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EDITED BY:

**PROF. BOLANLE AISHAT AKINWANDE || PROF. ADEBANJO A. BADEJO
PROF. GRACE O. BABARINDE || DR. WASIU AWOYALE
DR. ADEKOLA ADEGOKE || DR. KAZEEM OLATOYE**

PASTING PROPERTIES AND SENSORY ACCEPTABILITY OF YELLOW-FLESHED PLANTAIN-BASED POUNDO AS INFLUENCED BY DIFFERENT STEAMING CONDITIONS

Awoyale W.^{1*}, Sanuola R.R.¹, Aisha A.A.¹, Omopariola F.², Olatoye K.K.¹, Oyafajo L.A.³, Irondi E.A.¹, Bello A.S.¹, Omohimi C.⁴, Mahmud H.U.¹, Sunmonu B.A.⁵, Aina T.H.¹, and Sanni L.O.²

¹Kwara State University, Malete, Ilorin, Kwara PMB 1530, Nigeria.

²Nigerian Stored Product Research Institute, PMB 1489, Ilorin, Kwara State, Nigeria.

³Osun State University, PMB 4494, Osogbo, Osun State, Nigeria.

⁴Federal University of Agriculture, PMB 2240, Abeokuta, Ogun State, Alabata Road, Abeokuta, Ogun State

⁵The Federal Polytechnic Offa, PMB 420, Offa, Kwara State

*Corresponding author: wasiu.awoyale@kwasu.edu.ng, 08062146482

Abstract

Steaming, which breaks down cell walls and gelatinises the starch, is one of the essential unit operations in the production of pondo, which may affect the pasting properties and acceptability of the cooked dough. Therefore, this study aimed to evaluate the pasting properties and sensory acceptability of plantain-based pondo as influenced by different steaming conditions. The unripe, yellow-fleshed plantain fingers were washed, peeled, and sliced with a mechanical slicer. They were then steam-cooked at 92 °C for 8 min, 93 °C for 7 min, 94 °C for 6 min, 94 °C for 7 min, and 95 °C for 5 min, with the sliced unsteamed/uncooked plantain fingers used as a control. The samples were dried, cooled, milled, sieved, and sealed in Ziploc bags for subsequent use. The pasting properties were assessed using standard methods, and the sensory attributes were determined using a 9-point hedonic scale with 15 panelists familiar with the product. Results showed that significant differences ($p < 0.05$) exist in the peak and breakdown viscosities and the peak time of the plantain-based pondo, but no significant difference ($p > 0.05$) in all the sensory attributes of the unsteamed flour and pondo samples. The unsteamed plantain flour had significantly higher peak (628.32 RVU), trough (385 RVU), and breakdown (243.32 RVU) viscosities, but lower peak time (4.97 min) compared to the pondo samples. Although the sensory acceptability of all the samples was the same, the Principal Component Analysis biplot showed that the acceptability of the cooked pondo produced from the steaming conditions of 8 min at 92 °C, and 7 min at 94 °C was based on their texture, and the final and setback viscosities of the pondo. Therefore, an acceptable plantain-based pondo may be produced from the steaming conditions of 8 min at 92 °C or 7 min at 94 °C.

Keywords: Plantain fingers, steaming conditions, pondo, pasting properties, sensory acceptability

Introduction

Although the demand for plantains in Nigeria is year-round, the production of high-quality plantain fingers mostly takes place between October and February (Adewunmi et al., 2009). Among other reasons, insufficient processing facilities account for 35–60% of plantain finger post-harvest losses each year. Beyond its conventional use as basic food, plantains provide a variety of value-added goods, such as flour, chips, and snacks that may be made from both ripe and unripe fruits. Value addition lowers plantain finger post-harvest losses while simultaneously raising profit potential (Asogwa et al., 2021). Pondo is another possible value-added product that could be made from plantain fingers, although it has not been thoroughly investigated and documented. Steaming is one of the most important unit operations in the process of converting plantain fingers into pondo.

Saturated steam is used in the thermal processing method known as steaming to cook food. Cell walls break down, proteins become denatured, and carbohydrates become gelatinised because of the heat from the steam being transferred to the food. This cooking could facilitate the body's ability to digest and absorb the nutrients (Rennie and Wise, 2010). Reconstituting floury products using hot water is a typical instance of starch pasting, a process in which starch granules absorb water and swell when heated, ultimately causing the granules to rupture and the liquid to thicken (Awoyale et al., 2020). This gelatinisation process, which gives cooked dough its desired texture and viscosity, is essential to the preparation of many foods.

The pasting properties and sensory acceptability of the plantain-based pondo are expected to be affected by variations in the steaming temperature and time. However, no research has been published on how steaming affects the cooked plantain-based pondo's pasting properties and sensory acceptability. Therefore, this study aimed to evaluate the effects of different steaming temperatures and times on the pasting properties and sensory acceptability of the pondo.

Materials and methods

Materials

The yellow-fleshed plantain bunches were bought from Sabo market in Ilesha, Osun State, and processed into plantain-based pondo.

Methods

Production of plantain-based pondo

The plantain fingers were processed into pondo by washing in clean portable water, peeling with a knife, and slicing using a mechanical slicer. After that, they were steamed using the steaming conditions derived from the Simplex Lattice Mixture Design of the Design Expert software (Version 6.0) (Table 1), with the steaming temperatures and time as the independent variables. The unsteamed/uncooked sliced plantain fingers were used as a control. After steaming, the samples were dried in a cabinet dryer at 60 °C for 48 h, cooled, milled using a stainless steel grinder, sieved through a mesh size of 0.5 mm, and sealed in Ziploc bags for subsequent examination.

Table 1. Steaming temperatures and times used to produce pondo

Runs	Steaming temperature (°C)	Steaming time (min)
1	92	8
2	93	7
3	94	6
4	94	7
5	95	5

Pasting properties

A Rapid Visco Analyser (Model RVA 4500, Perten Instrument, Australia) equipped with a 1000 cmg sensitivity cartridge was used to measure the samples' pasting properties. A dried, empty canister was filled with 25 mL of distilled water and 3.5 g of the samples. After properly stirring the mixture, the canister was inserted according to instructions into the rapid visco analyzer (RVA). The slurry was heated at a rate of 1.5°C/min from 50 to 95°C, maintained for 15 min, and then cooled to 50°C. Peak, trough, breakdown, final, and setback viscosities, peak time, and pasting temperature were the attributes of the viscosity profile that was obtained from the pasting profile using Thermocline for Windows Software connected to a computer (Donaldben et al. 2020).

Preparation of pondo samples for evaluation and ethical approval

The samples (100 g) were reconstituted in boiling water (105 mL) inside a stainless steel pot with a wooden stirrer to get a homogenous cooked dough. The cooked dough was wrapped with aluminum foil, coded in three-digit numbers, and kept in a closed warmer before evaluation. The ethical approval of the study was given by the Kwara State University Center for Research and Development, with approval number KWASU/CR & D/REA/2023/0035. Verbal consent was also obtained from the participants before the study.

Sensory evaluation

The assessment of the sensory attributes of the samples was carried out at the Nigerian Stored Products Research Institute (NSPRI), Ilorin, using a well-structured questionnaire modified from Awoyale et al. (2020). About 15 trained panelists among the staff and Interns of NSPRI who consumed the product regularly rated the coded samples based on taste, texture, colour, appearance, aroma, and overall acceptability, using a 9-point hedonic scale, where 1 is disliked extremely, and 9 is liked extremely.

Statistical analysis

A statistical package for the social sciences (SPSS version 21) was used to analyze the variance and separation of means of the generated data. The XLSTAT (Free Version 2021) was used for the principal component analysis of the data.

Results and Discussion

Pasting properties

Since the plantain-based pondo will be reconstituted in hot water before consumption, its pasting properties are significant in predicting the behaviour of the cooked dough during and after cooking (Awoyale et al., 2020). Table 2 shows the pasting properties of plantain-based pondo as influenced by different steaming conditions. The average of the pasting properties is peak 506.43 RVU, trough 365.19 RVU, breakdown 141.24 RVU, final 526.14 RVU, and setback 161.56 RVU, viscosities. The average peak time and pasting temperature are 5.34 min and 82.74 °C, respectively. The different steaming conditions significantly influenced only the peak and breakdown viscosities and the peak time, out of all the pasting properties of the samples, which means that all the pasting properties of the plantain-based pondo were the same statistically, except for the peak and breakdown viscosities and peak time.

Table 2. Pasting properties of yellow-fleshed plantain-based pondo from different steaming conditions

Samples	Peak viscosity (RVU)	Trough viscosity (RVU)	Breakdown viscosity (RVU)	Final viscosity (RVU)	Setback viscosity (RVU)	Peak time (min)	Pasting temperature (°C)
92°C 8min	511.19±23.39b	389.31±0.96a	122.32±22.42b	562.44±33.21a	176.80±28.98a	5.49±0.02a	82.74±1.12a
93°C 7min	487.50±28.99b	363.94±1.91a	123.57±27.08b	523.96±2.12a	160.03±0.21ab	5.57±0.14a	83.19±1.12a
94°C 6min	444.25±72.41b	335.36±46.22a	108.90±26.19b	496.98±54.72a	161.63±8.49ab	5.37±0.09a	83.15±1.13a
94°C 7min	501.19±27.31b	377.29±18.44a	123.90±8.87b	555.23±18.77a	177.94±0.33a	5.34±0.09a	82.72±0.66a
95°C 5min	465.69±15.29b	340.26±20.98a	125.44±5.69b	502.48±36.85a	162.21±15.85ab	5.32±0.21a	82.28±0.53a
Control	628.32±36.97a	385.00±6.01a	243.32±30.96a	515.77±0.38a	130.77±6.39b	4.97±0.09b	82.34±1.26a
Mean	506.43	365.19	141.24	526.14	161.56	5.34	82.74
p level	*	NS	**	NS	NS	*	NS

Means with different superscripts within the same column are significantly different ($p < 0.05$).

Control-Unsteamed plantain flour, * $p < 0.05$, ** $p < 0.01$, NS-Not significant.

The peak viscosity is the maximum viscosity developed during or soon after the heating process, and which will contribute to the good texture of the cooked pondo (Awoyale et al., 2020). The peak viscosity was significantly higher in the unsteamed plantain flour (control) (628.32 RVU) and lower in the plantain-based pondo produced at 94 °C for 6 min (444.25 RVU). However, there was no significant difference ($p > 0.05$) in the peak viscosities of the plantain-based pondo produced from all the steaming conditions (Table 2). This implies that people who prefer the firm-textured cooked dough may consume the control sample because of its high peak viscosities, while those who prefer the soft-textured cooked dough may consume any of the plantain-based pondo due to their low peak viscosities. It is important to add that the quantity of water added to the flour during reconstitution may change the peak viscosity of the cooked dough.

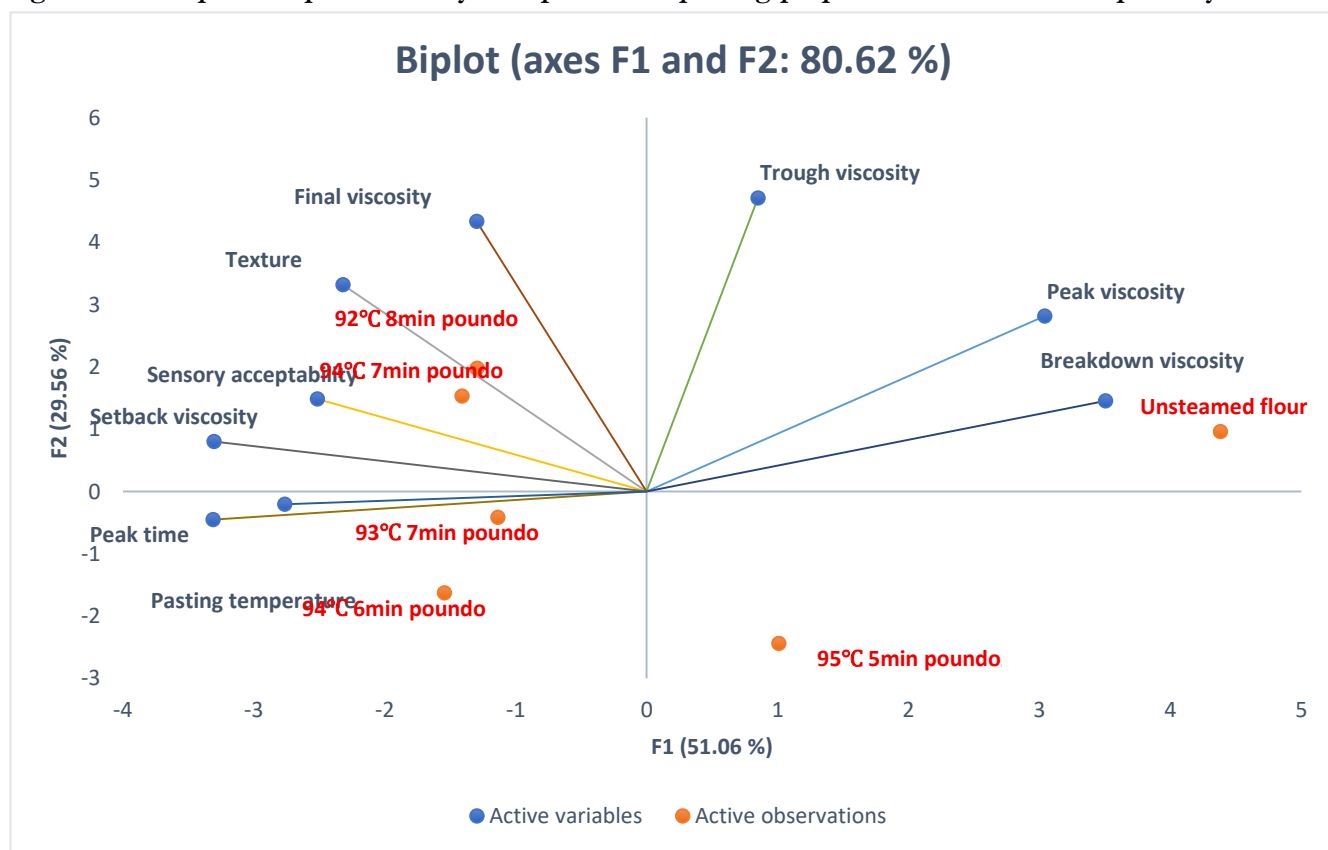
The sample's capacity to endure shear stress and heating during cooking is indicated by the breakdown viscosity. Also, the higher the breakdown viscosity, the lower the sample's capacity to endure heating and shear stress during cooking (Adebawale et al. 2008). The breakdown viscosity was higher in the control sample (243.32 RVU) and lower in the plantain-based pondo produced at 94 °C for 6 min (108.90 RVU). There was no significant difference ($p > 0.05$) in the breakdown viscosities of the plantain-based pondo produced from all the steaming conditions (Table 2). Therefore, the control sample cooked dough may not be able to tolerate heating and shear stress during cooking because of its high breakdown viscosities, while the pondo samples

may be able to withstand heating and shear stress during cooking due to their low breakdown viscosities (Adebawale et al. 2008).

The peak time, which is a measure of the period taken to cook the samples (Awoyale et al., 2020), was significantly lower in the control sample (4.97 min) and higher in the pondo produced at 93 °C for 7 min, although the peak time of all the pondo samples is statistically the same ($p>0.05$) (Table 2). This implied that the control sample may take less time to cook compared with all the pondo samples, thus reducing the cost of energy.

Additionally, the principal component analysis biplot revealed that the plantain-based pondo produced at 93 °C for 7 min, and 94 °C for 6 min are the same in terms of the peak time and pasting temperature, while the key attributes of the control sample are peak, trough, and breakdown viscosities (Figure 1).

Figure 1. Principal Component Analysis Biplot of the pasting properties and overall acceptability of



yellow-fleshed plantain-based pondo

Sensory attributes of sweet potato flour amala

Sensory evaluation of products is very important before consumer acceptability testing to determine the products to be scaled up for commercialisation. On average, the sensory attributes of the control and pondo samples were the same statistically ($p>0.05$), and fell within the moderately liked, except for the taste and texture, which fell within the slightly liked, as evaluated by the panelists (Table 3). This implies that the different steaming conditions did not significantly influence the sensory attributes of the plantain-based pondo compared to the control. However, the principal component analysis biplot (Figure 1) showed that the sensory acceptability of the cooked pondo produced from the steaming conditions of 8 min at 92 °C, and 7 min at 94 °C was based on their texture, and the final and setback viscosities of the pondo. This was because the overall

acceptability of the pondo produced from the steaming conditions of 8 min at 92 °C, and 7 min at 94 °C is in the same quadrant as the texture, and the final and setback viscosities of the pondo.

Table 3. Sensory attributes of yellow-fleshed plantain-based pondo from different steaming conditions

Samples	Taste	Texture	Colour	Appearance	Aroma	Overall acceptability
92°C 8min	6.42±0.33a	6.68±0.46a	6.65±0.42a	6.71±0.16a	6.36±0.16a	6.62±0.29a
93°C 7min	6.27±0.04a	6.39±0.29a	6.50±0.30a	6.56±0.21a	6.44±0.21a	6.65±0.16a
94°C 6min	6.45±0.37a	6.50±0.13a	7.00±0.08a	6.88±0.08a	6.92±0.37a	6.85±0.13a
94°C 7min	6.83±1.00a	6.53±0.25a	7.21±0.87a	6.91±0.88a	6.85±0.71a	7.00±0.49a
95°C 5min	6.18±0.42a	6.03±0.13a	6.50±0.37a	6.44±0.54a	6.53±0.33a	6.39±0.21a
Control	5.89±0.25a	6.27±0.63a	6.18±0.08a	6.59±0.42a	6.33±0.37a	6.47±0.00a
Mean	6.34	6.4	6.67	6.68	6.57	6.66
p level	NS	NS	NS	NS	NS	NS

Means with different superscripts within the same column are significantly different ($p < 0.05$), NS-Not significant. Control- Unsteamed plantain flour

9-like extremely, 8-like very much, 7-like moderately, 6-like slightly, 5-neither like nor dislike, 4-dislike slightly, 3-dislike moderately, 2-dislike very much, 1-dislike extremely

Conclusion and Recommendation

The steaming condition significantly influenced the peak and breakdown viscosities and the peak time of the plantain-based pondo compared to the unsteamed plantain flour, but with no statistical changes in all the sensory attributes. The unsteamed plantain flour has significantly higher peak, trough, and breakdown viscosities and lower peak time compared to the pondo samples. Although the sensory acceptability of all the samples was the same, the principal component analysis biplot indicates that the acceptability of the cooked pondo produced from the steaming conditions of 8 min at 92 °C, and 7 min at 94 °C was based on their texture, and the final and setback viscosities of the pondo. Therefore, an acceptable plantain-based pondo may be produced from the steaming conditions of 8 min at 92 °C or 7 min at 94 °C

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References

- Adebowale, A.A., Sanni, L.O., and Onitilo, M.O. (2008). Chemical composition and pasting properties of tapioca grits from different cassava varieties and roasting methods. *African Journal of Food Science*, 2, 077-082.
- Adewumi, M.O., Ayinde, O.E., Falana, O.I., and Olatunji, G.B. (2009). Analysis of post-harvest losses among plantain/Banana (*Musa Spp. L.*) marketers in Lagos State, Nigeria. *Nigerian Journal of Agriculture, Food and Environment*, 5(2-4), 35 – 38.
- Asogwa, V.C., Isiwu, E.C., Nwakpadolu, G.M., Ibe, V.S.O. and Ubah, G.N. (2021). Plantain value addition: Opportunities, challenges and prospects in Enugu State, Nigeria. *Journal of Agricultural and Crop Research*, 9(3), 50-59.
- Awoyale, W., Oyedele, H.A., and Maziya-Dixon, B. (2020): Correlation of the sensory attributes of thick yam paste (amala) and the functional and pasting properties of the flour as affected by storage periods and packaging materials. *Journal of Food Processing and Preservation*, 44 (10), 1-13.



- Donaldben, N. S., Tanko, O. O., and Hussaina, T. O. (2020). Physicochemical properties of starches from two varieties of sweet potato and yam tubers available in Nigeria. *Asian Food Science Journal*, 14(4), 28–38.
- Rennie, C. and Wise, A. (2010). Preference for steaming vegetables. *Journal of Human Nutrition and Dietetics*, 1, 108-110.