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INFLUENCE OF DIFFERENT STEAMING CONDITIONS ON THE TEXTURAL CHARACTERISTICS AND CONSUMER ACCEPTABILITY OF RE-CONSTITUTED INSTANT PLANTAIN-BASED POUNDO

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ABSTRACT

One of the key unit operations in making poundo is steaming, which breaks down cell walls and gelatinises the starch, and may influence the cooked dough's texture and consumer acceptance. Hence, the need for this study. The unripe plantain fingers (white and yellow flesh) were washed, peeled, and sliced with a mechanical slicer. They were then steam-cooked for 8 min at 92 °C, 6 min at 94 °C, and 7 min at 94 °C, with the unsteamed fingers used as a control. The samples were dried, cooled, milled, sieved, and sealed in Ziploc bags for storage and subsequent use. The textural qualities assessment was done using standard methods, while the consumer acceptability test was carried out at three locations in Ilorin, Kwara State - Ojatuntun, Mandate, and Gambari. The findings showed that all the cooked poundos and the control were relatively soft, mouldable, stretchable, and sticky, with no differences in the sensory texture characteristics. However, there were significant variations in the instrumental texture attributes (except for springiness and adhesiveness). The yellow-fleshed plantain poundo prepared at 92 °C for 8 min had the lowest levels of gumminess, cohesiveness, and hardness when compared with other samples, including the control sample, which had higher values. However, the Mandate and Gambari communities' poundo consumers preferred the yellow-fleshed plantain poundo made at 94 °C for 6 min, while the Ojatuntun community's consumers preferred the yellow-fleshed plantain poundo made at 92 °C for 8 min. Although Ojatuntun consumers liked cooked dough that is not very hard, cohesive, or gummy, Mandate and Gambari consumers preferred cooked dough that is hard, cohesive, and gummy. Thus, the hardness, cohesiveness, and gumminess of the cooked dough - all of which were impacted by the steaming conditions - are textural characteristics considered by the consumers of plantain-based poundo for acceptance.

Keywords: White- and yellow-flesh plantain, steaming conditions, plantain-based poundo,

1. INTRODUCTION

In Nigeria, consumer's demand for plantain persists throughout the year, while producing good quality plantain primarily occurs annually from October to February (Adewunmi et al., 2009). About 35-60% of post-harvest losses of plantain fingers occur annually due to inadequate processing facilities, among other factors. However, plantains offer a range of value-added products beyond their traditional use as a staple food; these include flour, chips, and snacks, which can be processed from unripe and ripe fruits. Value addition not only increases the profit potential but also reduces post-harvest losses of plantain finger (Asogwa et al., 2021). Another possible value-added product from plantain fingers is poundo, which has not been properly worked on and documented. One of the most important unit operations in the conversion of plantain finger into poundo is steaming.

Steaming is the thermal processing method that utilises saturated steam to cook food. It involves the transfer of heat from steam to the food, resulting in the denaturation of proteins, gelatinization of starches, and breakdown of cell walls. This may make the nutrients available for easy digestion and absorption in the body (Wise and Rennie, 2010). However, no work has been reported on the impact of steaming on the textural attributes and consumer acceptability of cooked plantain-based poundo. It is anticipated that differences in the steaming temperature and time may affect the texture and acceptance of the plantain-based poundo among consumers. Thus, this study aimed to assess how different steaming conditions affect the textural attributes and consumer acceptance of **re-constituted instant** plantain-based poundo.

2. MATERIALS AND METHODS

Materials

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

Methods

Production of plantain-based poundo

The plantain fingers were processed into poundo 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 reported by Sanuola (2025) for the most accepted (7 min at 94°C), slightly accepted (6 min at 94°C), and least accepted (8 min at 92°C) derived from the sensory evaluation results of eighteen cooked plantain-based poundo samples. The unsteamed sliced plantain fingers were used as a control. After steaming, the samples were dried in a cabinet dryer at 60 ^{o}C for 48 h, cooled, milled using a stainless steel grinder, sieved through a mesh size of, (too large) and sealed in Ziploc bags for storage and subsequent use.

Preparation of poundo samples for evaluation and ethical approval

The poundo sample (100 g) was 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 Texture Attributes

The assessment of the sensory textural attribute 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. (2022). About 17 trained panelists among the staff and Interns of NSPRI who consumed the product regularly rated the coded samples based on softness, moldability, stickiness, and stretchability, using a 3-point rating scale of 1 to 3. For instance, 1 is soft, 2 is moderately soft, and 3 is hard.

Instrumental Texture Attributes

The instrumental texture attributes of the samples were carried out at the National Centre for Agricultural Mechanization (NCAM), Ilorin, Kwara State using a Universal Testing Machine (Testometric, M50-100AT. Unit 1 Lincoln Business Park, Lincoln close, Rochdale, Lancashire, England) equipped with a 50 kg load cell, a probe diameter of 100 mm, deflection of 50%, speed of 102 mm/min, Preload of 20 mm and thickness of cutting ring of 20 mm. The parameters derived from the Universal Testing Machine were the hardness, stretchability, adhesiveness, cohesiveness, and gumminess of the cooked poundo (Awoyale et al., 2022).

Consumer acceptability study

The consumer acceptability study of the samples was carried out at three locations (Ojatuntun, Mandate, and Gambari) in Kwara State using a 5-point hedonic scale contained in a well-structured questionnaire with 50 panelists in each area, where 5 is like extremely, 4 is like slightly, 3 is neither like nor dislike, 2 is dislike slightly, and 1 is dislike extremely.

Statistical analysis

The data collected was analyzed using the Statistical Package for Social Sciences (SPSS) version 21 to determine the mean values, standard deviations, and significant differences between test samples at 95% confidence level.

3. RESULTS AND DISCUSSION

Although there were no significant differences ($p>0.05$) in the sensory texture attributes of all the re-constituted instant plantain-based poundo samples from various steaming conditions compared to the control, all the samples were moderately soft, stretchable, mouldable, and sticky (Table 1). Awoyale et al. (2022) noted a similar finding for cooked fufu flour dough. The means of the instrumental texture attributes of the cooked plantain-based poundo are hardness 2 N, stretchability 0.86, adhesiveness -0.07 N.s, cohesiveness 0.79, and gumminess 1.61 N. All the instrumental texture attributes of the samples were significantly different ($p<0.05$) except stretchability and adhesiveness (Table 2).

Hardness is the force required to compress a cooked dough (Awoyale et al., 2022). The yellow-fleshed cooked poundo steamed at 94 ºC for 6 min (2.44 N) was significantly harder than the yellow-fleshed cooked poundo steamed at 92 ºC for 8 min (1.29 N). However, the hardness of the white-fleshed poundo steamed at 94 ºC for 7 min, and the unsteamed yellow-fleshed cooked dough was statistically the same as that of the yellow-fleshed cooked poundo steamed at 94 ºC for 6 min. The high hardness of the cooked poundo doughs may be attributed to their high amylose content (Oyeyinka et al., 2017). Cohesiveness defines how well a product withstands a second deformation relative to its first resistance and is calculated as the work area during the second compression divided by the work area during the first (Awoyale et al., 2022). The white-fleshed cooked poundo steamed at 94 ºC for 7 min (0.84) was more cohesive compared to the yellow-flesh cooked poundo steamed at 92 ºC for 8 min (0.71) ($p<0.05$) (Table 2). Although the cohesiveness of the cooked poundo from the white fleshed steamed at 94 ºC for 7 min was not significantly different ($p>0.05$) from those of the yellow-fleshed steamed at 94 ºC for 6 min and the unsteamed yellow-fleshed. The energy required to disintegrate semi-solid food until it can be swallowed is known as gumminess. It is calculated as cohesiveness multiplied by hardness (Awoyale et al., 2022). The white-fleshed cooked poundo steamed at 94 ºC for 7 min (2.06 N) had significantly higher gumminess than the yellow-fleshed cooked poundo steamed at 92 ºC for 8 min (0.94 N) (Table 2). The gumminess of the cooked poundo from the white fleshed steamed at 94 ºC for 7 min was not significantly ($p>0.05$) different from that of the yellow-fleshed steamed at 94 ºC for 6 min and the unsteamed yellow-fleshed. The reduction in the steaming temperature and increase in steaming time may be responsible for the low cohesiveness and gumminess of the yellow-fleshed cooked poundo steamed at 92 ºC for 8 min.

Table 1: Sensory texture attributes of plantain-based poundo from different steaming methods

Plantain-based poundo samples	Softness	Mouldability	Stretchability	Stickiness
White-fleshed at 94ºC for 7 min	1.94±0.66b	2.29±0.77a	2.12±0.70a	2.06±0.75a
Yellow-fleshed at 94ºC for 6 min	2.06±0.75ab	2.24±0.66a	1.88±0.60ab	1.82±0.73a
Yellow-fleshed at 92ºC for 8 min	2.29±0.69ab	2.53±0.62a	1.82±0.64ab	1.82±0.73a
Yellow-fleshed unsteamed (control)	2.47±0.51a	2.24±0.66a	1.59±0.71b	1.88±0.78a
Mean	2.19	2.32	1.85	1.9
p level	NS	NS	NS	NS

Means with different letters within the same column are significantly different ($p<0.05$).
± Standard Deviation. NS-Not Significant.
Mouldability: 1= Not mouldable, 2=Moderately mouldable, 3=Mouldable
Stretchability: 1=Not stretchable, 2=Moderately stretchable, 3=Stretchable
Stickiness: 1=Not sticky, 2=Moderately sticky, 3=Sticky
Softness: 1=Soft, 2=Moderately soft, 3=Hard.

Table 2. Instrumental texture characteristics of plantain-based poundo from different steaming methods

Plantain-based poundo samples	Hardness (N)	Stretchability	Adhesiveness (N.s)	Cohesiveness	Gumminess (N)
White fleshed at 94ºC for 7 min	2.44±0.12a	0.78±0.02a	-0.11±0.10b	0.84±0.05a	2.06±0.22a
Yellow fleshed at 94ºC 6 min	2.44±0.25a	0.81±0.01a	-0.20±0.19ab	0.82±0.04a	2.01±0.31a
Yellow fleshed at 92ºC 8 min	1.29±0.55b	0.95±0.21a	0.00±0.00a	0.71±0.08b	0.94±0.50b
Yellow-fleshed unsteamed (control)	2.04±0.10a	0.87±0.02a	0.00±0.00a	0.80±0.02a	1.63±1.11a
Mean	2.00	0.86	-0.07	0.79	1.61
p level	**	NS	NS	*	**

Means with different letters within the same column are significantly different ($p<0.05$)
*$p<0.05$, **$p<0.01$, NS-Not Significant

Table 3. Consumer acceptability of plantain-based poundo produced from different steaming methods carried out at three different locations in Ilorin, Kwara State

Plantain-based poundo samples	N	Ojatuntun	Mandate	Gambari
Yellow-fleshed at 94ºC for 6 min	50	2.18±0.85b	1.40±0.76c	1.38±0.67c
Yellow-fleshed at 92ºC for 8 min	50	1.48±0.71c	2.18±0.69b	2.08±0.88b
White-fleshed at 94ºC for 7 min	50	2.78±0.89a	2.92±1.02a	2.84±1.09a
Yellow-fleshed unsteamed	50	1.68±0.65c	1.84±0.98b	1.86±0.83b
Mean		2.03	2.09	2.04
p level		***	***	***

Means with different letters within the same column are significantly different ($p<0.05$), ***$p<0.001$
N = Number of respondents
1= Like extremely, 2= Like slightly, 3= Neither like, nor dislike, 4= Dislike slightly,
5= Dislike extremely

The consumer acceptability of the re-constituted instant plantain-based poundo samples depicts that all the samples were significantly different ($p<0.05$) within each location (Table 3). The Mandate and Gambari communities' poundo consumers preferred the cooked yellow-fleshed plantain poundo made at 94 °C for 6 min, while the Ojatuntun community's poundo consumers preferred the cooked yellow-fleshed plantain poundo made at 92 °C for 8 min. At the Ojatuntun, Mandate, and Gambari communities, the consumer's acceptance of the cooked yellow-fleshed plantain poundo made at 92 °C for 8 min and that of the yellow-fleshed unsteamed cooked dough was the same ($p>0.05$). This suggests that although Ojatuntun consumers mostly preferred cooked dough that is not very hard, cohesive, or gummy, Mandate and Gambari poundo consumers preferred cooked dough that is hard, cohesive, and gummy.

4. CONCLUSION

All the cooked plantain-based poundos and the control (unsteamed yellow-fleshed cooked dough) were relatively soft, mouldable, stretchable, and sticky, with no differences in the sensory texture characteristics. The cooked yellow-fleshed plantain poundo prepared at 92°C for 8 min was not as hard, cohesive, and gummy when compared to the other samples and the control. The Mandate and Gambari communities' poundo consumers preferred the cooked yellow-fleshed plantain poundo made at 94 °C for 6 min, while the Ojatuntun community's poundo consumers preferred the cooked yellow-fleshed plantain poundo made at 92 °C for 8 min. This suggests that although Ojatuntun consumers preferred cooked dough that is not very hard, cohesive, or gummy, Mandate and Gambari poundo consumers preferred cooked dough that is hard, cohesive, and gummy. Thus, the hardness, cohesiveness, and gumminess of the cooked dough - all of which were impacted by the steaming conditions- are textural attributes considered by the consumers of plantain-based poundo for acceptance.

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