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COMPARATIVE EVALUATION OF THE FUNCTIONAL AND SENSORY CHARACTERISTICS OF THREE TRADITIONAL FERMENTED CASSAVA PRODUCTS

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ABSTRACT

This study provides scientific evidence to test the hypothesis that the flours and cooked forms of *fufu, lafun* and *pupuru* can suitably serve as substitutes for each other in the food markets and eateries, respectively. Sixteen functional properties of flours were compared statistically. Similarly, discrimination and preference tests were also conducted on the cooked dough. About 88% of the functional properties of the products were significantly different ($p<0.05$). Cooked dough samples were significantly different in terms of the appearance, odour and texture. *Pupuru* had the highest preference scores for all the sensory attributes. Dough appearance was the most important factor determining the overall acceptability of the products. Conclusively, the flours and cooked dough from traditionally processed *fufu, lafun* and *pupuru* cannot suitably substitute for each other in food markets and consumers end.

Key words: *Fufu, lafun, pupuru,* sensory acceptability, functional properties

INTRODUCTION

Fufu, pupuru and lafun are variants of dried fermented cassava products consumed as cooked dough at homes and eateries with various soups across West African countries where they are identified with different tribal or ethnic names. Production of *lafun* and *pupuru* has remained at the traditional scale while their consumption is predominantly found with indigenous people. However, *fufu* is now consumed by many non-indigenous people worldwide. In the wake of immigration and enculturation more of indigenous African foods are likely to be patronized by non-indigenous consumers (Mitchell, 2006). However, issues related to adulteration or faking at foodservice outlets may need to be addressed concurrently as the food-culture diffusion is taking place.

The innovative approaches to cassava processing industry in Nigeria to improve from the cottage to commercial level has spurred the development of high capacity processing equipment like the flash dryer has assisted to realize cassava *fufu* powder which are now sold locally and for exportation (Sanni *et al*., 2007). The *fufu* does not have the obnoxious odour characteristics of traditionally produced *fufu* (Tomlins *et al.,* 2007). The typical processing steps undergone in making *fufu*, *lafun* and *pupuru* in Nigeria have been outlined in Figure 1. The choice of method depends on the scale of production. Commercialization of *lafun* and *pupuru* processing is yet unrealistic as technological data required for upgrading their processing technology is scanty.

Very few scientific studies have been conducted on these two products. For example, Shittu (1998) studied the effect of drying methods on the quality of *pukuru* another dialectical name of *pupuru*. The functional properties of the *pukuru* samples differed significantly. It was also reported that kiln drying gave products with better sensory acceptability than oven dried samples but more similar to traditionally dried samples. Also, Shittu *et al.* (2005) carried out a survey of the indigenous processing technology of *pupuru* in the south west while some of the constraints to its commercialization were reported. Previously published data have indicated that the quality of fermented cassava products depends on post harvest handling of roots, processing methods, cassava variety and so on (Almazan, 1992; Idowu & Akindele 1994; Blanshard *et al.* 1994; Oyewole & Afolami 2001; Opare-Obisaw *et al.* 2004; Akingbala *et al.,* 2005). Specifically, Opare-Obisaw *et al.* (2004) studied the effect of cassava root storage in polyethylene bag on the sensory characteristics of cassava *fufu*. It was concluded that cassava roots stored for periods up to 8 weeks in polyethylene sacks produced *fufu* of similar characteristics as fresh cassava *fufu*.

Over the years there has been some misunderstanding, especially among the non -indigenous consumers and some food scientists, that *fufu* is essentially the same product as *pupuru* since they have similar physical characteristics when cooked in dough form. Sometimes lafun is confused with pupuru at food outlets by consumers. The practical implication of this is that unknowingly to these consumers, these products may be served interchangeably at the food outlets or their flours may be adulterated with each other in the food markets thus allowing fraudulent practices. Therefore, it was hypothesized that these products are essentially having the same physicochemical and sensory characteristics. However, the truthfulness of this statement needs to be verified experimentally.

This study was therefore conducted to determine if the typical physicochemical and sensory characteristics of traditionally produced cassava fufu, lafun and pupuru are the same.

MATERIALS AND METHODS

Cassava roots:

Roots from cassava variety TMS 30572 were obtained from a farm plot in University of Agriculture, Abeokuta, Nigeria campus at the maturity age of about nine months.

Cassava product manufacture:

In making the products, the traditional steps were followed Fig. 1. The cassava roots were washed peeled and cut into small pieces (50-70 mm diameter) and soaked in plastic containers at room temperature (27±1^{o}C) to ferment for about 72 h. For *pupuru* production, the ferment roots were mashed and dewatered using hydraulic press to reduce the moisture content to about 45% (wet basis). The wet mash was decorticated manually to remove large fibre before moulding into ball. Decortication step is taken by the traditional processor to ensure presence of large fibre does not prevent formation of cohesive wet ball. The wet balls (of about 1.0 kg) were laid on meshed rack about 1.2 m above a wood fed fire and

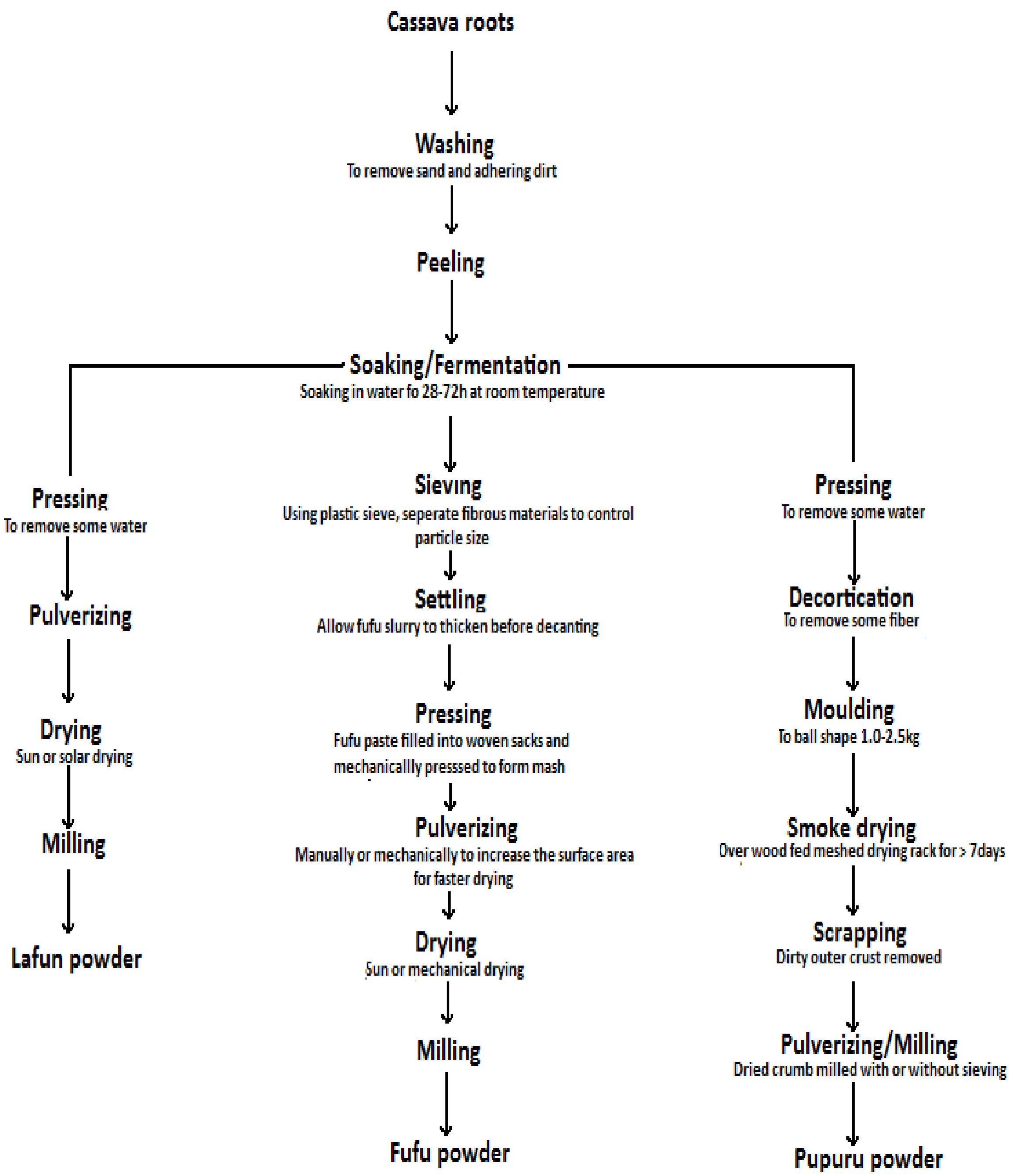

Figure 1: Chart showing traditional and/or improved steps followed in the manufacture of the fermented cassava products

smoked dried for about 7 h with drying air temperature ranging between 60 and 75^{o}C throughout the drying period. The outer crust of the dried balls was scrapped with knife while the dried crumb were pulverized and sieved to flour. For *fufu* production, the fermented mash was manually mixed with water and sieved through a muslin cloth. The sediment was further pressed, pulverized and sun dried. The dried meal was milled and sieved to obtain *fufu* flour. For *lafun* production, the wet fermented cassava mash was dewatered using hydraulic press. Prior to sun drying, the pressed mash was pulverized and spread thinly to increase the surface area available for drying. The dried stuff was milled and sieved. Sun drying for *fufu* and *lafun* production took about 48 h under typical dry season condition (air temperature of 29-35^{o}C and relative humidity of 62-75%). All the flours were sieved through a 0.21 mm screen.

Chemical and functional analyses

Moisture content and pH of the flour was determined according to AOAC (2002). pH determination was performed using a Orion digital meter (Model 720A, Orion Research Inc., USA). The bulk density of the flour sample was determined as the ratio of flour weight to its tapped volume. Water absorption index was determined according to Ruales *et al.* (1993). Swelling power and water solubility were determined according to Leach *et al.* (1959). Total titratable acidity was determined using a titrimetric method as described by Oyewole and Odunfa (1990). Pasting characteristics of the cold water slurry of the products was determined using a Rapid Visco Analyser (Model 3D, Newport Scientific, Australia).

Sensory analyses of cooked products

A twenty-member panelist group was organized consisting of students and staff of the Department of Food Science and Technology, University of Agriculture, Abeokuta, Nigeria, to assist in the sensory discrimination and preference analyses of the products. One criterion used in recruiting the panelist members was some past experience in consuming any fermented cassava dough from anyone or more of fufu, lafun and pupuru; most panelists had no past experience of consuming pupuru. In this study, the cassava variety used was the same. Moreover, dough was prepared using the same quantity of flour with boiling water (Flour/water of 2/3, w/v) to avoid bias in the assessment of sensory attributes. For the discrimination test, panelists were presented with three coded samples (fufu, pupuru and lafun cooked dough) and a reference sample coded R (fufu dough). Panelists were asked to compare and state whether there was or no detectable difference in terms of appearance texture and odour of coded samples compared with R. If yes, the degree of difference should be indicated using scores ranging between 1 and 4 (1= slightly different and 4=extremely different). A 9-point hedonic scale (9=Like extremely and 1=Dislike extremely) was used by the panelists to assess their preference for each sample in terms of appearance, texture (hand-feel), odour and overall acceptability.

Data analyses

One-way analysis of variance (ANOVA) was conducted to establish the significance of differences between the means, which were separated using Duncan's multiple range test (DMRT). Data from sensory discrimination test were also subjected to binomial distribution test to determine whether differences detected in the samples are significant or not (Rao, 1996; Bower, 1996).

RESULTS AND DISCUSSION

Table 1 shows the mean values of physicochemical parameters of the cassava products. All the parameters were found to be significantly different between the products. The pH and total titratable acidity (TTA) ranged between 5.45-5.60 and 0.21-0.27% lactic acid equivalents, respectively. These values are within the range of values reported earlier for various fermented cassava foods. All the products were acidic in nature due to the role of the lactic acid bacteria during fermentation of the cassava root (Oyewole and Odunfa 1990).

The moisture content of the dried products, which ranged between 12.10 and 14.00% (Table 1), was highest in *pupuru*. The difference in moisture content may be due to the efficiency of the drying methods used. The moisture content of *lafun* and *pupuru* is slightly higher than 12% required for safe keeping of powdered food. The bulk densities of the products, which ranged between 0.45-0.50 g/cm^3, are not significantly different from each other. This implies that the products have similar bulk handling and packaging requirements. Statistically, the bulk density correlated negatively with the moisture content ($r= -0.996$, $p<0.05$).

Water absorption capacity of starchy foods indicates the level of granular integrity which also determines the weakness of associative forces between the starch granules, which allows for more molecular surfaces to be available for binding with water molecules (Rickard *et al.,* 1991). *Lafun* had the highest water absorption index (WAI) while *pupuru* had the least (Table 1). Shittu (1998) reported that drying methods affects the physicochemical properties of *pukuru.* The low swelling accompanied by the high solubility obtained is indicative of the weak associative forces in the starch granules in these varieties.

Before consumption, pupuru, fufu, and lafun flours are reconstituted and cooked into stiff dough. The parameters indicating the behavior of cold water slurries of the flour during cooking are shown in Table 2. The gelatinization temperature, which is an index of minimum energy required to initiate rapid water ingression and swelling of starch granules, ranged from 63.65 to 64.55°C. The combination of pasting temperature and time would determine the amount of energy required to cook the flours' paste. Although, the pasting temperature of the products did not differ significantly, the longer cooking time of *pupuru* simply implies that it would need more energy for completing the cooking process. Moorthy *et al.* (1992) reported that elevation in the gelatinization temperature of cassava flour might be attributed to high fibre content. The peak viscosity is the maximum viscosity attainable during the heating cycle (or cooking). It determines ease of handling of the paste. Our result shows that *pupuru* may be the most easily handled especially during cooking with its lowest peak viscosity. Trough viscosity is a measure of hot paste stability i.e. an index of starch granule stability to heating. The trough viscosity is highest in pupuru flour and least in fufu. *Pupuru*, however, showed the greatest tendency to retrogradate (with highest setback viscosity) thereby giving more consistent dough on cooling. This has a great implication on the textural characteristics of the dough made from the flours. Essentially, this means that pupuru flour of the same weight will give more consistent dough with the same volume of water than lafun and fufu. Since the same root variety was used, the significant differences observed in the

Table 1: Physico-chemical properties of the flours of the fermented cassava

Property	Fufu	Pupuru	Lafun
pH	5.45a	5.56b	5.60c
TTA (w/v, Lactic acid)	0.21a	0.27c	0.24b
Moisture content (%)	12.10a	14.00c	13.00b
Bulk density (g/cm3)	0.50a	0.45a	0.48a
Water Absorption Index	2.44b	2.03a	2.53c
Swelling index	8.53c	7.49b	6.78a
Water solubility (%)	2.64a	2.81b	2.82b

Means (n=3) followed by the same alphabet are not significantly different at 95% confidence limit

Table 2: Pasting properties of *fufu, pupuru and lafun flours*

Property	Fufu	Pupuru	Lafun
Peak viscosity (RVU)	524.70a	414.42b	543.67a
Trough (RVU)	98.67c	302.33a	277.42b
Breakdown viscosity (RVU)	376.08a	112.08c	265.58b
Final viscosity (RVU)	129.25c	379.92a	337.58b
Setback viscosity (RVU)	30.58b	77.58a	60.17a
Gelatinization time (min)	2.73b	2.90a	2.75b
Time to reach peak viscosity (min)	3.62b	4.43a	3.97b
Cooking time (min)	0.89c	1.53a	1.22b
Pasting temperature (oC)	63.65a	64.05a	64.55a

differentiate between these three products in terms of the texture, odour and appearance (Table 3). The result further indicates that fufu is distinctly different from lafun and pupuru in terms of all the sensory attributes measured. Textural characteristics contributed mostly to the differences perceived by the panelists (Figure 2). Thus, the hypothesis maintaining that these samples are not different sensory-wise is hereby rejected.

In terms of the appearance, odour, texture and the overall acceptability pupuru was the most preferred. Only the preference scores for appearance and overall acceptability of the cassava products differed significantly ($p<0.05$) (Table 4). Scores for the product's appearance correlated most significantly with the overall acceptability (Table 5). These products are expected to be whitish in colour. The variation in appearance may be due to the effect of drying method. It should be noted that fufu and lafun were sun dried thereby leaving opportunity for greater contamination as well as discoloration compared to pupuru which was dried using an artificial means. Once the outer crust is formed on the pupuru balls, the crumb is well protected from further contamination and discoloration unless it becomes mouldy. This may be partly the reason why pupuru had significantly higher score for appearance than others. However, removal of outer crust may indicate some processing loss in case of *pupuru*, which is currently not given any attention in this study.

functional behavior of the flours may be attributed to the drying methods used.

The result of sensory discrimination test indicates that panelists were able to completely

Although, the odour of cooked samples did not have any significant linear correlation with the acceptability of *pupuru* and *lafun*, it did in case of *fufu*. This simply means that odour characteristics may be more important for *fufu* acceptability than *lafun* and *pupuru*. This result is in line with the observation of Tomlins *et al.* (2007) who reported that the sour odour of traditionally processed *fufu* greatly influenced consumer acceptability which might result in either liking or not liking the product. The characteristic odour of traditionally processed *fufu* has been attributed to the synthesis of certain organic acid due to the presence of certain hetero-fermentative anaerobic bacteria present in fermenting cassava medium (Brauman *et al.* 1996). Good quality lafun is the one that has little or no odour (Oyewole & Afolami 2001). To date the odour aspect of *pupuru* as a smoke dried product is unknown and may need to be studied in future along with that of *lafun* and *fufu* to further establish the sensory differences.

Table 6 indicates the parameter of linear regression equations for predicting the acceptability of each product from the appearance, odour and texture rating scores. The predictive equations are about 66 to 79% accurate, depending on product; similarly, the errors attached to the prediction are quite insignificant. In agreement with the earlier observation, appearance had highest loading effect on the overall acceptability. Although, the textural effect was also significant on *fufu*, it had the least loading effect for *lafun* and *pupuru*. A more robust view of the effects of the independent variables (appearance, odour and texture) was obtained when sensory scores for each product were merged for developing the regression model for predicting the products' overall acceptability. Thus, it could be maintained that the acceptability of cooked fermented dried cassava dough depends significantly on the appearance and textural appreciation as these attributes very. It should be mentioned that the insignificant effect odour on the acceptability of the products, especially *fufu,* may be due to the fact the fermented mashes have been dried before milling to powder. The drying process could have driven off the volatiles which give the characteristic offensive odour of traditionally processed *fufu*.

The practical implications of the findings in this study are as follow. Firstly, these three traditional fermented cassava products are not the same functionally and sensory-wise. Secondly, cooking of the flours from these products to consumable form may not be done similarly to give acceptable products; each product should be prepared with suitable water/flour ratio to give acceptable cooked dough at homes and eateries unlike the similar preparation steps followed in this

Table 3: Sensory discrimination test (n= 10) between the cassava products

Property	Number of panelists with detectable difference		
	*Fufu	Pupuru	Lafun
Texture	1 (ns)	10 (sd)	10 (sd)
Odour	2 (ns)	10 (sd)	10 (sd)
Appearance	2 (ns)	10 (sd)	10 (sd)

ns: discrimination not significant at 95% confidence limit
sd: discrimination is significant at 95% confidence limit
*Product used as reference sample

Table 4: Sensory preference test of the cassava products

Property	Fufu	Pupuru	Lafun
Odour	6.75a	7.35a	6.90a
Texture	6.25a	6.95a	6.45a
Appearance	6.75b	8.05a	6.90b
Overall preference	6.55b	7.60a	6.75b

Means (n=20) followed by the same alphabet are not significantly different at 95% confidence limit

Table 5: Correlation coefficients of sensory attributes in relation to overall preference of the cassava products

	Sensory attribute		
Product	Odour	Appearance	Texture
Fufu	0.49*	0.82**	0.79**
Pupuru	0.30	0.75**	0.58**
Lafun	0.44	0.82**	0.44

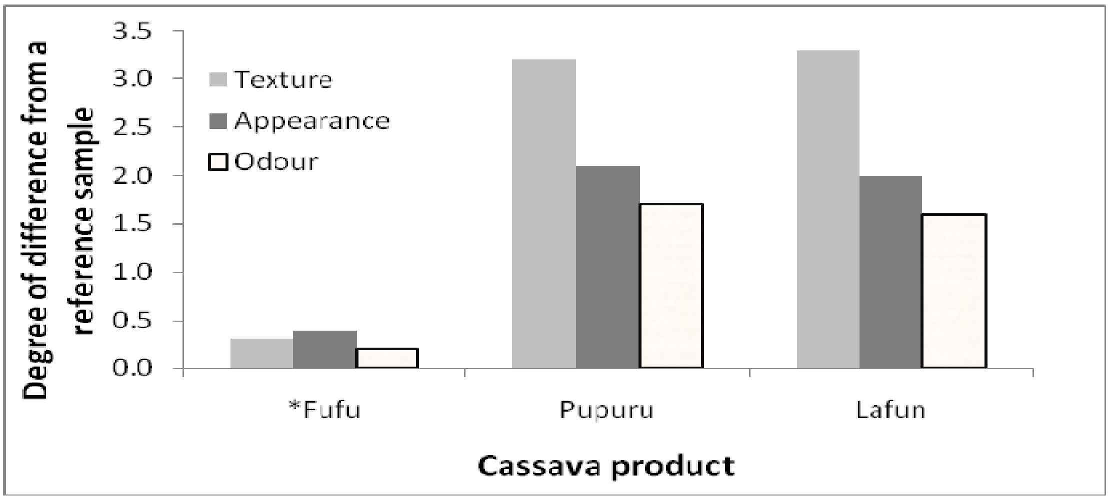

Figure 2: Degree of difference perceived by panelist in terms of the sensory attributes of fufu, pupuru and lafun and a reference sample (Fufu was also used as the reference sample; 1= different slightly, 4= different extremely)

Table 6: Multiple linear regression parameters showing the relationship between sensory attributes and overall acceptability of the fermented cassava products

Product	Parameter	Regression coefficient	Standard Error of Estimate	Sig P	R2
Fufu	Constant	0.146	0.711	1.046E-05	0.792
	Odour	0.203			
	Appearance	0.438**			
	Texture	0.330*			
Lafun	Constant	-0.622	0.719	5.726E-05	0.667
	Odour	0.111			
	Appearance	0.752**			
	Texture	0.135			
Pupuru	Constant	1.267	0.694	4.25E-04	0.742
	Odour	-0.185			
	Appearance	0.834**			
	Texture	0.090			
All	Constant	1.364	0.645	1.835E-15	0.719
	Odour	-0.040			
	Appearance	0.651**			
	Texture	0.178**			

* Effect of variable is significant at 5% error level ** Effect of variable is significant at 1% error level

CONCLUSION

Significant differences were found in about 88% of the physicochemical properties of the three fermented cassava products investigated. Using sensory discrimination test, panelists were able to completely differentiate between cassava *fufu* and the two other products in terms of the texture, odour and appearance. With the cooking formula used, *pupuru* flour gave the most acceptable dough. Appearance of cooked dough had the highest correlation with the products' acceptability whereas the greatest degree of sensory discrimination was attributed to the textural difference. Only the acceptability of *fufu* was however found to be significantly correlated with its odour. Following the traditional steps taken to produce these products in this study, it could be concluded that though *fufu, lafun* and *pupuru* have certain similarities, they may not be essentially acceptable as substitutes for each other by consumers. A consumer study, taking into consideration their socioeconomic situation and life style is therefore necessary to further establish this fact.

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study. Probably, if appropriate preparation is followed for each product, the differences observed in the sensory acceptability could have not been realized.

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