.50) RVU and Tse-Kucha14 (255.50) RVU which were not significantly different ($p>0.05$) from each other and also Tse-Kucha10 (161.33) RVU and Tse-Kucha11 (158.04) RVU which were not significantly different ($p>0.05$) from each other. The reference sample has the highest final viscosity (374.83) RVU. The final viscosity is the most commonly used parameters to define a particular sample quality (Martin *et al,* 1972

The setback values ranged from 23.25RVU to 139.21RVU.There is significant difference ($p<0.05$) in the setback of the yam flour samples. The reference sample had the highest setback value of 139.21 RVU while Tse-Kucha10 (23.25) RVU had the lowest set back value. The higher the setback, the lower the Retrogradation during cooling and the lower the rate of staling in yam flour products (Adeyemi and Idowu, 1990).

Peak time ranges from 4.68min to 6.37min of the yam flour samples are significantly different ($p<0.05$). Tse-Kucha10 (6.37 min) had the highest peak time and Tse-Kucha2 had the lowest peak time (4.68 min).

The Pasting temperature which is the temperature at which viscosity first increases by at 25 RVU over 20 seconds (IITA, 2001) ranges from 61.62 ^{O}C to 62.05 ^{O}C The pasting temperature is not significantly different ($p>0.05$). Higher pasting temperature which is observed in Tse-Kucha4 (61.95) ^{O}C, Tse-Kucha6 (61.90) ^{O}C and Tse-Kucha11 (61.87) ^{O}C implies higher gelatinization and lower swelling power of starch due to high degree of association between starch granules (Emiola and Delarosa., 1981). The amylograph pasting viscosities graphs are shown in appendices 1 to 14.

4.8 Sensory Evaluation of Yam Flour sold in Tse-Kucha Market

Table 6 shows the scoring difference of the sensory attributes of market yam flour samples in comparison with the reference sample. These shows there were significant difference ($p< 0.05$) in the panelist score for all sensory attributes: Colour (2.26 to 5.60), Taste (3.20 to 4.50), Mouldability (2.75 to 3.65), Texture (3.10 to 4.05) and Aroma (2.80 to 3.85). It was observed that majority of the panelists preferred the colour of Tse-Kucha

TABLE 5: Sensory Evaluation of Yam Flour sold in Tse-Kucha Market (Scoring Difference Test)

Samples	Colour	Taste	Mouldability	Texture	Aroma
Tse-Kucha2	3.30^{cd}	3.60^{bc}	3.50^{a}	3.10^{a}	3.10^{ab}
Tse-Kucha4	4.25^{b}	3.70^{bc}	2.75^{a}	3.30^{a}	3.45^{ab}
Tse-Kucha6	5.60^{a}	4.50^{a}	3.65^{a}	3.45^{ab}	3.10^{ab}
Tse-Kucha10	4.05^{bc}	3.35^{bc}	3.50^{a}	3.35^{ab}	2.80^{b}
Tse-Kucha11	2.26^{d}	3.80^{bc}	3.45^{a}	3.60^{ab}	3.30^{ab}
Tse-Kucha14	2.60^{d}	4.00^{ab}	3.55^{a}	3.30^{ab}	3.50^{ab}
Reference	3.50^{bc}	3.20^{c}	3.55^{a}	4.05^{ab}	3.85^{a}

4.9 Means value of two replicates

Sample means followed by the same superscript in a column are not significantly different ($p>0.05$)Tse-Kucha2, tse-Kucha4, Tse-Kucha6, Tse-Kucha10, Tse-Kucha 14-Representative yam flour samples Reference-yam flour sample produced in the Laboratory(5.60) which has the darkest colour and the taste of sample Tse-Kucha14 (4.00) which has a bitter after taste. The yam paste developed bitter taste presumably due to the yam flour content and rate of browning that occurred during processing (Samir et al, 2005).Table 7 shows the result of the hedonic scale test, it's observed that there were significant difference ($p<0.05$) in the panelist score for all the representative samples except texture of the yam flour samples which was not significantly different ($p>0.05$).The overall acceptability of the yam flour samples were significantly different ($p>0.05$) from each other. Tse-Kucha2 (6.85) had the highest overall acceptability which was not significantly different from the reference sample (6.80) and Tse-Kucha4 (6.65). Tse-Kucha6 (6.15) had the lowest overall acceptability which could be due to the extremely dark appearance of its Amala paste.

Table 6: Hedomic Scale Test on Yam Flour sold in Tse-Kucha Market

Samples	Colour	Taste	Moulda	Texture	Aroma	Overall
Tse-Kucha2	4.85^{a}	5.80^{a}	6.50^{ab}	5.78^{a}	6.90^{a}	6.85^{a}
Tse-Kucha4	6.20^{ab}	5.95^{ab}	6.80^{a}	6.30^{a}	6.25^{abc}	6.65^{a}
Tse-Kucha6	7.10^{a}	6.10^{ab}	5.75^{a}	6.20^{a}	6.00^{abc}	6.15^{ab}
Tse-Kucha10	6.50^{ab}	6.05^{ab}	6.45^{ab}	6.10^{a}	6.35^{abc}	6.30^{ab}
Tse-Kucha11	6.65^{ab}	5.75^{a}	6.10^{ab}	6.10^{a}	5.90^{ab}	6.30^{ab}
Tse-Kucha14	6.95^{ab}	6.90^{a}	6.35^{ab}	6.55^{a}	6.75^{ab}	6.50^{ab}
Reference	5.95^{b}	5.55^{a}	6.00^{ab}	5.60^{a}	5.80^{a}	6.80^{a}

4.10 Means value of two replicates

Sample means followed by the same superscript in a column are not significantly different ($p>0.05$)Tse-Kucha2, Tse-Kucha4, Tse-Kucha6, Tse-Kucha10, Tse-Kucha11, Tse-Kucha14-Representative yam flour samples Reference –yam flour sample produced in the laboratory.

5.0 Conclusion and Recommendation

5.1 Conclusion

The study shows that the yam flour samples sold in Tse-Kucha market were significantly different ($p<0.05$) in terms of the physical, functional and sensory properties of the collected samples. The sieve analyses showed that the yam flour sold in the market were adulterated and this affect the percentage of brownness of the yam flour, this could increase or decrease the brown colour of yam flour depending on what is mixed with the yam flour. Tse-Kucha2 had the highest overall acceptability for the sensory attributes.

5.2 Recommendation

Further studies should be carried out on microbial analysis and storage stability of the yam flour sold in Tse-Kucha market. It is also recommended that yam flour ‘Elubo’ sold in markets should be displayed in covered containers to protect it from the changing weather conditions and contamination. Regulatory agencies should pay more attention to locally processed food products.

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