PROPERTIES AND CONSUMER ACCEPTABILITY OF SELECTED VARIETIES OF MAIZE GROWN IN GHANA

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by

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A B S T R A C T

Two high-yielding varieties of maize, namely "Dobidi" (Ejura 7843) and "Aburotia" (Tuxpeno P.B. C16), and one local unimproved variety were evaluated for their physical, chemical, functional and sensory properties in relation to their suitability for common Ghanaian traditional maize foods. Effects of variety and soaking time on the milling characteristics were determined by sieve analysis of meals from soaked samples while sensory properties were determined for three traditional maize food products by triangle and preference tests. Significant varietal differences ($P<0.05$) were observed in the test weights (kg/hl), the 1000 kernel weights (g) and hull composition of smaples tested. The "Dobidi" variety had the highest values for test weight and 1000 kernel weight but the least hull proportion of kernel. Milling properties of grains increased with period of soaking for the "Dobidi" variety while the fineness modulus values for "local" and "Aburotia" varieties did not increase significantly after 36h of soaking. A minimum of 60h of soaking was required for "Dobidi" to attain the same average meal pacticle size as the "local" and "Aburotia" varieties soaked for only 36h. Spontaneous fermentation of dough samples showed no varietal effect on the development of flavour components as determined by titratable acidity. High consumer preference scores for the traditional maize foods were recorded for all the varieties.

INTRODUCTION

Maize (Zea mays) is a major staple food crop in many developing countries of the world. In Ghana, maize provides about 90% of the total calories in the diets of people in the Southern sector of the country (National Food & Nutrition Board, 1962). It is widely cultivated in different agro-ecological zones in Africa, covering over 21.2 million hectares of arable land (Kim, et al, 1986). However, maize yield in Africa is still at the one ton per hectare level being less than 25% of the yield obtained in the U.S. (Kim, et al 1986). The high cost of inputs for maize cultivation coupled with the low yield has made the local maize variety expensive and uncompetitive on the export market (Ashiama, 1986).

Maize breeders in the West-African Sub region are therefore actively involved in variety improvement research to obtain high-yielding varieties for cultivation by local farmers. Attention is focused mainly on improved open-pollinated varieties and hybrids for adaptation and selection. In Ghana, five high-yielding varieties have been successfully developed and released by the Crops Research Institute. Four of these were among varieties recommended to farmers for large scale cultivation (Ghana/CIDA Grains Development Project, 1987). Results of recent trials (Table 1) showed that yields of these improved varieties, namely La Posta CRI, "Dobidi" (or Ejura 7843), "Aburotia CRI" (or Tuxpeno P.B. C16) and Golden Crystal, could be twice as high as average yields obtained with local unimproved varieties.

The success of a breeder improvement programme does not, however, depend only on high production yield and other desirable agronomic characteristics, but also on the suitability of the products for the end-uses. Maize is used in many West African countries mainly in the form of a fermented dough or meal for a wide variety of dishes (Christian, 1967; Dovlo, 1970; Plahar and Osei-Yaw, 1978). The physicochemical, functional and sensory property requirements of this intermediate product have been

established for maize foods in Ghana and Nigeria (Akinrele, 1970; Amoa and Muller, 1976; Banigo and Muller, 1972; Plahar and Leung, 1982; 1983; 1985; Plahar et al, 1983). Consumer preference for maize products is based on grain type, colour, processing characteristics and general functional properties. Any improved variety will attract wide consumer acceptability only if it possesses desirable functional and sensory properties for the traditional maize food.

Ghanaian consumer reaction to the high-yielding maize varieties developed has not been encouraging. In a personal communication, Sallah and Dzah (1986), both maize breeders, listed some of the consumer complaints concerning the improved varieties as follows: hard grain texture, difficulty in milling (dry or soaked), chaffy meal with low rising quality and poor sensory characteristics of foods prepared with these varieties. There is, therefore, the need to establish the properties of the improved varieties in relation to their suitability for traditional processing and food uses. This will help breeders and Agricultural Extension workers to concentrate on high yielding varieties with properties desirable to the consumer.

The purpose of this study was to determine the physical, chemical, functional and processing characteristics of two high-yielding varieties of maize in comparison with a local variety in order to recommend, where necessary, any alternative methods of processing to enhance acceptability for traditional maize foods. The different varieties were also tested for consumer preference in three common Ghanaian traditional foods.

Table 1. Grain yield (tons/ha) of 4 maize varieties tested at 4 locations in Ghana during 1985 major season.

Variety	Grain Yield (tons/ha)				
	Kwadaso	Ejura	Pokoase	Kpeve	Across (mean)
Dobidi (Ejura 7843)	5.56	4.76	5.59	7.84	5.94
Aburotia (Tuxpeno P.B C16)	6.07	5.18	4.22	6.72	5.55
Local 1	4.15	3.38	2.24	3.31	3.28
Local 2	3.24	2.70	2.93	3.33	3.05

Source: Sallah and Twumasi-Afriyie (1986).

MATERIALS AND METHODS

Maize Samples

Two high-yielding varieties of maize and one unimproved "local" variety were used for this study. The high-yielding varieties, "Dobidi CRI" (Ejura 7843) and "Aburotia CRI" (Tuxpeno P.B. C16), were supplied by the Ghana - CIDA Grain Development Project, Ejura, Ghana, while the "local" variety was purchased from Ho in the Volta Region of Ghana. Dobidi and Aburotia are La Posta and Tuxpeno derived varieties, respectively. "Dobidi" is a full-season (110-120 days) variety while "Aburotia" is a medium (100-105 days) maturing variety. (Sallah and Twumasi-Afriyie, 1986). All the maize varieties used are white in colour with dent grain texture.

Physical and functional characteristics

A modification of the AACC method (AACC, 1983) was used to determine test weight per hectoliter of each maize variety. One-litre levels of original grain samples were weighed and the average test weight calculated in kg/hl from six replicates. Average Kernel weight for each variety was determined by the method of Adeyemi et al (1987) and recorded as 1000 kernel weight in grams. Proportions of the component parts of the kernels were obtained by breaking samples of dry grains in a mill and separating the hulls, germ and endosperm quantitatively from weighed samples of the mixture.

Effects of variety and period of soaking on the milling properties of maize grains were determined from sieve analysis of milled samples of grains soaked in water (1:5 w/v) at 28°C for different periods of time. The milling operation was done in a disc attrition mill (No. 2A Premier mill) using the same feed gap setting for all samples. From the particle size distribution, the fineness modulus and the average size for each sample were calculated (Henderson and Perry, 1979). Water absorption characteristics of the maize varieties were determined by steeping 20g samples of whole grains in distilled water (1:5 w/v) at 28°C for 6, 12, 24, 36, 48, 60 and 72 hours. At the end of each soaking period, triplicate samples were removed from the steep-water, wiped gently and weighed.

Maize dough preparation and fermentation characteristics

Samples of grains from each variety were cleaned and steeped at 28°C in distilled water for 36h ("Local" and "Aburotia" varieties) or 60h ("Dobidi" variety) to achieve the desired milling properties. The steeped grains were milled in a commercial disc attrition mill (No. 2A Premier mill) to an average particle size of about 0.4mm and the meal kneadded with water into a smooth dough with moisture content of 50%. Dough samples were packed in containers and left to ferment spontaneously for 3 days at 28°C. Daily samples were taken to determine the titratable acidity.

To determine the dough rising ability during fermentation, 200g samples of freshly prepared dough were packed in 250ml. beakers and the maximum increase in volume recorded over a 3 - day period of fermentation.

Chemical analysis

Moisture, protein (N x 6.25), fat and ash were determined by the AOAC (1980) methods, while the reducing and non-reducing sugars, iron, calcium and phosphorus were determined by AACC (1983) methods. Titratable acidity of fermented dough samples was determined by titrating aliquots of 10% (w/v) water extracts of the meal with 0.1N NaOH standard solution (AACC, 1976).

Sensory evaluation

Three common traditional maize foods ("Koko", Ga kenkey" and "Fanti kenkey") were used to evaluate consumer preference for the maize varieties. "Koko, a traditional breakfast porridge, was prepared by cooking a slurry of fermented maize dough (Andah and Muller, 1973). For the preparation of "Ga kenkey", one-third portion of fermented maize dough smaple was partially gelatinized by mixing with water (1:1 w/v) and cooking into a smooth paste with added salt (0.3%). The cooked paste was allowed to cool, and mixed thoroughly with the remaining two-thirds portion of the dough.

The mixture was moulded into balls (about 400g), wrapped in corn husks and boiled in water for about two hours to cook. A similar procedure was used for the preparation of "Fanti kenkey" except that no salt was added in this case, and also plantain leaves were used as wrapping material. Longer cooking period (about 4 hours) was required for "Fanti Kenkey" than for the "Ga kenkey".

Samples of food prepared from the different maize varieties were evaluated by triangle tests (Larmond, 1977) for differences between the improved and the local varieties. Twenty research Scientists at the Food Research Institute, Accra, Ghana, aged between 24 and 45 years were selected to form a laboratory taste panel. The presentation of samples to panelists was balanced and randomized.

Sensory preference of the food samples was determined using a consumer panel of 30 Ghanaians who were familiar with the products. Panelists' preferences in terms of aroma, taste, texture and overall acceptability were recorded on a 9 - point hedonic scale (1 = dislike extremely and 9 - like extremely). Mean sensory scores were analysed statistically for significance of observed differences.

Statistical analysis

Pairwise comparisons of means were performed by the Least Significant Difference test (Steel and Torrie, 1980) to determine significance of differences in the mean values obtained for the different varieties. In all cases, an analysis of variance (the F - test) was first used.

RESULTS AND DISCUSSION

Physical and functional properties of grains

Significant varietal differences were observed in the test weight, 1000 kernel weight and hull composition of the maize varieties tested (Table 2.). The "Dobidi" variety had the highest values for its test weight and average kernel weight (1000 kernel weight in grams). Test weight values obtained for "Aburotia" and the "local" varieties were not significantly different ($P \geq 0.05$) but the kernel weight value for the "local" variety was about 26% higher than that for "Aburotia" which had the least value among the three varieties tested. Adeyemi et al (1987) reported 100 kernel weight values in the range of 23.1-28.5g (equivalent to 231 - 285g per 1000 kernels) for six Nigerian maize varieties. The average kernel weight value for "Dobidi" was therefore higher than that for any of the Nigerian varieties, while "Aburotia" had a value lower than the least for these varieties.

Proportions of the component parts of the kernels showed that hull composition could not possibly be the cause for the chaffy meal texture reported as one major consumer complaint against "Dobidi" and "Aburotia" varieties. "Dobidi" had the least value for hull composition, while values obtained for hull and endosperm components were not significantly different ($P \geq 0.05$) for the "local and "Aburotia" varieties. Kernel sizes of the three varieties were quite distinct. "Aburotia" could easily be identified as the small-grain variety and "Dobidi" as the variety with large kernels. The local variety was described as medium-size.

The water absorption ability of each of the maize varieties tested is shown in Table 3. For each period of soaking, the "Aburotia" variety gave the highest water absorption capacity reaching a maximum of about 52g/100g solids in 60-72 hours of soaking. All three varieties had their highest rates of water absorption within the first twelve hours of soaking with the highest absorption values recorded for "Aburotia" and "local" varieties within this period. Thereafter, there was a relatively slow rate of absorption up to a period of readjustment when little or no water was absorbed by the grains.

Table 2. Physical characteristics of three varieties of maize grown in Ghana

	Local	Dobidi	Aburotia
Whole Kernel Properties			
Test weight (kg/hl)	75.8a	81.8b	75.7a
1000 kernel weight (g)	236.3a	293.7b	174.3c
Grain Colour	White	white	white
Grain Texture	dent	dent	dent
Proportion of kernel parts (%)			
Hulls	7.51a	5.95b	8.32a
Endosperm + Germ	92.49a	94.05b	91.68a

[1] Values are means of six replicates

[a,b,c] Means in a row with same letter are not significantly different ($P \geq 0.05$).

Table 3. Water absorption properties of three varieties of maize

Steeping period (Hours)	Water absorbed (g/100g solids)[a]		
	Local	Dobidi	Aburotia
6	31.84a	29.27b	33.08c
12	38.85a	36.91b	40.23c
24	42.30a	42.81a	46.24b
36	43.82a	45.53a	49.33b
48	43.90a	46.24b	49.64c
60	44.32a	46.18b	52.97c
72	46.43a	47.78b	52.37c

[a]Values are expressed as means of triplicate determinations

a,b,c, Means in a row with same letters are not significantly different ($P \geq 0.05$).

After the readjustment period, more water was taken up until the grains reached their maximum absorption limit.

For both "Aburotia" and "local" maize varieties, the period of readjustment (or "absorption lapse") occured between 36 and 48 hours of soaking while "Dobidi" had almost a negative net increase in absorption between 48h and 60h (Table 3). In a previous work, Plahar (1986) reported that both "Aburotia" and "local"varieties of maize required a soaking period of 36 - 48h while "Dobidi" variety required 60-72h for the desired milling characteristics. These soaking periods reported are similar to the periods of soaking required to get the "absorption lapse" stage, as observed in this study. The time of soaking for an "absorption lapse" to occur in maize grains may therefore be used as an index for minimum period of soaking required to achieve the desired milling characteristics.

Milling properties of grains

The fineness modulus and average particle size of meals from the different varieties of maize soaked for different time periods are shown in Table 4. The fineness modulus results were analysed to show the effect of soaking on the milling characteristics of each variety while the average particle size values (calculated from the fineness modulus) are presented to demonstrate varietal effect on the milling properties. For each variety of maize, better milling was achieved with increasing period of soaking. However, soaking beyond 36h did not change the fineness modulus significantly ($P \geq 0.05$) for the "local" and "Aburotia" varieties. In terms of good milling properties therefore, it would not be necessary to soak these two varieties for more than 36h. "Dobidi" variety, on the other hand, gave significantly different fineness modulus values for each period of soaking up to 60h.

Table 4. Effects of variety and soaking time on the milling properties of maize grains[a].

Soaking Time (Hrs.)	Fineness Modulus[b]			Av. Particle size (mm)[c]		
	Local	Dobidi	Aburotia	Local	Dobidi	Aburotia
0	2.95a	3.39a	3.24a	0.81x	1.10y	0.08z
24	2.26b	2.67b	2.38b	0.50x	0.66y	0.54z
36	2.06c	2.41c	2.04c	0.43x	0.55y	0.43x
48	1.99c	2.09d	2.01c	0.41x	0.44y	0.42x
60	1.96c	2.00e	1.94c	0.41x	0.42x	0.40x

[a] Values are means of three replicates, each replicate consisting of two observations.

[b] Within each column, means with same letter (a-c) are not significantly different ($P \geq 0.05$).

[c] Means in a row with same letter (x-z) are not significantly different ($P \geq 0.05$).

For each period of soaking, significant varietal differences were observed in the average particle size values for the meals. The best milling was achieved with the "local" variety (least average particle size) followed by "Aburotia" and "Dobidi" in that order, when soaked for 24hours. Thirty-six or forty-eight hours of soaking resulted in the same average particle size distribution for "Aburotia" and "local" varieties with "Dobidi" having poorer milling properties. Soaking for 60h did not however give any differences in the milling properties of the meals of the three varieties studied. To achieve the same particle size distribution, therefore, "Dobidi" requires a minimum soaking period of 60h while "Aburotia" and "local" varieties require a minimum of 36h.

Chemical Composition of maize varieties

There were no significant difference ($P \geq 0.05$) in the proximate composition and total energy content of the three maize varieties (Table 5). Andah (1979) also found no significant differences in the chemical compositions of five other varieties of maize (Laposta, Diacol 153, Composite 2, Composite 4 and local) grown in Ghana. Values obtained were similar for the two studies.

Significant varietal differences were however, observed in the sugars and mineral compositions of samples tested in this study. "Aburotia and "Dobidi", the two high yielding varieties had lower reducing sugars contents than the "local" variety which also had the highest value for invert sugars. Sucrose content was the same for all three varieties. The "local" variety was significantly higher in its iron and phosphorus contents but had a lower calcium content than the two improved varieties.

Maize dough fermentation properties

The final titratable acidity (mg/NaOH/g dry sample) contents of dough samples fermented spontaneously for three days, were not significantly different ($P \geq 0.05$) for the maize varieties used for this study (Table 6). The initial higher level of acidity observed in the "Dobidi" dough was due to the longer period of soaking used for this variety. Titratable

Table 5. Chemical composition of maize varieties[1]

Component	Variety		
	Local	Dobidi	Aburotia
Moisture (%)	13.42	12.14	12.80
Protein (%)	10.01	9.80	10.67
Fat (%)	4.82	4.55	4.01
Ash (%)	1.50	1.29	1.26
Carbohydrates (%)	83.68	84.35	84.06
Reducing Sugars (%)	0.77	0.50	0.42
Invert Sugars (%)	2.24	1.94	2.00
Sucrose (%)	1.40	1.37	1.50
Iron (mg/100g)	4.01	2.28	2.22
Phosphorus (mg/100g)	323.78	247.67	254.59
Calcium (mg/100g)	33.88	67.15	59.63
Energy (Kcals/100g)	404.90	404.77	401.45

[1] Values are expressed as means of triplicate determinations on dry-weight basis (except for moisture).

Table 6. Titratable acidity and dough rising ability of fermenting dough samples from three varieties of maize

Fermentation period (Days)	Titratable acidity (mg/NaOH/g sample)[1]		
	Local	Dobidi	Aburotia
0	2.25a	2.61b	2.06a
1	5.54a	5.11b	5.41a
2	6.01a	6.47b	6.42b
3	6.91a	6.82a	7.01a
Max increase in dough volume (%)[2]	37.70a	26.95b	27.75b

[1]Values are means of three replicates, expressed on dry-weight basis.

[2]Means within a row with same letter are not significantly different ($P \geq 0.05$).

acidity gives an indication of the degree of carboxylic acid development during fermentation. These acids are principally, lactic, acetic and butyric and are responsible for the desired flavour, and hence acceptability of the fermented dough (Banigo and Muller, 1972). The mean final acidity level of about 7mg NaOH/g sample (DWB) obtained for all the samples in this study is similar to the normal values for traditional Ghanaian maize dough (Plahar and Leung, 1983).

"Local" variety dough samples showed significantly higher swelling ability during fermentation than the other two varieties. "Aburotia" and "Dobidi" varieties had similar not increases in dough volume during fermentation. The percent increases in dough volume recorded for the two high-yielding varieties were about 10% less than that for the "local" unimproved variety. This finding supports the claim by consumers that the improved maize varieties have lower rising capacity. However, dough rising ability alone does not give much indication of the extent of product yield expected. Further tests are required to compare actual yields of maize products from equal weights of the different varieties. Determination of the pasting properties could also give a fair indication of the relative yields of food products from the raw materials.

Effect of variety on sensory properties

More than the minimum propertien of taste panelists required to establish significance in triangle taste tests (Roossler et al, 1978), were able to identify odd samples from like pairs of most of the food products tested in this study. This shows that there were detectable varietal differences in some of the sensory characteristics of the products.

Results of mean sensory scores (Table 7) showed no significant varietal effect on the aroma of each of the maize food products tested. For the two "Kenkey" products, consumer preference for aroma was slight to very much liking. With the other sensory characteristics, significant varietal differences were obtained for some products while others had similar scores. Mean preference scores for "Koko" showed significantly lower preference for "Aburotia" variety in the taste and overall acceptability. No. differences

Table 7. Preference test of traditional maize foods prepared from three varieties of maize

Food Product	Variety	Mean Sensory Scores[1]			
		Taste	Aroma	Texture	Overall acceptability
Koko (Porridge)					
	Local	7.75a	7.44a	7.75a	7.56a
	Dobidi	7.50a	7.63a	7.19a	7.50a
	Aburotia	6.88b	6.94a	7.06a	6.94b
Fanti Kenkey					
	Local	6.59a	6.24a	6.47a	6.53a
	Dobidi	7.24a	7.06a	7.59b	7.41a
	Aburotia	5.94a	6.24a	6.41a	6.59a
Ga Kenkey					
	Local	6.19a	6.62a	6.38a	5.67a
	Dobidi	7.14b	7.00a	7.57b	7.48b
	Aburotia	7.14b	7.38a	7.28b	7.48b

[1] Based on a 9 - point hedonic scale with 9 = like extremely and 1 = dislike extremely (Larmond, 1977).

[a,b] For each product, means in a column with sne letter are not significantly different ($P \geq 0.05$).

were observed in the texture of the "Koko" from the different varieties. On the whole the least score for all the sensory attributes of "Koko" prepared with the different maize varieties was 6.88 (equivalent to moderate liking) and the highest was 7.75 (like very much).

For "Fanti Kenkey" the only significant difference in sensory scores was for the texture of the "Dobidi" variety which gave the highest score of 7.59 (like very much); otherwise, there were no varietal differences in the sensory characteristics of "Fanti kenkey" samples from the different maize varieties. The "local" maize variety gave the least sensory scores for taste, texture and overall acceptability when used for the preparation of "Ga kenkey". "Dobidi" and "Aburotia" showed no significant varietal differences ($P \geq 0.05$) in all the sensory properties of the product.

From the summary of sensory attributes responsible for varietal differences in the maize foods tested (Table 8) "Dobidi" was not significantly different ($P \geq 0.05$) from the "local maize variety when used for "Koko" (porridge). Similarly, "Aburotia" could be used for "Fanti kenkey" preparation to achieve the same sensory properties as with the "local" maize. Dobidi and Aburotia could also be used interchangeably for "Ga kenkey" without any detectable differences in the sensory properties.

Table 8. Summary of sensory attributes responsible for detectable varietal differences in three traditional maize foods

Variety Pair	"Koko"	"Ga Kenkey"	"Fanti Kenkey"
Local vs. Dobidi	Nil	Taste Texture & Overall acceptability	Texture
Local vs. Aburotia	Taste & Overall acceptability	Taste Texture & Overall acceptability	Nil
Dobidi vs. Aburotia	Taste & Overall acceptability	Nil	Texture

CONCLUSION

Although the results showed significant varietal differences in most of the physical, chemical, functional and sensory properties of the grains, the high-yielding maize varieties used in this study can be better preferred in traditional Ghanaian maize foods than the local variety if the proper processing procedures are followed. Specifically, longer periods of soaking (60h minimum) are required for the "Dobidi" variety to achieve the same particle size distribution of meals as the "local" and "Aburotia" varieties soaked for 36h. Processed this way, the "Dobidi" variety can have the same sensory preference in the traditional breakfast porridge as the "local" variety, and even better sensory properties when used for the other traditional maize foods.

The time for an "absorption lapse to occur during steeping may give a good indication of the minimum period required for soaking a particular variety of maize grains to achieve the desired milling characteristics.

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