SENSORY AND PHYSICOCHEMICAL QUALITY OF POUNDED YAM: VARIETAL AND STORAGE EFFECTS

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ABSTRACT

*Tubers from nine yam cultivars (*Dioscorea rotundata, Dioscorea alata*) collected in two different growing areas of Bénin were stored for up to 5 months. Pounded yam was prepared from tuber samples each month and evaluated for their sensory and physicochemical attributes in order to assess the effect of tuber storage on suitability for processing into the product. Irrespective of the initial tuber dry matter content, the dry matter content of pounded yam remained almost constant with a mean value of 23% (wet basis). The general preference increased linearly with "elasticity" and "smoothness" ($r^2 = 0.945$) of the pounded yam. A principal component analysis coupled with a hierarchical classification produced five sample classes. Pounded yam prepared from cultivar Florido provided a single class, with low values for "elasticity" and "smoothness." This was opposite to the class of cultivar Laboco. Pounded yam samples from Gnidou were grouped in a class characterized by a low level of sweetness. The sweetness and elasticity of the product increased slightly when the yam tubers were stored, but this was not enough to raise the level of acceptability. The chemical and textural characteristics of pounded yam were poorly correlated with the sensory attributes. The elasticity of pounded yam appeared linked to yam tuber dry matter content.*

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PRACTICAL APPLICATIONS

This work showed that the quality of pounded yam mainly depends on the cultivar and not on the production area. It confirmed that high-yielding cultivars, such as Florido and Gnidou, give pounded yam of poor or barely acceptable quality. These cultivars should be mainly held in store for other end uses. Storing tubers induces few changes in their ability to give a good pounded yam. We observed a slight improvement of the elasticity and sweetness of pounded yam after tuber storage, but this was insufficient to greatly improve the pounding ability of the less preferred cultivars. Tuber storage was nevertheless never detrimental for quality, and farmers should take advantage of this, storing to sell at higher prices, outside the harvesting period.

INTRODUCTION

Yam (*Dioscorea* spp.) is an important food crop in many tropical regions of Africa, America, Asia and the Caribbean with a total production of 39.9 million tons in 2005. The bulk of edible yam production comes from the "yam zone" in West Africa (from Nigeria to Côte d'Ivoire), which accounts for about 91% of world production (Faostat 2005). In the "yam zone," particularly in Bénin, people distinguish yam varieties depending on their end use suitability: for pounding, boiling, frying or for *amala* (a thick paste prepared from dried yam flour) (Hounhouigan *et al.* 2003). Among these forms of consumption, pounded yam remains the traditional widespread and preferred dish. In this respect, varieties suitable for pounding are considered as the "king" of yams, and are therefore sold at higher prices. Pounding ability is thus an important criterion for farmers' choice for planting, even if other factors such as tuber size, yield and agronomic requirements are also taken into account.

A consumer survey conducted in Bénin showed that the quality attributes important for acceptability of pounded yam are firstly those related to texture (should be elastic or extensible, smooth and fairly firm) and taste (low sweetness but no bitterness). Creamy colored and fairly yellow pounded yams are also preferred (Nindjin *et al.* 2002; Hounhouigan *et al.* 2003). Some high-yielding varieties (with large tubers) are rejected by consumers for pounding, notably just after harvesting (Hounhouigan *et al.* 2003). Storage of some cultivars increases total reducing sugars (Onayemi and Idowu 1988) or improves the texture of boiled tubers (Onayemi *et al.* 1987). Respiratory activity takes place during storage, which is associated with important weight losses (Mozie 1987; Girardin *et al.* 1997), and a starch–sucrose interconversion (Kouassi *et al.* 1990). The level of polyphenolic and glycoalkaloid substances also increased during storage (Ikediobi and Oti 1983; Onayemi and Idowu

1988) together with the cell wall content (Brillouet *et al.* 1981). The first was associated with an increase in bitterness (Mestres *et al.* 2004), and the second with an increase in firmness of *amala*. The effect of postharvest changes on the sensory quality of pounded yam has not received much research attention. This is, however, an important issue because of the short period when fresh yam is available. This study reports the sensory evaluation of pounded yam prepared from nine yam cultivars stored for 0–5 months, and the relationship of the sensory attributes with some tuber physicochemical properties.

MATERIALS AND METHODS

Yam

Eleven yam samples were collected from two farmers in the northern and central regions of Bénin. Five samples were obtained in Glazoué (central region) and six in Ina (northern region). These represented nine cultivars, among the most common in Bénin (Dansi *et al.* 1997; eight of *Dioscorea rotundata* and one of *Dioscorea alata*) (Table 1). Two cultivars (Laboco and Florido) were collected in both regions. Tubers were harvested carefully (to avoid wounding) in December, 8–9 months after planting. Healthy, undamaged tubers were selected, cleaned and stored for up to 5 months in a well-ventilated room. The temperature of the room ranged from 26 to 29C, and the

TABLE 1.
YAM GROWING AREAS AND TUBER CHARACTERISTICS

Cultivar local name (*Dioscore*a species)	Pounding ability*†	Origin*	Tuber size (cm)‡		
			Length	Diameter head	Diameter tail
Laboco (*Dioscorea rotundata*)	Very good	Ina and Glazoué	36	7.0	4.0
Florido (*Dioscorea alata*)	Poor	Ina and Glazoué	22–29	5.0–8.0	6.0–12.1
Anago (*D. rotundata)*	Very good	Glazoué	27–34	4.0–6.0	4.5–6.2
Alakodjèhoué or Ala (*D. rotundata)*	Poor	Glazoué	62	8.0	5.0
Gnidou (*D. rotundata)*	Poor	Glazoué	37–43	6.0–8.5	3.5–8.1
Morokorou (*D. rotundata)*	Very good	Ina	35–43	6.0–9.1	4.0–7.0
Tabané (*D. rotundata)*	Very good	Ina	26	8.5	4.1
Moki (*D. rotundata)*	Good	Ina	55	7.0	6.0
Kpakpanrou (*D. rotundata)*	Poor	Ina	66	6.2	4.0–6.1

* Dansi *et al.* (1997).
† Hounhouigan *et al.* (2003).
‡ Akissoé *et al.* (2003).

relative humidity from 65 to 80%. Two cultivars were rotted during storage, Laboco after 4 months and Moki after 5 months.

Pounded Yam Preparation

For each period (at harvest, and 1, 2, 3, 4 and 5 months later), three or four tubers of each cultivar were randomly selected. Samples from one region were processed on the same day. Tubers from three cultivars were peeled, sliced and boiled in three separate pots at the same time. After cooking, they were rapidly weighed and pounded at the same time in three separate mortars by a team of women with long experience in preparation of pounded yam. Hot water (preferably boiling water) was added to the dough during pounding to obtain the desired texture. The amount of water added was freely adjusted by the women to obtain the desired texture, based on their experience. Each batch was rapidly divided in numerous 20–25 g balls that were sealed in plastic bags and stored in a thermostatic box. As an example, two samples from Glazoué or three from Ina were rapidly boiled and treated as described earlier. Both preparations were performed within 1 h. Some processing parameters were recorded such as the quantity of samples at the different stages, amount of water added and durations of cooking and pounding.

Sensory Analysis

Two types of sensory tests were performed at 40 min intervals on the same samples with different types of panelists, using methods described by Issanchou (1990) and Mestres *et al.* (2004) with slight modification.

Quantitative Sensory Analysis. It was performed with 22–27 trained panelists on the attributes of texture (elasticity, firmness, smoothness) and taste (sweetness, bitterness). Each panelist received five or six alphabetically coded pounded yam samples. They were asked to score the intensity of each attribute by plotting a vertical mark on a semistructured scale (from 0 to 17.5, e.g., 17.5 cm long). To facilitate the scoring, six intensity levels (from "not at all" to "very intense") were regularly plotted along the scale. Then, two examples of reference products with extreme intensities were indicated at both ends of each attribute scale: for sweetness (drinking water, sweet potato), for bitterness (drinking water, *Vernonia* sp. leaf), for elasticity (*akassa* – fermented maize dough, *agbeli* – fermented cassava dough), for firmness (mashed potatoes, doughnut) and for smoothness (doughnut, fresh tomato).

Preference Test. A hedonic test was also conducted to check the trend for the ideal pounded yam (Issanchou 1990; Mestres *et al.* 2004), by 40–50 ordinary consumers on a continuous −9 to +9 scale (e.g., 18 cm long), with 0 representing the ideal. The left end of the scale indicates the expression "much too low," and the right end indicates "much too high" that I cannot eat it. The panelists were asked to put a mark on the scale for each of the same five attributes listed. Samples were tested successively one by one. A general score (from 0 to 10) was also given for each pounded yam.

In both cases, distance between the mark and zero position was measured and used as the score of each panelist to a given attribute.

Physicochemical Analyses

The dry matter content of fresh or pounded yam was measured after drying at 105C for 48 h (AACC 1984). Amylose content was determined by differential scanning calorimetry on a PerkinElmer DSC7 (Norwalk, CT) as described by Mestres *et al.* (1996). Protein content was calculated from the nitrogen content ($N \times 6.25$) obtained by the Kjeldahl method. Fat content was determined by Soxhlet extraction (AACC 1984). The color was measured using a Minolta CR-210 portable chromameter (illuminant D65 CIE 1976, Azuchi-Machi, Chuo Ku, Osaka, Japan) as described by Hounhouigan *et al.* (1993). Firmness was determined by uniaxial extrusion using a texture analyzer (Stevens LFRA texture analyzer, HAAKE instrumenten, Albertdonk, Roosendaal-Nederland) as described by Akissoé *et al.* (2006).

Statistical Analyses

For the quantitative sensory test, only 12 panelists who were present five times out of six were considered. Data of two consecutive tests were grouped to form three periods: period 1 = 0 and 1-month storage; period 2 = 2 and 3-month storage; period 3 = 4 and 5 month-storage. This procedure has the advantage of imitating repetition, considering that the variation of the quality remains low for 1-month storage. The same procedure was applied to the instrumental data.

Multivariate analysis of variance (MANOVA) and principal component analyses (PCAs) were performed using Statistica 7.1 (StatSoft, Paris, France). A hierarchical classification «cultivar*date» was also performed with factorial coordinates using the method described by Ward, based on distance between classes with minimum variance (StatSoft). A T2 test of Hotelling was performed with the «panellipse» function of the SensoMineR package operating under R environment.

RESULTS AND DISCUSSION

Processing Parameters

Table 2 shows some processing parameters measured during the preparation of pounded yam. MANOVA showed a significant effect of sample and

TABLE 2.
PROCESSING PARAMETERS DURING PREPARATION OF POUNDED YAM

Cultivar	Mean tuber DM* (%, w.b.)	Range of cooking duration (min)	Range of pounding duration (min)	Range of added water (g/kg)	Pounded yam DM at the harvesting (%, w.b.)†	Pounded yam DM 5 months after (%, w.b.)
Gnidou	37.1ab	15.9–20.1	15.4–24.3	388–757	21.9	21.1
Anago	38.7ab	16.2–20.4	13.2–22.1	243–612	23.8	23.0
Ala	36.4ab	14.4–18.6	12.0–21.0	379–749	22.2	21.4
Mokki	40.2a	16.1–20.3	11.5–20.4	277–647	22.3	nd
Tabane	41.8a	16.6–20.8	7.9–16.9	151–520	23.7	22.9
Kpakpannou	33.1bc	15.2–19.4	8.4–17.3	131–501	23.8	23.0
Morokoro	36.6ab	15.4–19.6	14.9–23.8	232–602	23.4	22.6
Florido_gl‡	29.4c	18.3–22.5	11.1–20.0	130–500	24.5	23.7
Florido_in‡	29.6c	15.4–19.6	8.0–17.0	238–699	nd	23.7
Laboco_gl‡	40.7a	14.2–18.3	12.7–21.6	204–664	24.2	21.1
Laboco_in‡	nd	14.9–19.1	7.5–16.5	136–506	nd	23.0
Mean	36.0	17.8	15.6	421.0	22.9	22.5
CV (%)	14.6	6.5	18.2	22.2	5.4	1.0

* Dry matter content.
† Values of two replicates per month.
‡ Origin: gl, Glazoué; in, Ina.
nd, not determined.

storage period on tuber dry matter content. The Newman–Keuls test revealed two groups of cultivars: Florido (*D. alata*), with a mean dry matter content of 29.4% (wet basis [w.b.]), and the other varieties, with a mean dry matter content ranging between 35.7 and 42.9% (w.b.). These results are in agreement with those previously reported (Onayemi and Potter 1974; Girardin *et al.* 1998; Akissoé *et al.* 2003). In addition, dry matter content increased during storage, at a mean ratio of 1.3% per month.

Mean cooking duration of tuber slices was 17.8 min, with a coefficient of variation (CV) of 6.5%. Mean duration of pounding was 15.6 min, with a greater variability (CV of 18.2%). The amount of hot water added during pounding showed large variability (CV of 22.2%), while the dry matter content of resulting pounded yam was remarkably stable (CV of 5.4%), around a mean value of 22.9%. The quantity of added water was significantly and positively correlated with the dry matter content of the fresh tuber ($R^2 = 0.36$). Hence, the higher the water content of the tuber, the less the amount of water added during pounding. Processors were thus able to adjust empirically the quantity of water necessary to obtain a product with a quasi-invariable dry matter content. Despite this adjustment, sample differences were still in evidence: Gnidou, Ala and Moki gave pounded yam with lower dry matter contents (21.3 and 21.9%) than the others (between 23.2 and 24.0%). Furthermore, the dry matter content of pounded yam slightly decreased during storage by –0.16% per month. This could be related to the hardening phenomenon that occurs after harvesting tubers, which is associated with an increase in cell wall content (Brillouet *et al.* 1981); more water is thus needed to produce the desired texture.

Determination of Ideal Pounded Yam

Quantitative sensory scores were highly correlated with the hedonic ones (Table 3): correlation coefficients (r) were around 0.9, with the exception of attributes for bitterness ($r = 0.81$) and firmness ($r = 0.78$). In addition, the global hedonic score was correlated with the quantitative sensory attributes, particularly with elasticity and smoothness. Multiple regression analysis showed that 94.5% of the variability of the global hedonic score of pounded yam could be explained by these two attributes: hedonic score = 1.34 + 0.24 × elasticity + 0.24 × smoothness ($R^2 = 0.945$).

This result is consistent with the consumers' survey that underlined the importance of texture for consumers' acceptance of pounded yam (Hounhouigan *et al.* 2003). Bitterness was negatively correlated with the global hedonic score ($r = -0.47$), confirming the aversion and rejection of this attribute by consumers.

The hedonic scores of ordinary consumers were plotted against the quantitative scores of the trained panelists. Ideal pounded yam was evaluated by extrapolation of regression curves to 0 hedonic score (Fig. 1): ideal values (in centimeters) were 12.3 for elasticity, 11.5 for smoothness, 11.6 for firmness and 10.9 for sweetness. The levels of these attributes ranged between "moderate" and "high" on the semistructured scale (plotted at 10.5 and 14.0 cm) and agree with consumers' surveys (Akissoé *et al.* 2001; Hounhouigan *et al.* 2003). It was, however, difficult to determine the ideal value for bitterness because the relation between hedonic and quantitative scores was not linear but polynomial ($R^2 = 0.46$). This should be related to the interaction between the perception of both taste attributes (sweetness and bitterness) and to the types of samples tested: Florido, the most bitter cultivar, was also perceived as sweet. This cultivar has high contents of total phenols (responsible for bitterness) and sugar (Mestres *et al.* 2004). Because bitterness is negatively correlated with the global hedonic score, it is reasonable to think that consumers would prefer pounded yam with low bitterness. Overall, ideal pounded yam should be elastic, very smooth, fairly sweet, weakly bitter and firm. These characteristics are in agreement with the consumers' survey reported by Hounhouigan *et al.* (2003).

Effect of Yam Cultivars and Growing Area on Sensory Quality

A PCA performed (Fig. 2) on the quantitative sensory variables indicated that the first two components explained 92.3% of the total variation. The first

TABLE 3.
CORRELATIONS BETWEEN SENSORY ATTRIBUTES AND PHYSICOCHEMICAL PARAMETERS

	H_ sweetness	H_ bitterness	H_ firmness	H_ smoothness	H_ elasticity	Score_ hedonic	Q_ sweetness	Q_ bitterness	Q_ firmness	Q_ smoothness	Q_ elasticity	*L*	*b*	F_ extru	DM_ pounded
H_sweetness	1														
H_bitterness		1													
H_firmness			1												
H_smooth	0.60***		0.57***	1											
H_elastic	0.69***		0.55**	0.90***	1										
Score_ hedonic	0.64***		0.50**	0.93***	0.92***	1									
Q_sweetness	0.89***			0.41*	0.48**	0.43*	1								
Q_bitterness		0.81***				−0.47**		1							
Q_firmness			0.78***	0.48**		0.39*			1						
Q_smooth	0.60***		0.59***	0.98***	0.90***	0.95***	0.40*	−0.37*	0.52**	1					
Q_elasticity	0.70***		0.50**	0.90***	0.96***	0.94***	0.53**		0.39*	0.92***	1				
L				−0.62***	−0.50**	−0.43*			−0.38*	−0.55**	−0.46**	1			
b							0.39*	−0.45*	0.40*				1		
F_extru		0.38*				−0.36*								1	
Dm_pounded												0.42*	0.56***		1
Dm_tuber	0.53**			0.74***	0.69***	0.64***				0.72***	0.65***	−0.68***			
Amylose													−0.46**	−0.52**	−0.46**

* Significant at 5% level.
** Significant at 1% level.
*** Significant at 0.1% level.
ddl: 32.
F_extru, extrusion force; Q, quantitative; H, hedonic.

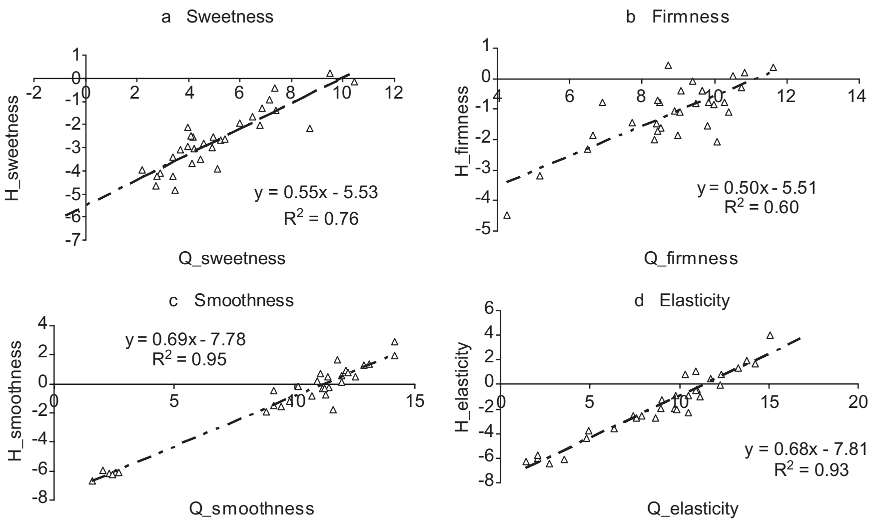

FIG. 1. RELATIONSHIP BETWEEN QUANTITATIVE AND HEDONIC SCORES

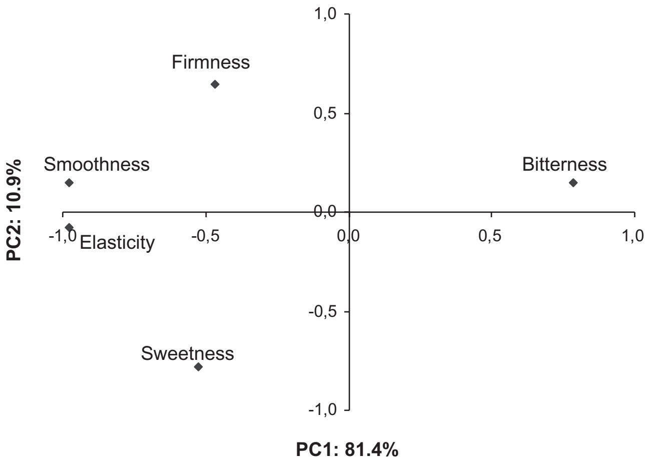

FIG. 2. PRINCIPAL COMPONENT LOADINGS OF QUANTITATIVE SENSORY SCORES OF POUNDED YAM ON 1/2 FACTORIAL PLAN

axis mainly described variability of texture attributes: the first component was positively correlated with smoothness and elasticity, which contributed about 45% of the definition of this axis. The second component was related to the taste, particularly sweetness, which accounted for 62% of the definition of this

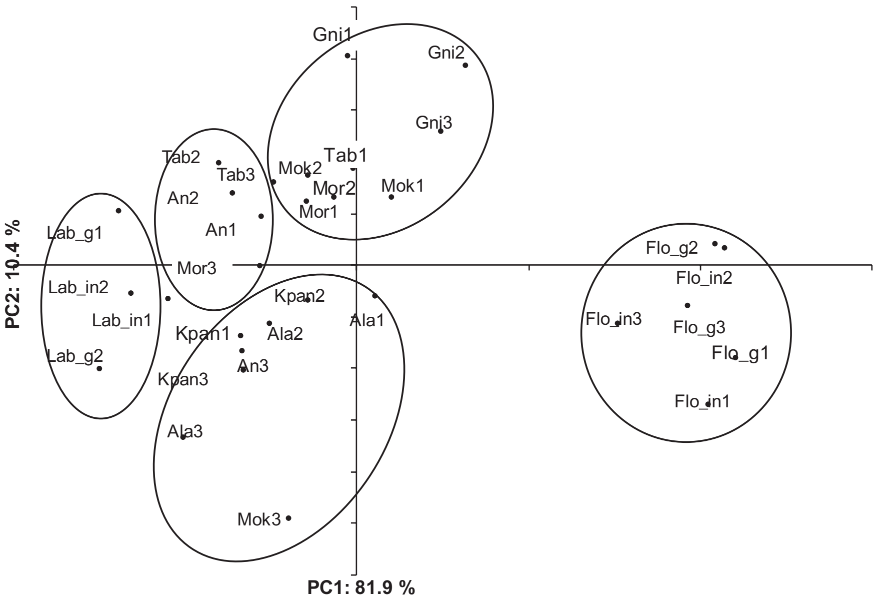

FIG. 3. SAMPLE (VARIETY*PERIOD) SCORE PLOT ON THE 1/2 FACTORIAL PLAN
* The first three letters indicate variety name; sometimes, they are followed by the initial of the locality numbers that indicates period of test (1 = 0–1 month; 2 = 2–3 months; 3 = 4–5 months).
** The areas represent varietal grouping by hierarchic classification.

axis. Firmness and bitterness had smaller contributions to the formation of these axes. Ideal pounded yam should thus be located on the left hand of the factorial plane (high score of smooth and elastic attributes). A hierarchical classification performed on PC sample scores gave five major groups that can be clearly distinguished on the factorial plane (Fig. 3). Pounded yam obtained from Florido and Laboco showed individual classes, grouping samples from both production areas and of various storage durations. Their specific behavior could be mainly attributed to influence of the genotypes. They showed opposite positions on the first axis; pounded yam samples derived from Florido were located on the right hand of the plane, opposite to the other samples. Gnidou pounded yam samples were located on the top of the plane.

MANOVA confirmed these observations: the cultivar effect was highly significant ($P < 0.01\%$); elasticity and smoothness attributes were the most discriminating (Table 4). Florido, in particular, gave pounded yam with low scores (around 2.5) for these attributes, in contrast to Laboco (values around 14). Gnidou had a low value for sweetness (2.3).

Previous work reported that consumers rejected Florido for preparing pounded yam (Dansi *et al.* 1997; Hounhouigan *et al.* 2003); Gnidou, when

TABLE 4.
QUANTITATIVE SENSORY SCORES OF POUNDED YAM (MEAN VALUES FOR PRODUCTS FROM TUBERS STORED FOR 0–5 MONTHS)

Cultivar	Sweetness	Elasticity	Smoothness	Bitterness	Firmness
Gnidou	2.3e*	6.3c	10.3a	2.6b	10.6b
Anago	5.1ab	11.3a	11.8bc	1.6a	9.0ab
Ala	6.9f	10.2a	10.4a	1.2a	8.4ad
Mokki	5.3ab	8.7d	10.2a	2.0ab	9.1ab
Tabane	3.7cd	10.2a	12.0bc	2.9b	9.6ab
Kpakpannou	7.4g	10.5a	10.8ab	1.2a	9.7ab
Morokoro	4.3ad	10.2a	11.1ab	2.0ab	9.6ab
Laboco_gl†	5.3ab	14.5f	14.1d	1.2a	8.9ab
Laboco_in†	6.3b	13.4e	12.8c	1.1a	9.4ab
Florido_gl†	3.0ce	2.4b	2.5d	4.3c	6.4c
Florido_in†	3.9cd	3.0b	2.2d	3.8c	7.4cd
Value of *F*	26.5	102.8	124.8	21.0	10.1

* Data in the same colunm with different letters are significantly different at 5% level.
† Origin: gl, Glazoué; in, Ina.

prepared just after harvesting, gave barely acceptable pounded yam (Dansi *et al.* 1997). Our results are consistent with these observations and revealed that the former was defective in texture and the latter in sweetness.

The effect of growing area was tested for Florido and Laboco for the first two periods of storage (Laboco was rotten by the third period). A Hotelling T2 test of the factorial scores of the PCA revealed the similarity between samples from the two growing localities. MANOVA confirmed this similarity. No significant effect of growing area was found, except for smoothness. Laboco harvested at Ina gave a less smooth pounded yam (12.8 versus 14.1 at Glazoué).

Changes in Sensory Quality during Storage

Sensory scores slightly changed because of the storage of yam tubers. MANOVA revealed significant differences in sweetness, elasticity and firmness. The first two variables slightly increased by 0.40 and 0.28 points per month. Firmness reached its maximum level at period 2, i.e., after 2–3 months of storage. The increase of sweetness in pounded yam is in agreement with the previous work of Onayemi and Idowu (1988) who reported an improvement in the sweet taste of boiled yam after storage. It is also consistent with the significant increase in the content of reducing sugars during storage (Onayemi and Idowu 1988; Kouassi *et al.* 1990). This positive change could be associated with a partial enzymic hydrolysis of starch (Ikediobi and Oti 1983; Kouassi *et al.* 1990).

Storage did not actually modify the general classification of yam varieties as plotted on the factorial plane (Fig. 3). Pounded yam that was disliked (class of Florido or Gnidou) was not significantly improved during storage. This is because storage does not sufficiently improve the texture scores that are the first factors contributing to the acceptance of pounded yam. Our results are partially in agreement with consumers' surveys, which pointed out that varieties giving a disagreeable pounded yam just after harvest can show improvements after few months of storage (Hounhouigan *et al.* 2003).

Physicochemical Characteristics of Pounded Yam

MANOVA revealed a significant cultivar effect on the physicochemical characteristics of pounded yam (Table 5): proximate composition (fat, protein and amylose contents) and color (*L*, b^*). Duration of tuber storage did not, however, significantly influence these parameters. Ravindran and Wanasundera (1992) also did not find any variation in the total fat content during yam tuber storage. A drastic drop of proteins during storage was described by Onayemi and Idowu (1988) and Ravindran and Wanasundera (1992). Apart from transport to the growing stem (sprouting), it is unlikely that proteins can be lost in the tuber during storage. We barely observed any sprouting during the 5-month storage of our experiment and that can explain the stability of the protein level in our work. As far as protein is concerned, a Newman–Keuls test could bring out three homogenous groups. Kpakpannou was separate, giving

TABLE 5.
PHYSICOCHEMICAL CHARACTERISTICS OF POUNDED YAM (MEAN VALUES FOR PRODUCTS FROM TUBERS STORED FOR 0–5 MONTHS)

Cultivar	DM (%, w.b.)	*L*	*B*	Amylose (%, d.b.)	Proteins (%, d.b.)	Fat (%, d.b.)
Gnidou	22.2ab	68.2b	6.3b	26.6a	1.32d	0.32b
Anago	20.9b	70.0ab	11.6c	21.0c	3.41b	0.14c
Ala	23.3ab	70.9ab	6.6b	22.1c	1.14d	0.14c
Mokki	22.6ab	71.2ab	9.6a	22.1c	1.25d	0.19c
Tabane	23.9ab	71.5ab	8.6a	21.4c	1.29d	nd
Kpakpannou	23.8ab	73.3a	13.6d	18.9b	5.70a	0.63a
Morokoro	23.4ab	69.2ab	9.6a	20.3bc	2.40c	0.23bc
Florido_gl	24.2a	76.8c	9.2a	20.5bc	1.40d	0.17c
Florido_in	23.1ab	72.9a	8.9a	20.8c	nd	nd
Laboco_gl	23.2ab	69.6ab	12.1c	22.4c	2.72c	0.25b
Laboco_in	24.3a	73.8a	11.4c	21.9c	nd	nd

Data in the same column with different letters are significantly different at 5% level.
Origin: gl, Glazoué; in, Ina.
DM, dry matter; w.b., wet basis; d.b., dry basis; *L*, luminance; nd, not determined; b, yellow index.

pounded yam with a protein content over 5% (dry basis [d.b.]). In contrast, pounded yam samples from Ala, Laboco, Florido and Gnidou had low protein contents (less than 1.6% d.b.). Kpakpannou pounded yam was also rich in lipids (0.63% d.b.), followed by that of Gnidou (0.32%). Kpakpannou therefore had particularly high nutritive value. With regard to the amylose content, Gnidou had a significantly higher value (26.6% d.b.), whereas all other samples had amylose contents between 18.9 and 22.1% (d.b.).

Kpakpannou and Florido gave the whitest pounded yam ($L > 73$), whereas Anago, Laboco and Kpakpannou gave the most yellow products ($b^* > 12$). Kpakpannou is thus unique, producing a yellow and clearest pounded yam, close to the demand of consumers (Hounhouigan *et al.* 2003) and to the «reference» product from Laboco (Dansi *et al.* 1997). Furthermore, the luminance and the red index significantly decreased, with about 0.72 and 0.29 points, respectively, per month of storage. Therefore, this would lead to the decrease of their acceptance by consumers.

The firmness measured using the Stevens texture analyzer varied significantly with the cultivar and storage period. Laboco, Ala, Anago and Gnidou gave the weakest pounded yam (mean value less than 0.7–1.3 N over the storage period against 1.6–1.9 N for the other samples). Irrespective of yam sample, firmness increased at a rate of 0.25 N per month of tuber storage. This shows a kind of hardening of pounded yam when it was prepared from stored tubers. This phenomenon appeared despite the increase in water content. It was in agreement with the increase of firmness (maximum force) of boiled yam reported by Afoakwa and Sefa-dedeh (2001) during the storage of *Dioscorea dumetorum*. It was also consistent with the increase in cell wall content (Brillouet *et al.* 1981), which certainly contributes to the hardening of yam products.

Very few correlation coefficients between sensory attributes and physicochemical characteristics of pounded yam are significant (Table 6). We observed in particular no clear relationship between the texture attributes and firmness measured by the extrusion test. This appeared contradictory to previous studies on *amala* (a dough prepared from yam flour; Akissoé *et al.* 2006) or on rice (Meullenet *et al.* 1998). The dry matter content of yam tubers was, however, positively and significantly correlated ($r > 0.7$) with elasticity (Fig. 4) and smoothness.

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TABLE 6.
CORRELATIONS BETWEEN QUANTITATIVE SENSORY SCORES AND PHYSICOCHEMICAL CHARACTERISTICS

Sensory attributes	St (N/mm)	*L*	*B*	Dm_py (%, w.b.)	Dm_tuber (%, w.b.)	Fat (%, d.b.)	Protein (%, d.b.)	Amylose (%, d.b.)
Sweetness	–0.03	–0.27	0.29	–0.2	0.4	0.35	0.39	–0.34
Bitterness	0.33	0.35	–0.4	0.18	–0.54	–0.25	–0.34	0.02
Elasticity	–0.3	–0.51	0.42	–0.11	0.72	0.2	0.28	–0.02
Firmness	–0.01	–0.39	–0.1	–0.17	0.32	0.35	0.21	0.3
Smoothness	–0.27	–0.6	0.24	–0.28	0.82	0.25	0.27	0.19

St: Firmness measured by extrusion with Stevens.
Dm_py: Dry matter content of pounded yam.
L, luminance; *b*, yellow index; w.b., wet basis; d.b., dry basis.

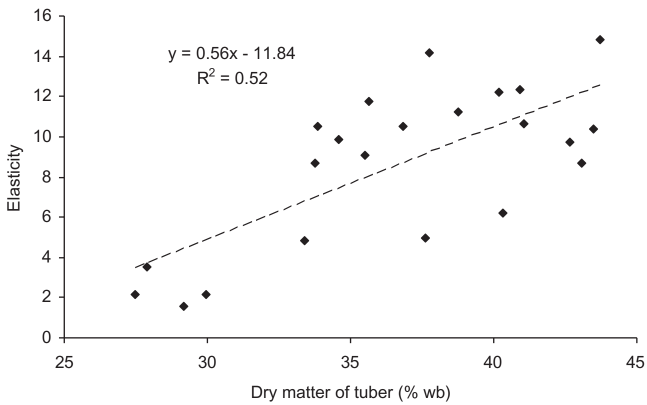

FIG. 4. RELATIONSHIP BETWEEN SENSORY ELASTICITY OF POUNDED YAM AND DRY MATTER CONTENT OF RAW TUBERS

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