Chemical, Functional and Sensory Properties of Instant Yam - Breadfruit Flour

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Abstract

Yam (*Dioscorea rotundata*) tubers and breadfruits (*Artocarpus communis*) were processed separately into instant flour and mixed at different proportions (100% yam flour; 100% breadfruit flour; 80 : 20%, 70 : 30%, 60 : 40%, 50 : 50% yam - breadfruit flour). The chemical, functional and pasting properties of the composite flours were determined while the instant yam - breadfruit flours were then reconstituted, made into paste and subjected to sensory evaluation. The study showed that there were significant differences (P<0.05) in the chemical, functional and pasting properties of the different formulations of instant yam - breadfruit flours. The sensory panelist ratings showed that 60:40% instant yam - breadfruit flour paste possess sensory qualities very close to the traditional pounded yam.
Keyword: yam, breadfruit, instant flour, properties

Introduction

Yams are a member of the genus D*ioscorea* and produce tuber, bulbils and rhizomes that are of economic importance especially as food for man (Ayensu, 1972). Losses of up to 40-50% after six months of yam storage were recorded by Adesuyi (1971). Various studies have been directed towards minimizing post-harvest losses of yam, which include tuber curing and irradiation (Adesuyi, 1982), and wound repair (Passam *et al.*, 1976). All these techniques still need many refinements before they can be put to any practical use for improving yam storage (Akintunde and Ige, 1981). Processing the yam tuber into a shelf-stable product offers an alternative to storage in the fresh stage.

Yam is consumed in many different forms including boiled, roasted or pounded and eaten with soup. Yam has been pounded with many other root crops (such as cocoyam, cassava, potato, etc), and plantain to improve the taste, nutritional value and physical properties (Akintunde and Ige, 1981). Breadfruit is a very useful substitute for yam and this has been a traditional practice among people in the South Western part of Nigeria (Fasasi *et al.*, 2004). The traditional process for preparing pounded yam is a tedious process, which involves pounding cooked slices of yam in a mortar using a pestle to a smooth dough consistency. However, instant pounded yam flour which is a modern invention to simplify the tedious traditional process of preparing pounded yam has been produced by drying pre-cooked yam chips in oven, then pulverizing the dried chips to flour. The flour when reconstituted produces a white to creamy smooth dough similar to the yam pounded in the mortar. However, *Poundo yam* (dough from instant yam flour) is not very acceptable because of certain sensory limitations, which include colour development during drying and poor textural quality of the reconstituted product. Attempts to improve the chemical and sensory qualities of instant yam flour have been reported by various authors (Ngoddy and Onuoha, 1983; Ofi, 1983; Sanni, *et al.,* 2006).

In Nigeria, the breadfruit is regarded as the poor man's substitute for yam because it is used in several traditional food preparations of yam, but costs less than one-third the cost of procuring yam at the market (Onayemi and Potter, 1974). The breadfruit has been made into flour and evaluated in bakery products (Olatunji and Akinrele, 1978). However, this study is aimed at producing instant yam – breadfruit flour and determining the chemical, functional and pasting properties of the blend as well as the sensory properties of the *poundo yam* obtainable from the yam-breadfruit flour blends.

Materials and Methods

Materials

Yam tubers (*D. rotundata)* were purchased from Osiele market in Abeokuta, Ogun State, Nigeria and Freshly harvested matured but unripe breadfruit (*Artocarpus communis*) was obtained from Oja Ife, Ile-Ife, Osun State, Nigeria.

Methods

Production of instant yam flour

The method described by Sanni *et al.* (2006) was employed. The yam tubers were peeled and washed totally devoid of all dirts. The peeled yam was sliced and cut into chips with a stainless steel knife; the thickness of the chips was about 0.2- 0.3 cm. The chips were immediately soaked in an already prepared 0.5% solution of potassium metabisulphite for 15 minutes. The chips were then drained and parboiled by steaming for 15 minutes so as to allow partial gelatinization to occur which is known as parboiling. After the parboiling stage, the chips were spread out uniformly on a stainless steel perforated tray and dried in a cabinet dryer at 65°C for 8 hours. The dried chips were finally milled into flour using a hammer mill and sieved to obtain flour of particle size range from 50 – 70 µm. The flour was packaged in polyethylene bag and stored at 4°C until use.

Preparation of Breadfruit flour

The breadfruit was washed in clean water to remove adhering latex and dirt. Then the fruits were peeled manually and then cut into pieces with a stainless steel knife. It was then cooked in boiling water for 10 minutes and dried in cabinet dryer at 65°C for 8hrs. The dried chips were ground in a hammer mill and sieved to obtain the breadfruit flour of particle size range from 40 – 50 µm. The flour was packaged in polyethylene bag and stored at 4°C until use.

Preparation of Instant yam-breadfruit flours

Yam and breadfruit flours were mixed at different proportions (80:20%; 70:30%; 60:40%, and 50:50% yam – breadfruit flour). A Kenwood mixer (Model FP 505, Kenwood, Britain, UK) was used for mixing samples at speed 6 for 5 minutes to achieve homogeneity.

Determination of Chemical Properties

Moisture, ash, protein, and fat contents were determined using (AOAC 1990) method. Amylose content was determined using the method of Williams *et al.* (1958) while starch and sugar was determined using the method of Dubois *et al.* (1956).

Functional Properties

The water binding capacity was carried out using the Medcalf and Gillies (1965) method. The Swelling Power and Solubility Index were carried out according to the method described by Takashi and Sieb (1988). Anderson (1982) method was employed for determining Water Absorption Index (WAI). The bulk density of the sample was determined by the method of Wang and Kinsella (1976), Least Gelation Concentration was determined by the method described by Coffman and Garcia (1977) and the pasting properties were determined using a Rapid Visco Analyser (RVA) (model RVA 3D+; Network Scientific, Australia) as described by Adebowale *et al* (2005).

Sensory Evaluation

Sensory evaluation was carried out on the reconstituted and cooked instant yam-breadfruit flour samples using preference test. A 9-point Hedonic scale was used with 1 corresponding to dislike extremely and 9 corresponding to like extremely. Panelists were asked to indicate their preference for the samples in terms of colour, texture, taste, mouldability, drawness and overall acceptability.

Statistical Analysis

All data obtained were subjected to Statistical Analysis of Variance (ANOVA) using SPSS (version 10.1, 2003). Means were separated using Duncan's Multiple Range Test (DMRT).

Results and Discussion

Chemical properties

The chemical composition of the yam-breadfruit instant flour is shown in Table 2. The fat content ranged from 2.73 to 2.44%, 50: 50 % instant yam-breadfruit flour had the highest value and 70 : 30 % instant yam- breadfruit flour had the lowest mean value. The 100 % instant breadfruit flour had higher fat content than the 100 % instant yam flour. There was significant difference ($P<0.05$) in the protein content, which ranged from 4.31 to 4.89 %. Ash content of the samples did not differ significantly ($P > 0.05$) with the values ranging from 1.2 to 1.5 %. This finding agrees with findings of Graham and de Bravo (1981), who reported that breadfruit is a very valuable food source on accounts of its higher ash, fat and protein content as compared with cassava and yam flours. There was significant difference ($P < 0.05$) between sugar content of 100 % breadfruit flour and all other samples. The 100 % instant breadfruit had the highest mean value of 2.91 % and 100 % instant yam flour having the lowest mean value of 1.09 %. The high sugar content of 100 % instant breadfruit flour results in faint sweetness in breadfruit flour product (Onayemi and Potter, 1974) which is undesirable in instant yam flour or pounded yam or pounded breadfruit or flour. This could have been the reason why the 100 % instant breadfruit *poundo* had the lowest rating in terms of taste. There was no significant difference, ($P>0.05$) in the amylose content in all the samples, the values ranged from 9.66 to 21.15 %. The amylose content of the 100 % instant breadfruit flour was higher than that of 100 % instant yam flour. The values obtained for carbohydrate content ranged from 58.66 to 65.00 %. There was no significant difference ($P>0.05$) in the carbohydrate content of the instant yam-breadfruit flour. The 60:40 % instant yam-breadfruit flour had the highest value while 100 % instant yam flour had the lowest carbohydrate content. The starch content ranged from 57.47 to 63.15 %. The moisture content of all samples was not significantly different ($P>0.05$) (7.0 - 8.00 %). The lower the initial moisture content of a product to be stored the better the storage stability of the product (Pierre, 1989). Low residual moisture content is advantageous in that microbial proliferation is reduced and storage life is enhanced and prolonged. High moisture content in foods has been shown to encourage microbial growth (Kuye and Sanni, 1999). The moisture content of the flour samples were lower than 10 %, hence, they are expected to store more than 6 months under ambient storage condition (Ukpabi and Ndimele, 1990).

Functional properties

The functional properties determine the application and use of food material for various food products. The results for functional properties of instant yam-breadfruit flour are shown in Table 3. Bulk density values were found to be between 0.58 g/cm^3 to 0.77 g/cm^3. There were significant differences ($P < 0.05$) between 100 % instant yam flour and all other samples. 100 % instant breadfruit flour had the lowest mean value, this indicates that 100 % yam flour was denser than all other samples. The bulk density is generally affected by the particle size and the density of the flour and it is very important in determining the packaging requirement, material handling and application in wet processing in the food industry (Karuna *et al*., 1996).

There were significant differences in water binding capacity of the instant yam-breadfruit flours ($P<0.05$). 100 % instant breadfruit flour had the highest value of 483.80 % while 100 % instant yam flour had the lowest value of 312.2 %. Addition of breadfruit flour to yam flour confers high water binding capacity to yam flour, which in turn improves the reconstitution ability (Kulkarni *et al.,* 1991) and textural properties of paste obtainable from instant yam – breadfruit flour. It has been reported that water binding by starches is a function of several parameters including size, shape, conformational characteristics, hydrophilic and hydrophobic balance in the molecule, lipids and carbohydrates associated with proteins, thermodynamic properties of the system (energy of bonding, interfacial tension etc,), physicochemical environment (pH, ionic strength, vapor pressure, temperature, presence/absence of surfactant etc), and the solubility of starch molecules (Chou and Morr, 1979). The 100 % instant yam flour had the maximum water absorption index value of 87.3 % while 100 % breadfruit flour had the minimum value of 76.52 %. There was no significant difference ($P > 0.05$) between all samples in terms of water absorption index. However, there was significant difference ($P < 0.05$) in the dispersibility of instant yam-breadfruit flour. Dispersibility values ranged from 36.00 (100 % instant breadfruit flour) to 61.50 % (100 % yam flour). Dispersibility is a measure of reconstitution of flour or flour blends in water, the higher the dispersability the better the flour reconstitutes in water (Kulkarni *et al,* 1991).

There were no significant differences ($P > 0.05$) in the solubility indices of all samples at 90°C and 100°C while significant differences existed in the solubility index of the instant flours at 70°C and 80°C. Solubility index of the instant flours increased up to 90°C and decreased considerably at 100°C. The swelling power of instant yam-breadfruit flour at different temperature is presented in Fig. 1. The swelling power increased with increasing temperature for all the samples. Swelling power is an indication of the water absorption index of the granules during heating (Loos, *et al*, 1981). Swelling power of all samples at 70°C, 80°C, 90°C had no significant difference while at 90°C there was significant difference ($P < 0.05$) between 100 % instant breadfruit flour and all other samples. The 100 % instant breadfruit flour had the highest mean of 20.99 % and 100 % instant breadfruit flour had the lowest mean of 13.19 %. Moorthy and Ramanujam (1986) suggested that the swelling power of granules reflected the extent of the associative forces within the granule. The least gelation concentration obtained for all samples except 100 % instant breadfruit flour was 8 % (w/v) while that of the 100 % instant breadfruit flour was 10% (w/v). LGC is a measure of the minimum amount of flour or blends of flour that is needed to form a gel in a measured volume of water. The higher the LGC the higher the amount of flour needed to form a gel (Adebowale, *et al, 2005*). The values obtained for the 100 % instant breadfruit flour was similar to that obtained by Odoemelam (2000). Variations in the gelling properties of different flours may be due to variations in the ratio of different constituents such as carbohydrates, lipids and proteins that make up the flours, (Abbey and Ibeh, 1998).

Pasting Properties

Results of the pasting properties of instant yam - breadfruit flour are shown in Table 4. When starch-based foods are heated in an aqueous environment, they undergo a series of changes known as gelatinization and pasting. These are two of the most important properties that influence quality and aesthetic considerations in the food industry, since they affect texture and digestibility as well as the end use of starchy foods (Adebowale *et al*, 2005). There were significant differences ($P < 0.05$) in the pasting profile of the different formulations of instant yam-breadfruit flour. Peak viscosity, which is the ability of starch to swell freely before their physical breakdown (Sanni, *et al*, 2004) ranged from 157.08 to 340 RVU. The 100 % instant breadfruit flour had the highest peak viscosity value of 340 RVU and 80:20% instant yam-breadfruit flour had the lowest value of 157.08 RVU. High peak viscosity is an indication of high starch content (Osungbaro, 1990). It is also related to the water binding capacity of starch (Adebowale *et al*, 2005). The relatively high peak viscosity exhibited by 100 % instant breadfruit flour is indicative that the flour may be suitable for products requiring high gel strength and elasticity (Adebowale, *et al.*, 2005). The trough, which is the minimum viscosity value in the constant temperature phase of the RVA profile and measures the ability of paste to withstand breakdown during cooling ranged between 140.83 and 257.42 RVU. The 100 % instant breadfruit flour had the highest trough value of 257.42 RVU and 80:20 % instant yam-breadfruit flour had the lowest value of 140.83RVU. The 100 % instant breadfruit flour had the highest breakdown viscosity (85.58 RVU) while 70:30 % yam-breadfruit had the lowest (14.83 RVU). The breakdown viscosity value is an index of the stability of starch (Fernandez and Berry, 1989). The final viscosity, which is the change in the viscosity after holding cooked starch at 50°C ranged from 215.88 to 300.67 RVU. Final viscosity is the most commonly used parameter to define the quality of a particular starch-based sample, as it indicates the ability of the material to form a viscous paste or gel after cooking and cooling as well the resistance of the paste to shear force during stirring (Adeyemi and Idowu, 1990). Setback value of the 100 % breadfruit flour was the highest with mean of 123.08 RVU and 70:30 % instant yam breadfruit flour had the lowest mean value of 29.58 RVU. The higher the setback value, the lower the retrogadation during cooling and the lower the staling rate of the products made from the flour (Adeyemi and Idowu, 1990). The peak time, which is a measure of the cooking time, ranged between 5.13 and 5.80 minutes. The 70:30 % instant yam breadfruit flour was highest with a value of 5.8 minutes and that of 100 % instant breadfruit flour having the lowest pasting time of 5.12 minutes. Pasting temperature of the 100 % breadfruit was significantly different (P<0.05) from all samples with a mean value of 84°C and 50:50% instant yam-breadfruit had the lowest mean value of 81°C. Pasting temperature gives an indication of the gelatinization time during processing. It is the temperature at which the first detectable increase in viscosity is measured and is an index characterized by the initial change due to the swelling of starch (Emiola and Delarosa, 1981). Pasting temperature has been reported to relate to water binding capacity. A higher pasting temperature implies higher water binding capacity, higher gelatinization, and lower swelling property of starch due to a high degree of association between starch granules (Emiola and Delarosa, 1981; Numfor *et al.*, 1996).

Sensory Evaluation

Table 5 shows the mean sensory evaluation scores of instant yam-breadfruit flour paste. There were significant differences (P<0.05) in all the sensory parameters. The values obtained for aroma ranged from 5.13 to 5.90, which was lower than the panelist score (7.79) for conventional pounded yam. The taste of 100% instant breadfruit paste was least preferred by the panelist compared to conventional pounded yam. In terms of mouth feel, there was significant difference (P<0.05) between the conventional pounded yam and instant yam-breadfruit paste. Textures of all samples except the conventional pounded yam had no significant difference (P>0.05). There was no significant difference between the 100 % instant breadfruit flour paste and conventional pounded yam in terms of drawiness. The 100 % instant yam flour paste had the lowest mean value for 5.47. Mouldability of pounded yams was significantly different (P<0.05) with the values ranging from 7.38 to 5.37, and 100 % instant yam flour paste had the lowest mean sensory panelist score for mouldability.

Conclusion

The study showed that the breadfruit flour improved the chemical, and pasting properties of the instant yam flour. Sensory panelist's scores showed that there is no significant difference (p<0.05) in the sensory texture of conventional pounded yam and that from instant yam - breadfruit and that paste from 60:40% instant yam-breadfruit is a potential substitute owing to its high sensory appeal.

Table 1: Chemical Composition (%) of instant yam-breadfruit flour

Instant flour	Moisture content	Fat	Sugar	Starch	Carbohydrate	Amylose	Protein	Ash[ns]
100% yam flour	7.60 ±0.57	2.62±0.14	1.09±0.02 [e]	57.57±0.11	58.66±0.13	18.02±0.04	4.31±0.40[b]	1.2±0.28
100% breadfruit flour	7.90±0.14	2.69±0.25	2.97±0.04[a]	57.47±6.95	60.44±6.99	21.15±0.21	4.78±0.11[a]	1.4±0.28
80:20% yam – breadfruit flour	8.00±0.56	2.62±0.14	2.63±0.04[b]	59.35±0.91	61.47±0.57	17.12±0.28	4.63±0.16[ab]	1.3±0.14
70:30% yam – breadfruit flour	7.00±0.00	2.44±0.00	1.25±0.04[c]	63.75±0.16	65.00±0.14	17.54±0.13	4.89±0.98[a]	1.5±0.42
60:40% yam - breadfruit flour	8.00±0.00	2.57±0.00	1.13±0.01[cd]	60.45±0.33	61.57±0.33	17.85±0.28	4.70±0.59[a]	1.4±0.28
50:50% yam – breadfruit flour	8.00±0.00	2.79±0.00	1.18± 0.21[d]	61.77±0.01	62.94±0.01	9.66±11.27	4.73±0.24[a]	1.5±0.42

± standard deviation (n=3)
Means in the same column with the same superscript are not significantly different at P>0.05.

Table 2: Functional Properties of instant yam-breadfruit flour

Samples	Bulk density (g/cm^3)	Water binding capacity (%)	Water absorption index (%)	Dispersibility (%)	Solubility index (%)				Least gelation concentration
					70°C	80°C	90°C[ns]	100°C[ns]	
100% yam flour	0.77±0.00[a]	312.20±48.66[d]	87.3±6.73	61.50±0.71[a]	17.00±1.42 [ab]	15.00±0.00[bc]	21.00±1.41	17.50±0.71	8%
100% breadfruit flour	0.58±0.11[e]	483.80±29.13[a]	76.52±2.26	36.00±0.00[e]	15.50±0.71[c]	20.22±2.83[ab]	20.5±0.71	19.00±1.41	10%
80:20% yam – breadfruit flour	0.69±0.00[b]	347.60±5.65[cd]	83.71±6.70	58.50±0.71[b]	16.00±0.00 [bc]	14.5±3.54 [c]	21.00±0.00	17.00±1.41	8%
70:30% yam – breadfruit flour	0.66±0.16 [c]	371.60±13.58[bc]	81.90±2.23	57.50±0.71[b]	17.00±0.00 [ab]	16.00±1.41 [ab]	22.00±0.41	17.5±0.71	8%
60:40% yam - breadfruit flour	0.64±0.14[cd]	421.00±46.67[ab]	78.58±1.78	48.50±0.71[c]	19.00±0.00 [a]	21.00±0.00 [a]	24.00±1.41	16.50±0.71	8%
50:50% yam – breadfruit flour	0.63±0.00[d]	441.40±30.26[ab]	80.34±0.71	46.50±0.71[d]	18.00±1.41 [ab]	21.00±1.41 [a]	20.5±0.71	17.5±0.71	8%

± standard deviation (n=3)
Means in the same column with the same superscript are not significantly different at P>0.05.
ns not significantly different (P>0.05)

Table 3: Pasting properties of instant yam-breadfruit flour

Sample	Peak viscosity (RVU)	Trough (RVU)	Breakdown (RVU)	Final viscosity (RVU)	Set back (RVU)	Peak time (minutes)	Pasting temperature °C
100% yam flour	230.08^{b}	214.33^{b}	15.67^{e}	300.67^{a}	86.33^{d}	5.67^{b}	83.50^{b}
100% breadfruit flour	340.00^{a}	257.42^{a}	85.58^{a}	300.50^{b}	123.08^{a}	5.13^{f}	84.05^{a}
80:20% yam – breadfruit flour	157.08^{f}	140.83^{f}	16.25^{d}	215.58^{f}	74.75^{e}	5.61^{c}	81.55^{d}
70:30% yam – breadfruit flour	188.42^{d}	173.58^{d}	14.83^{f}	253.17^{d}	29.58^{f}	5.80^{a}	82.00^{c}
60:40% yam - breadfruit flour	221.83^{c}	194.42^{c}	27.42^{b}	297.42^{c}	103.00^{b}	5.47^{d}	81.40^{e}
50:50% yam – breadfruit flour	172.25^{e}	144.92^{e}	27.33^{c}	235.50^{e}	90.58^{c}	5.40^{e}	81.00^{f}

Means in the same column with the same letter are not significantly different at P>0.05.

Table 4: Mean sensory evaluation scores of instant yam-breadfruit flour paste
Means in the same column with different superscript are significantly different at p<0.05

Samples	Colour	Aroma	Taste	Mouthfeel	Texture	Drawiness	Mouldability	Overall acceptability
100% yam flour	7.03[ab]	5.90 [b]	6.60[b]	6.83[a]	6.1[b]	5.47[b]	5.37[c]	6.67[b]
100% breadfruit flour	4.87 [e]	5.13 [b]	5.56[c]	5.43 [b]	6.23[b]	6.67[a]	6.33[b]	6.13[b]
80:20% yam – breadfruit flour	6.37[bc]	5.55[b]	5.76[bc]	5.86[b]	6.41[b]	6.01[ab]	6.00[bc]	6.03[b]
70:30% yam – breadfruit flour	6.06[cd]	5.67[b]	5.67[bc]	5.90[b]	5.67[b]	5.67[b]	6.20[bc]	6.23[b]
60:40% yam – breadfruit flour	6.40[bc]	5.73 [b]	6.13[bc]	5.93[b]	6.23[b]	6.10[ab]	6.03[bc]	6.43[b]
50:50% yam – breadfruit flour	5.41[de]	5.24 [b]	6.00[bc]	5.97[b]	6.10[b]	6.24[ab]	5.86[bc]	6.27[b]
Pounded yam	7.48[a]	7.79 [a]	7.66[a]	7.48[a]	7.48[a]	6.97[a]	7.38[a]	8.27[a]

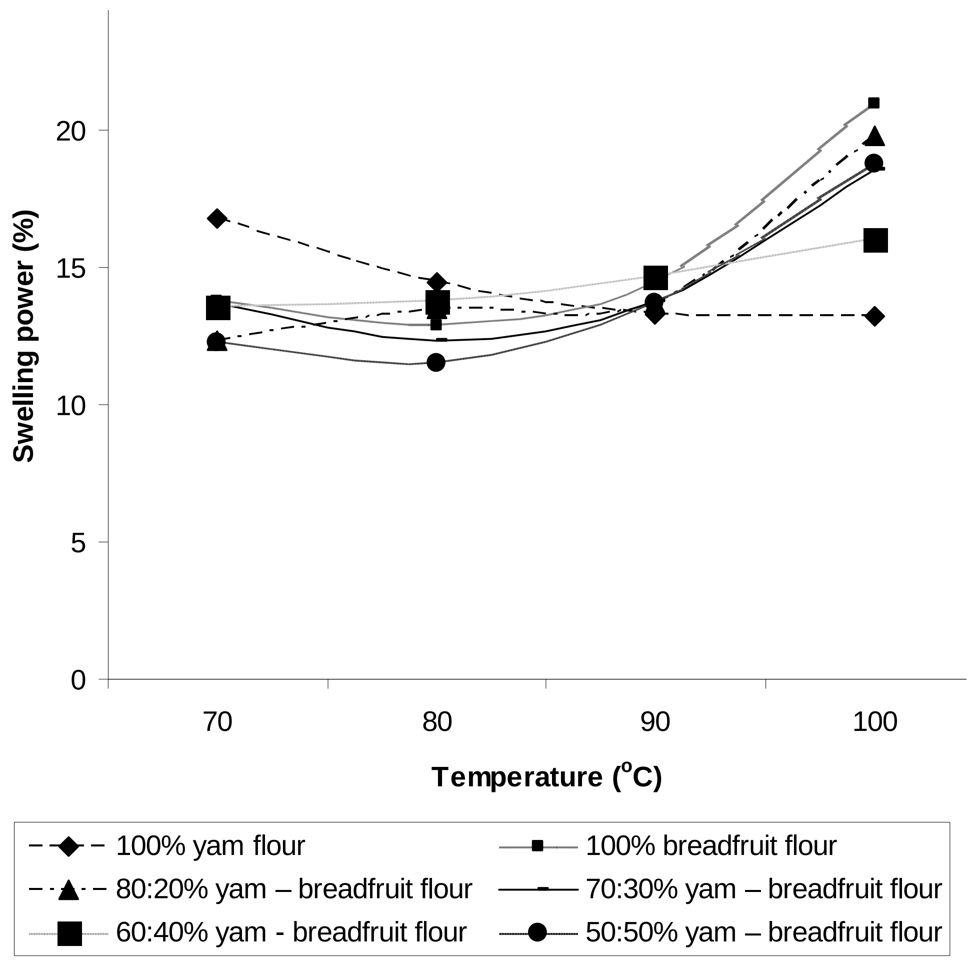

Figure 1: Swelling power at different temperatures of instant yam – breadfruit flour

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