The Optimization of Production of Instant Pounded Yam Flour Using Cultivars of White Yam (*Dioscorea rotundata*)

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Authors' contributions

This work was carried out in collaboration among all authors. Author OFOY processed the raw materials used for the study, did literature search and wrote the first draft of the manuscript. Authors AA and OS were involved with study experimental design and data interpretation. Author LS supervised the research study. All authors read and approved the final manuscript.

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ABSTRACT

Background and Objective: Instant pounded yam dough obtained from instant pounded yam flour (IPYF), is an emerging alternative to pounding boiled yams. IPYF dough that possesses similar organoleptic properties with conventional pounded yam (CPY) is of high demand in the West Africa market. The objective of this study was to produce IPYF dough of similar qualities to the CPY through optimization technique in other to enhance its marketability value.
Methodology: The study optimized IPYF samples obtained from three white yams (*Dioscorea rotundata*) cultivars (*Efuhu, Dariboko and Aro*) that were pre-treated (using blanching and steam method) and dried (using cabinet and oven driers). General factorial optimization design was utilized using pasting properties response of IPYF samples. Hedonic and Degree of difference

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sensory evaluation were conducted on the selected optimized IPYF and CPY samples using nine and seven points scales respectively.

Result: The selected optimized sample was *Dariboko* pre-treated with steam and dried using cabinet drier with 0.63 desirability value. A mean score of 7.4:7.5, 6.8:8.5, 7.2:8.5, 7.3:8.5, 6.0:8.5, 7.3:8.5, 7.2:8.5, 6.8:8.5 and 7.4:7.5 was obtained correspondingly for cohesiveness, smoothness, springiness, adhesiveness, hardness, stretch ability, taste, mouth feel, aroma and overall acceptability for the optimized IPYF sample and CPY. Scores for these attributes indicated that the optimized IPYF sample was acceptable. The degree of difference test showed that CPY was not significantly different from optimized sample in terms of smoothness, stretch ability, adhesiveness and mouth feel.

Conclusion: This demonstrates that this sample can easily pass as pounded yam has it possess important similarities with conventional pounded yam.

1. INTRODUCTION

Yams are cultivated for the consumption of their starchy tubers [1] and it is the most important staple food in West Africa, after cereals [2]. Yam belongs to the *Dioscoreaceae* family, with many species widely cultivated in West and Central Africa zones. White yam (*Dioscorea rotundata* Poir)*, is the most favoured yam species in West Africa because it possesses a highly viscous starch [3]. Traditional foods in Nigeria derivable from yam tubers include roasted yam, fried chips, amala and pounded yam. Pounded yam is a stable food, which is consumed in many tribes of Nigeria and some other West African countries. However, its traditional processing steps are found to be unhygienic, time consuming and rigorous which in turn add to the cost of preparation [4]. The aforementioned challenges together with some other environmental and hygienic factors gave rise to the need for a less strenuous and cheaper method of making pounded yam [5]. Instant pounded yam dough (IPYD) obtained from instant pounded yam flour (IPYF), a product of innovation has become an emerging substitute for conventional pounded yam. The flour can be easily turned to pounded yam dough by dispersing a measured quantity in quantified volume of boiled water and carefully stirring the mixture until a solid of desired texture is formed, making the process easier, more efficient and less time consuming [6]. General acceptability of IPYD is accessed through subjective method by its consumer using sensory (mouth feel, stretch ability, aroma and taste) and textural attributes as the basal for judgment. Pasting characteristics of starch has been associated with cooking qualities and texture of various food products [7-9]. High peak viscosity, breakdown, final viscosity and set back viscosity are pasting characteristics associated with IPYD

with excellent textural quality [10]. Textural qualities of importance to instant pounded yam dough consumer include springiness, cohesiveness (mould ability) hardness, adhesiveness (stickiness) and smoothness [11]. They are potential indicator of textural quality in pounded yam and in due time helps in the selection of breeding and selection of yam variety in commercial processing [11]. However, IPYD that possesses similar organoleptic properties with conventional pounded yam is of high demand in the market. This work optimized IPYF samples obtained from three white yams (*Dioscorea rotundata*) cultivars (*Efuhu, Dariboko and Aro*) which are popularly used in the preparation of conventional pounded yam in South-West Region of Nigeria. The cultivars were pre-treated (using blanching and steam method) and dried (using cabinet and oven dryers). The selected optimized instant pounded flour sample was evaluated for its sensory scores alongside the conventional pounded yam to determine its overall acceptability and to emphasize its difference/similarity with the conventional pounded yam.

2. MATERIALS AND METHODS

2.1 Experimental Design

A 3x2x2 full factorial design was used. Factors were Yam variety (*Efuhu, Aro and Dariboko*), Pre-treatment (Steaming and Blanching), Drying methods (Cabinet and Oven drying), generating 12 samples.

2.2 Instant Pounded Yam Flour Production

The method described by Akinwande et al. [12] was used in producing Instant pounded yam flour

with modification. Whole yam tubers were washed to remove sand and other adhering materials. Yam tubers were peeled with stainless knives, sliced and immersed in water containing potassium meta-bisulphite, in other to prevent enzymatic browning reaction and then placed in a sieve to drain excess water. Yam chips were sectioned into two and pre-treated. First portion was pre-treated for 10 mins at 100ºC using hot water and second portion was steamed for 15 mins. However both pre-treated yam chips were portioned again into two and dried simultaneously using hot air oven (Model OV-160, BS Gallenkamp, Japan) and cabinet drier (Model 3114, LEEC Limited, Nottingham United Kingdom). Drying was followed by milling using hammer mill (Model TWHM48E, SME, China). The instant pounded yam flour was sieved with 250 micron sieve size, packaged in Ziploc bag (Freezer quart, 7" x 7 7/16) and stored at -10ºC prior to analysis.

2.3 Pasting Properties

Pasting characteristics of produced instant pounded yam flour were determined with a Rapid Visco Analyser [13].

2.4 Optimization

Data from pasting properties of the 12 instant pounded yam flour samples were optimized using General Factorial design. The factors (variety, pre-treatment and drying methods) were optimized with respects to the response of peak, trough, final, breakdown, and setback viscosity, pasting temperature and pasting time. A numerical optimization technique was used for simultaneous optimization of the multiple responses. The desired goal for each processing parameter and response was chosen. The processing parameters (cultivars, treatment and drying methods) were kept in range, maximum goal was selected for peak, breakdown, final and set back viscosity while minimum goal was set for trough viscosity, peak time and pasting temperature. This was done to obtain instant pounded yam dough with high sensory and textural attribute. To obtain solution for this procedure, goals were combined into an overall composite function, D(x), called the desirability function [14] defined as:

$$D(x) = (d_1 \times d_2 \times d_3 \times \ldots d_n)^{1/n}$$

Where, d_1, d_2, d_3,… d_n are the responses, and 'n' is the total number of responses in the measure.

2.5 Sensory Evaluation

Dough preparation: The optimized instant pounded yam flour sample was reconstituted from flour into dough; 20 g quantity of the flour was poured in the boiling water and stirred continuously till it gelatinized into thick dough. A little quantity of water was added to allow the flour cook properly. The paste was stirred till dough was obtained. Textural qualities of instant pounded yam sample and conventional pounded yam were evaluated subjectively using "Degree of difference test" and "Hedonic test".

Hedonic Test: Thirty trained panellists made up of students of Federal University of Agriculture Abeokuta, Ogun state, Nigeria were asked to grade each coded sample; optimized instant pounded yam dough and conventional pounded yam (cooked and pounded *Dariboko* yam) in terms of stretch ability, mould ability, cohesiveness, smoothness, springiness, adhesiveness, hardness, mouth feel, taste, flavour and overall acceptability. Hedonic test was done using nine point hedonic scales. Where 1 represented like extremely and 9 represented dislike extremely; responses of the panellists were then analysed statistically [15].

Degree of difference test: Thirty trained panellists made up of students of Federal University of Agriculture Abeokuta, Ogun state, Nigeria were asked to compare pairs of coded samples (blind control and sample); one pair at a time, in terms of cohesiveness, smoothness, springiness, adhesiveness, aroma, mouth feel and taste. Overall degree of difference and degree of difference between the control sample and the coded sample was done using a seven point scale. Where 0 represented "no difference from control" 1 represented "very slight difference" 2 represented "slight/moderate difference" 3 represented "moderate difference" 4 represented "moderate/large difference" 5 represented "large difference" and 6 represented "very large difference" [16].

2.6 Statistical Analysis

The effect of ingredient combination and optimization procedure was investigated using Design expert version 6.0.8 based on general factorial design.

3. RESULTS AND DISCUSSION

The data of the pasting properties of instant pounded yam flour which was used for the optimization design is presented in Table 1. The peak viscosity content of IPYF samples were high and ranged from 187 to 444 RVU, this is similar to the result reported by Otegbayo et al., [11] (325-414 RVU) . *Dariboko* pre-treated with steam and dried with cabinet drier had the highest peak viscosity. The High value implied that the flour sample was able to form thicker pastes on cooking. As reported by Coursey [17], high peak viscosity reached by *D. rotundata* starches is significant in the making of pounded yam. High peak viscosity is an important criterion for the production of instant pounded yam dough with good textural properties; hence, it was set as maximum in the optimization design criteria.

Setback viscosity content ranged from 95 to 257 RVU, the values recorded were lower than the result reported by *Oluwakomi and Adeyemi* [18] *but similar to the report by Otegbayo et al., 2006.* The higher setback observed for the IPYF sample in this study suggested that its flour/starch is relatively not stable when cooked and would have higher tendency to undergo retrogadation. However instant pounded yam dough/pounded yam with good textural quality are expected to have this high value for better mould-ability (Cohesiveness). Oduro et al. [19] reported that pounded yam with low set back value was difficult to mould. This finding was also in support with Kim et al. [8] about potato paste having low cohesiveness due to low set back value. Hence, the optimization design criterion for setback viscosity was set as maximum.

Low values were recorded for the breakdown viscosity of the instant pounded yam flour samples. The values ranged from 3.5 to 51.7 RVU, similar to the values recorded for dioscorea varieties of yam by Babajide et al. [20]. Lower breakdown values indicate that the flour samples were less resistant to breakdown in viscosity and thus less stable. On the contrary, high breakdown viscosity was correlated with good textural properties as reported by Otegbayo et al. [10]. Hence for this reason also, the breakdown criterion for the optimization design was set at maximum. In this study, Dariboko pre treated with steam and dried with cabinet drier had the highest breakdown value.

Final viscosity is the viscosity attained after cooling cooked paste to 50ºC. Final viscosities reported in this study were high and ranged between 197 to 648 RVU. Positive correlation has been reported in literature for final viscosity and springiness. Otegbayo et al. [10] further stressed the relationship. It was reported that pounded yams with high final viscosity were more firm and springy. For the optimization procedure to generate dough with best textural attribute, the final viscosity thus was set to maximum.

Trough viscosity measures the ability of a paste to withstand breakdown during cooking [16] and its low value depicts high pasting stability. The values obtained in this study varied from low to moderately high (102-39 RVU). Since, stability is of great importance, thus the parameter was set as minimum in the optimization experimental design.

Peak time is a measure of the cooking time. It depicts the minimum time required to cook the instant pounded yam flour. *Dariboko* pre-treated with steam and dried using oven drier would require the least cooking time (5.5 mins) while samples produced from *Aro* would require the longest time to cook than other cultivars.

IPYF samples exhibited low pasting temperature which indicate that the samples will cook faster and less energy would be consumed, thus saving time and cost.

The regression model coefficient for the pasting properties is presented in Table 2. The models (cultivar, treatment and drying method) and some quadratic models were significant (P< 0.05) and they provided a moderate to good fitness (R^2 ranged from 77.1- 88.9) for the experimental data. This means that in other to produce instant pounded yam dough with suitable pasting properties, that is high peak, final viscosity, setback viscosity, breakdown and low trough viscosity, pasting time and temperature, the white yam cultivar, treatment and drying method employed are important and therefore, must be put into consideration.

Upon optimizing the pasting properties of the instant pounded yam flour samples, the instant pounded yam flour sample selected by the optimization design and with best desirability value (0.6) was instant pounded yam flour sample produced from *Dariboko* pre-treated with steam and dried using cabinet drier. This means this sample would produce pounded yam dough of good textural and sensory properties.

Table 1. General factorial optimization result for pasting parameters of Instant pounded yam flour

Run	Cultivar	Treatment	Drying	Peak viscosity (RVU)	Trough viscosity (RVU)	Breakdown viscosity (RVU)	Final Viscosity (RVU)	Set back viscosity (RVU)	Peak Time (mins)	Pasting Temperature (°C)
1	*Efuhu*	Steam	Cabinet	257	246	18.2	375	130	6.1	77.9
2	*Dariboko*	Steam	Cabinet	444	392	51.7	624	232	5.5	73.4
3	*Aro*	Hot water	Oven	187	166	20.5	306	140	7.0	77.1
4	*Aro*	Steam	Cabinet	265	252	12.3	399	147	6.9	77.5
5	*Aro*	Hot water	Cabinet	330	319	11.1	508	189	6.5	76.7
6	*Efuhu*	Steam	Cabinet	344	321	23.4	495	175	5.6	75.8
7	*Efuhu*	Hot water	Oven	286	280	5.4	451	171	6.70	77.2
8	*Dariboko*	Hot water	Cabinet	300	290	7.9	481	200	5.9	77.1
9	*Dariboko*	Steam	Oven	295	282	13.1	476	194	6.0	76.3
10	*Efuhu*	Hot water	Cabinet	441	396	45.2	648	257	5.6	72.3
11	*Aro*	Steam	Oven	120	102	17.3	197	95	7.0	88.0
12	*Dariboko*	Hot water	Oven	272	268	3.5	447	178	6.7	76

Table 2. Regression coefficient responses as a function of pasting properties of instant pounded yam flour

Predictor variable	Coefficient estimates (amounts)						
	PV	TV	BDV	FV	SBV	PT	PTemp
Cultivar	-66.3*	-66.3*	-3.8*	-105*	-33.0*	0.5*	2.6*
Treatment	-10.4	-10.4	-3.5*	-15.6*	-13.6*	-0.1*	1.0*
Drying	-52.1*	-52.1*	-6.1*	-68.1*	-24.4*	0.3*	1.6*
C x T	-22.2*	-22.2*	-4.0*	-38.7*	-8.1*	0.2*	1.9*
C x D	-23.6	-23.6*	9.7*	-32.9	-0.9*	-0.0	1.0*
T x D	-3.7	-3.7	-0.3	4.2	2.0	-0.0*	1.0*
C x T x D	4.4*	4.4	-0.8*	-4.0	-2.4	-0.1	1.6*
R²	93.3	93.0	94.2	88.3	89.3	79.0	88.1
Adj R²	87.2	86.6	88.9	77.5	79.5	59.8	77.1

Significant at P < 0.05. PV= Peak viscosity, TV+ Trough viscosity, BDV= Breakdown viscosity, FV= Final viscosity, SBV= Set back viscosity, PT= Pasting time, PTemp=Pasting temperature

3.1 Sensory Attributes of Dough Samples

Fig. 1 shows the mean scores for the hedonic test. The likeness for degree of cohesiveness showed the control (Pounded dariboko yam) was liked very much (8.5) by the panelist, however, the optimized sample (*Dariboko* pretreated with steam and dried using cabinet drier) was close to the control (7.7). This value implied that the panellists found moulding the instant pounded yam dough as easy as it was to mould the conventional pounded yam. In terms of smoothness, the optimized sample was liked very much (7.9) and preferred than its control (pounded *Dariboko* yam) (6.0). This was expected as the treatment of steaming and drying causes starch cells disintegration thus affecting the yam fibre texture. The degree of likeness for springiness showed that the control sample was liked moderately (6.9), while the optimized sample had a close score of 6.3 and both score were not significantly different from each other for springiness. In terms of adhesiveness, the control was liked extremely (8.5) as compared to the optimized sample which

also was liked moderately (6.7) by the panellist. The panelist liked the optimized sample (6.7) moderately and was rated higher above its control (5.5) for hardness. Hardness is an important factor that is changing the consumption trend of pounded yam. Instant pounded yam dough keeps its textural quality hours after preparation unlike conventional pounded yam which tends to become hard. In terms of stretch ability, the control was liked extremely (8.5) and was significantly different from the optimized sample which had score of 6.0. The control was liked extremely (8.5) for taste parameter more than the optimized sample which was liked moderately (7.3). Also, in terms of mouthfeel, the control was also rated best for likeness (8.5), while the optimized sample was liked moderately with a score of 7.2. For aroma, the control was rated highest and was liked extremely (8.5) while optimized sample had moderately like score of 7.0. In general, the total overall acceptability as rated by the panelist showed no difference between the optimized sample and the control (7.4:7.5). They were both liked moderately and accepted by the panellists.
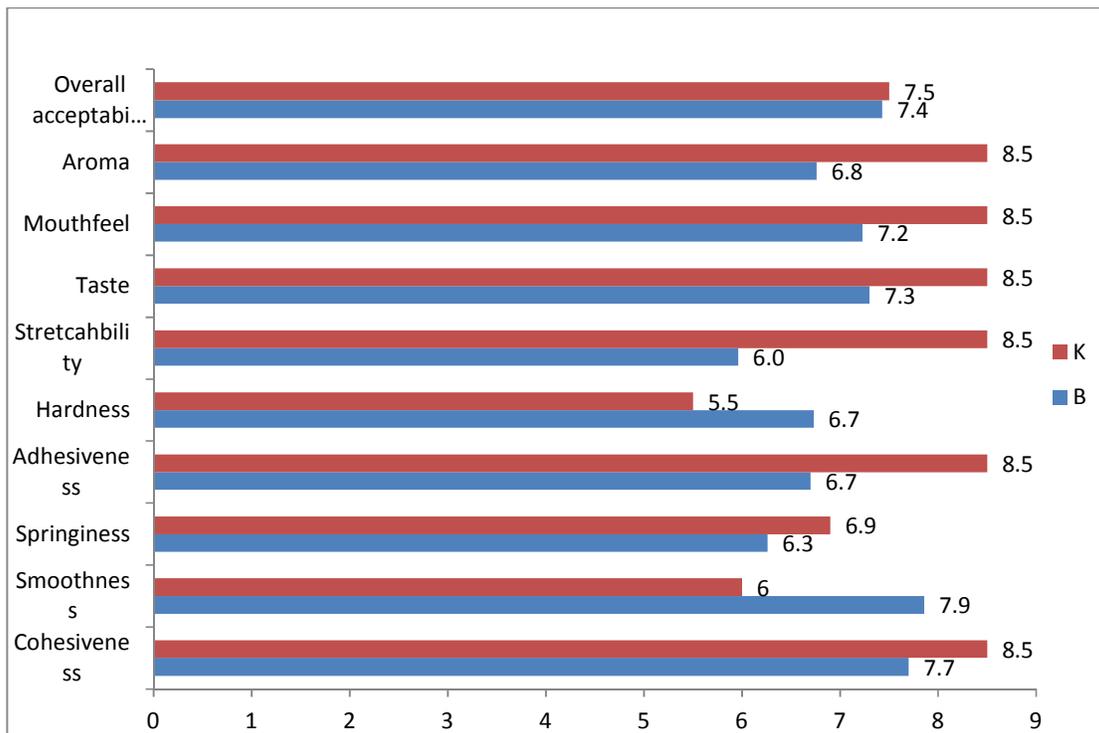
Fig. 1. Mean Hedonic Ratings for instant pounded yam flour dough and conventional pounded yam

B= Instant pounded yam flour dough (Dariboko variety, pre-treated with steam blanching and dried using cabinet drier). K= (conventional pounded Dariboko yam). Scale of 1-9 (1= dislike extremely, 2= dislike very much, 3= dislike moderately, 4= dislike slightly, 5= neither like nor dislike, 6=like slightly, 7= like moderately, 8= like very much, 9= like extremely)
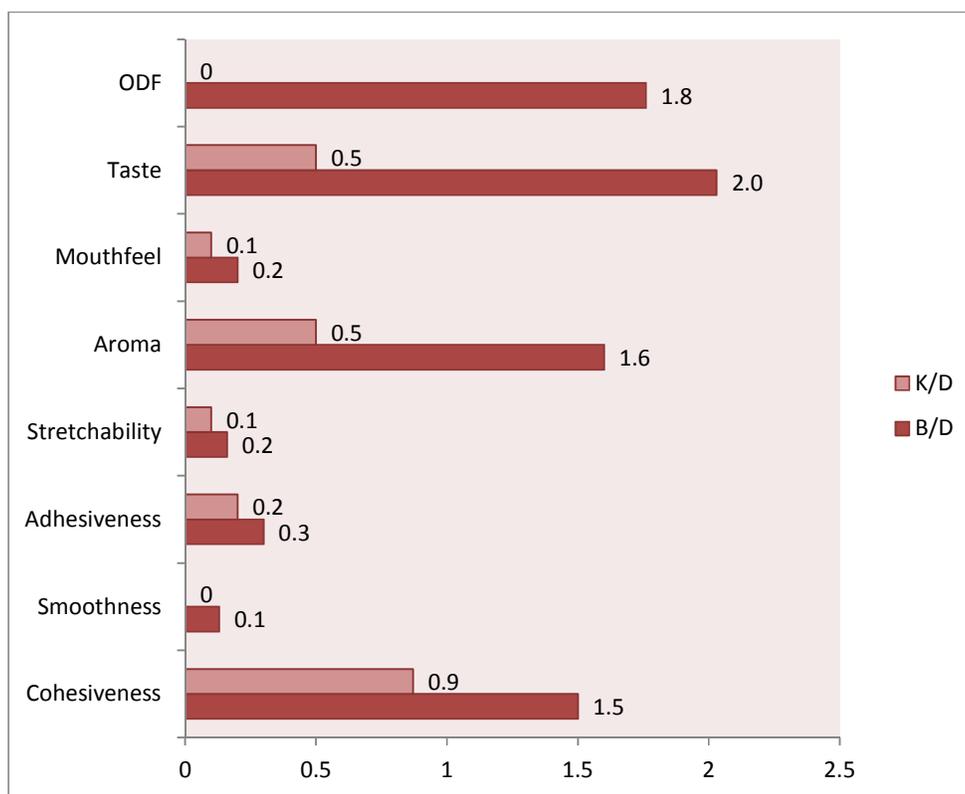
Fig. 2. Degree of Difference comparison test between instant pounded yam flour dough and conventional pounded yam

ODF= Overall degree of difference, B=instant pounded yam flour dough (Dariboko variety pre-treated with steam blanching and dried using cabinet drier]). K= (Control-conventional pounded Dariboko yam). D= (Blind control-conventional pounded Dariboko yam). Scale of 0-6 (0=No difference from control, 1=Very slight difference, 2=Slight/moderate difference, 3=Moderate difference, 4=Moderate/large difference, 5=large difference and 6= very large difference)

When pounded yam is compared to instant pounded yam, controversy always ensues with conclusion that both are incomparable with conventional pounded yam been most preferred over instant pounded yam dough. However, the degree of difference test partially disagreed with the general conclusion. Fig. 2 represents the degree of difference sensory evaluation of the optimized sample and its control in terms of overall degree of difference, cohesiveness, smoothness, adhesiveness, stretchability, aroma and mouthfeel. For overall degree of difference, the optimized sample was slightly different (1.8) from the control. Also, it was slightly/moderately different form control for cohesiveness (1.5), taste (2.0) and aroma (1.6). However despite this, the optimized sample had no significant difference with the control in terms of smoothness (0.1), adhesiveness (0.3), stretchability (0.2) and mouthfeel (0.2) respectively.

4. CONCLUSION

Yam variety, pre-treatment and drying methods had significant effect on the pasting properties of instant pounded yam flour. The instant pounded yam flour samples had high viscosities and required reduced temperature and time to form dough. *Dariboko* variety pre-treated by steam blanching and dried using cabinet drier was the optimized sample and has potential to be used as conventional pounded yam. The optimized sample was found similar to its control in terms of smoothness, adhesiveness, mouth-feel and stretch-ability. The result revealed further that instant pounded yam produced from *Dariboko* pre-treated with steam can be compared excellently with conventional pounded yam. Food processors (researchers, entrepreneurs) should employ the use of *Dariboko* in the production of instant pounded yam flour with the use of steam blanching pre-treatment and

cabinet drier. Further research should be carried out on the effect of packaging materials on storage stability of poundo yam flour.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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