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Interactive effects of location x sampling time on organoleptic and nutritional properties of six maize genotypes

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ABSTRACT: Grains of three corn field varieties and their F1 hybrids obtained by crossing to a standard sweet corn were sampled at two different intervals for their organoleptic properties and at three intervals for nutritional qualities. the objective was to determine the most appropriate time to harvest for green maize consumption and also to detect changes which may have occurred in nutritional qualities in relation to time of sampling. Results obtained showed that location effect was significant ($P < 0.01$) for all organoleptic properties while time of sampling had significant effect on sweetness and texture. The interactive effects of location x sampling time and variety x sampling time were significant for flavour, sweetness, texture and preference respectively. With respect to nutritional qualities, there was an inverse relationship between grain protein concentration on one hand and nitrogen free extracts as well as carbohydrate content as sampling was delayed while crude lipid, ash and crude fibre remained relatively unchanged. The genotypes differed significantly for both properties with Suwan-1-SR being superior to others for flavour and texture at the milk stage While Obantanpa x sweet corn was superior for grain protein concentration (17.1 & 15.34 at each location) also at the milk stage. Associations among organoleptic properties were generally positive and significant at the milk stage while none of the association was significant at physiological maturity thus emphasising the importance of early harvesting of maize intended for green consumption. However, association among most of the organoleptic properties and nutrient composition were non significant except those of ash content with flavour, texture and likeness which were negative and significant only at the milk stage. This tend to corroborate earlier findings that consumer acceptability for green maize consumption may not necessarily be related to quality characteristics

Key Words: *Zea mays, Zea sauharata*, organoleptic properties.

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Introduction

Maize (*Zea mays* L.) is utilized in two main forms among the resource-poor communities of the West and Central Africa (including Nigeria). In the green form, freshly harvested maize cobs may either be boiled till the fresh grains are soft or roasted over hot charcoal until brown. In the fresh or dried form, it can also be processed, into various indeginous dishes which may be mixed with a wide range of vegetables, salt and vegetable oil before steaming to produce a stiff porridge (Okoh, 1998).

The kind and forms of such dishes have been presented by many workers (see for example, Fakorede *et al*, 1993). Since the major form of utilization is in the processed form, it therefore follows that the development of maize varieties (open pollinated and hybrids) with improved quality characteristics, which could be grown solely for direct human consumption, will likely enhance the nutritional status of the traditional communities who utilize them in preparation of various dishes.

Scientists at the Institute of Agricultural Research and Training (LAR&T), Ibadan have recently been focusing on the improvement of the existing popular maize varieties for green maize consumption by introgressing the *su* genes from the sweet corn (*Zea saccharata*) into some popular field corn varieties. It is believed that the introgression of the *su* genes into these popular field corn varieties will likely enhance their organoleptic properties (i.e. sweetness and flavour) without adverse effects on yield potentials.

Although genotypes do vary with respect to their nutritive values, studies in Nigeria and elsewhere have shown that consumer preference and/or acceptability is largely determined by subjective parameters such as colour (Taiwo & Adetayo, 1998); organoleptic properties (Alika & Okwechime, 1990; Okoruwa, 1997); attitudes and habit (Saba *et al*., 1998) and cookability among others, Similarly, the period at which genotypes are sampled is bound to play a significant role in determining both organoleptic properties especially of flavour, sweetness and texture as well as nutritive properties (Sowunmmi, 1981; Osayintola, 1992; Omorege *et al*., 1998).

While these studies have focused on the factors which determine consumer preference and/or changes in nutritional qualities in relation to period of sampling, there has been no report on the possible effects of the native soil nutrient status on the organoleptic and nutritional properties of maize genotypes intended for green maize consumption. However, empirical evidence from studies on crops normally grown for their quality parameters (for example, wheat) Hanson *et al*., 1986; Oscarson *et al*,. 1995) indicate that (i) increase in the native nitrogen (N) accumulation generally result in increased grain protein yield, (ii) grain N content is regulated not only by primary N uptake but also by remobilization and translocation to the grain of previously taken up and incorporated in the vegetative tissues and (iii) genotypes differ in their ability for N uptake. This study was therefore conducted to (i) assess the organoleptic properties of these hybrids in comparison with their parents and (ii) examine changes in the nutrient composition of the six genotypes in relation to the period of sampling beginning from the milk stage. It is hoped that such findings will assist consumers in determining an appropriate time to harvest either for utilization in the fresh or dried form.

Materials And Methods

The materials used for this study comprised of the three popular field corn varieties in the South Western Nigeria viz: Suwan-1SR, POP 31DMR and Obatanpa as well as their F1 hybrids. POP 31DMR and Suwan-1SR are two of the popular maize varieties in the South Western Nigeria while Obatanpa is a high quality protein maize variety developed in Ghana. The hybrids were produced by crossing the varieties to a standard sweet corn variety (as the pollen source) by maize scientist at the IAR&T, Ibadan, during the 1998 cropping season.

The materials were planted at both the Teaching and Research (T&R) farm (designated as location 1) and behind the Faculty of Agriculture (location 2) at the University of Ilorin in a typical Southern Guinea Savanna ecology during the 1998 late cropping season. The physical and chemical properties of the experimental sites are presented in Table 1. The experiment was laid out as a randomized complete block design (RCBD) at each location. Each plot consisted of four rows, 5M long with an inter and intra row spacing of 0.75M and 0.5M respectively: Planting at the Faculty of Agriculture farm was on the 30th July and the T&R farm on the 1st of August, 1998. The plots were over planted but later thinned to two stands/hill to give a plant population of 53,333 plants/ha. Weed was controlled at the Faculty of Agriculture farm by hand while a pre-emergence herbicide application, supplement by one hand weeding was carried out at the T&R farm. Fertilizer application at both locations was in a split-dosage at three and seven weeks after planting at the rate of 80kg N, 60kg P and 60kg K/ha respectively.

Data collection:

Organoleptic Properties

Two samplings were carried out at each location at an interval of four days beginning from 22 days after the last variety attained 50% silking (i.e. at the milk stage). Samples were obtained form the outer rows in a plot and for each sampling, a total of 20 plants were harvested per variety. Ten were used for palatability rating, five for visual assessment and the remaining five for proximate and nutrient analyses.

Visual assessment (Ear aspect):

Prior to the first sampling, ten partially trained panelists were selected form among the 15 screened. These panellists wee used throughout the sampling periods. For the ear aspect, five cobs of each variety were used. They were assessed before dehusking (to mimic acceptability rating by roadside corn sellers) and after dehusking (for consumer acceptability). The rating was on a scale of 1 (best) to 5 (poor) and the mean of the scores were recorded for the variety.

Table 1: Physical and chemical properties of the experimental sites.

	Faculty farm	Teaching & Research farm
% Sand	86.6	87.2
% Silt	9.7	8.0
% Clay	3.7	4.2
pH (H_2O)	6.3	6.3
pH (0.01m $CaC1_2$)	5.5	5.2
% N	0.11	0.09
% Organic Matter	1.93	1.55
Ca (ppm)	600	350
Mg (ppm)	120	150
K (ppm)	69	69
Na (ppm)	43	27
P_20_5 (pp)	20.62	25.19

Table 2: Means squares from the combined ANOVA for sensory scores of parents and F1 hybrid

Source	df	Flavour	Sweetness	Texture	Likeness	Ear Aspect	Overall Preference
Location(A)	1	12.68**	13.33***	11.41*	43.20**	0.08	0.00
Rep/Loc.	8	0.36	2.18	4.07	15.01	0.08	0.00
Time (B)	1	0.6B	28.03***	17.41***	4.03	0.01	0.00
Genotype(C)	5	6.70***	2.11*	12.48***	15.92**	8.83*	18.22***
A x B	1	0.01*	2.70*	1.00	0.53	0.01	0.00
A x C	5	2.22	0.49	5.90*	4.01	4.19	2.78
B x C	5	5.06***	1.35	5.21*	4.72	5.99	4.66*
A x B x C	6	0.91	2.14*	1.85	9.79*	0.95	3.06
Pooled Error	88	1.01	0.71	2.61	3.85	2.85	2.23

*,**,***; Significant F Test at 0.05, 0.01 and 0.001 levels of probability respectively.

Sensory evaluation :

The ten partially trained panelists were also used to collect sensory evaluation data form the test varieties as outlined by Larmond (1970). The sensory parameters used were flavour, sweetness, texture and likeness. Rating for flavour and sweetness was on a scale of 1 (excellent) to 6 (very poor) while texture was on a scale of 1 (extremely tender) to 8 (extremely tough). Likeness was rated on a scale of 1 (like extremely) to 9 (dislike extremely). The panellists also rated the genotypes for overall preference on the four sensory parameters on a scale of 1 (best) to 5 (poor). For each sampling, the genotypes were coded differently from the previous sampling both for the visual assessment and sensory evaluation. The test varieties were also boiled in separate pots before they were served to the panellists.

Nutritional Qualities:

Three samplings were also carried out at each location for the quality parameters. The first sampling was at the milk stage while the second and third samplings were at physiological maturity and dried stage (i.e. at final harvest) respectively. Five (5) random ears were selected in a plot followed by careful removal of the grains by hand. For each variety, equal number of grains were selected from each cob, mixed together to form a balanced, bulk and then subjected to proximate analyses in the laboratory.

Proximate analyses:

The grains obtained at the milk and physiological maturity were milled in a blender while those obtained at harvest were grounded to form a fine powder. Each sample was oven dried to a constant weight at 80°C to obtain percent (%) moisture content (MC). Crude protein (CP) and ash determination were carried out according to the methods described by AOAC (1980) and Person (1973) respectively. Crude lipid (EE) determination was by the Soxhlet method using petroleum ether at boiling point 40-60°C as solvent (AOAC, 1975). Crude fibre (CF) determination was done by digestion of the deffated sample followed by drying of the residue obtained from washing with boiling distilled water in an oven to a constant weight at 80-85°C. Nitrogen free extract (NFE) was determined by difference viz: %NFE = 100 - (%MC + %CP = %Ash + %CF + %EE) while total carbohydrate was obtained by the summation of CF which represents the insoluble carbohydrate and the NFE which is the soluble carbohydrate (i.e. %CF +

%NFE). Two replicated determinations were analyzed for each variety at each of the sampling periods and the mean recorded for each sample.

Data analyses:

Data collected for both the organoleptic and nutritional properties were subjected to the analyses of variance across locations and pertinent means were separated using the Duncan's New Multiple Range Test (Steel & Torrie, 1980). Data from five of the panellists who missed any of the four sampling were excluded from the analyses. With respect to the nutritional qualities, data obtained from the mean values for each character were used to compute variances using the formula

$$\delta^2 = \frac{\Sigma(Xi - X)2}{n-1}$$

Where 82 = variance; Xi = individual mean values; X = Overall mean for that character and n = number of observations.
Standard deviation was computed as $\delta = \frac{\sqrt{(Xi - X)^2}}{n - 1}$

Results and Discussion

The results of the combined ANOVA for the organoleptic properties are presented in Table 2. The genotypes (G) differed significantly for all the sensory parameters while location (L) effect was significant for flavour, sweetness, texture and likeness. The time (T) at which the genotypes were sampled also had a significant effect on sweetness and texture of the varieties. The first order interaction of location x sampling time (L x T) was significant for flavour and sweetness while genotype x sampling time (G x T) interaction effect was significant for flavour, texture and overall preference respectively. Genotype x location (G x L) interaction on the other hand had a significant effect on the texture of the varieties. Meanwhile, the second order interaction of G x L x S effect was significant for sweetness and texture indicating differences among the test varieties for this parameters at each location and time of sampling. The significant location effect for flavour and sweetness as well as its interaction with the genotypes for sweetness and texture tend to suggest the influence of G x L interaction for these characters. However, it is still not clear which of the soil nutrients may be responsible since the differences in the phisco-chemical properties of the experimental sites are negligible (Table 1). Further more, it is known that these sensory parameters are genotype dependent such that the results of the nutrient composition may be needed in order to ascertain the cause(s) of the observed interaction.

Effects of time sampling on organoleptic properties:

Only two of the sensory parameters (flavour and texture) as well as overall preference were significantly affected by time of sampling (Table 3). For the two organoleptic properties, the rating was higher at the milk stage than at physiological maturity. This is probably due to the fact that the cobs were more tender and sweeter than those obtained at physiological maturity. Other sensory parameters remained unaffected regardless of the time the genotypes were sampled. Suwan-1-SR rated best for texture followed by two of the hybrids (Obatanpa x Sweet corn and Suwan-1-SR x Sweet corn in that order) at the milk stage. However, in terms of overall acceptability, Suwan-1-SR and its hybrid were the least preferred.

Comparison of the parents with their respective hybrids (Table 3) showed that two of the hybrids (Obatanpa x sweet corn and POP 31 DMR x sweet corn) rated better than their parents for flavour and texture. However, there was a rapid decline in sweetness and tenderness of the hybrids between the first and second sampling periods. Conversely, these parameters appear to be relatively stable in the parents. This may be due to the rapid transformation of sugar to polysaccharides in the hybrids which tend to support the hypothesis that sucrose content of the edible corn (i.e. sweet corn) changes rapidly as from 15 days after kernel development (Culpepper & Magoon, 1927).

Table 3: Effect of time of sampling on sensory score of parents and F_1 hybrids of a Field x sweet corn at Ilorin (Nigeria)

	Flavour		Texture		Preference	
Variety	1	2	1	2	1	2
Parents						
Suwanl-SR	2.00a	3.30bc	2.5a	4.30bc	5.60e	4.30cde
Pop 31DMR	5.10d	3.60bc	5.30bcd	5.60cd	1.90a	2.40ab
Obatanpa	4.30cd	3.50bc	5.00bcd	4.30bc	2.70ab	4.50de
Hybrids						
Suwanl -SR+SC	3.50bc	3.50bc	2.70a	5.00bcd	4.60de	3.40abcd
Pop31 DMR+SC	4.40bc	3.50bc	4.40bc	6.10d	2.90abc	2.90abc
Obatanpa+SC	3.00b	3.60bc	3.90ab	5.20bcd	3.30abcd	3.50bcd
S.E		0.32		0.51		0.47

Means followed by same alphabets in a column are not significantly different.

Effects of location and time of sampling on nutrient composition

Generally, there were significant changes in the mean nutrient composition of the test varieties with delay in sampling period (Table 4). % MC and CP in the grains also varied within location at each of the sampling periods and in a decreasing manner, especially after milk stage. The result is consistent with the earlier observation of Omoregie *et al.*, (1998) who also reported a generally lower nutrient composition in dry season forage relative to the rainy season forages.

However, the rate of decrease was lower at the Faculty Farm than at the T & R farm with a low N status at each of the sampling periods (Table 1). These observations are consistent with the reports of Early and DeTurk (1948) and Alexander and Creech (1977) who independently noted that protein concentration was largely determined by the Nitrogen (N) content of the soil (with a higher CP values in high - N soils), cultural conditions (for example, sampling period) as well as by heredity. CF represents the insoluble carbohydrate (including hemato-cellulose and lignin) while NFE is the soluble carbohydrate in which sucrose, reducing sugar and glucose are dissolved. These two components increased with delayed sampling while crude lipid, ash and CF remained relatively unchanged (Table 4). That the CP values decreased as the CF and NFE increased could be due to conversion of protein into soluble carbohydrate arising from the decrease in the moisture content at the later sampling dates. However, NFE values varied with genotypes at both locations and were lower than the carbohydrate values as CF increased which agrees with the earlier report of Doty *et al.*, (1945) that the genetic constitution of the plant affected the conversion of sucrose (i.e. NFE) to polysaccharide (carbohydrate) during storage as well as that of Appleman and Eaton (1921) who noted a progressive decrease in total sugar with a corresponding increase in fat and starch during the development of kernels in OP maize varieties.

Association among organoleptic properties

Association among organoleptic properties (i.e. flavour, texture, sweetness and likeness) were generally positive and highly significant at the milk stage, the highest of which was between texture and acceptability [(r = 0.906**) Table 5]. Of particular interest is the strong association of likeness with other parameters at milk stage, which suggests the importance of these characters in consumer acceptability when the purpose is for green maize consumption. Similar positive associations between organoleptic properties have been reported for both OP and hybrid maize varieties (Omueti & Agbaje, 1997). However, none of the associations was significant at physiological maturity which tend to emphasize the importance of early harvesting of maize intended for green consumption. The association between overall preference (which include cob size, colour and grain type among others) and organoleptic properties were for most part negative and highly significant especially at the milk stage. This tends to confirm earlier reports (Alika & Okwechime, 1990; Okoruwa, 1997) that criteria for varietal acceptability for green maize consumption are sometimes highly subjective.

Table 5: Simple Linear correlation coefficients among sensory parameters in parents and the F_1 hybrids of a Field corn x Sweet corn cross at the milk stage (upper diagonal) and physiological maturity (lower diagonal)

	Flavour	Sweetness	Texture	Likeness	Preference
Flavour		0.678*	0.800**	0.851**	-0.834**
Sweetness	0.133		0.858**	0.806**	-0.568
Texture	0.045	0.361		0.906**	-0.786*
Likeness	0.100	0.290	-0.120		-0.786*
Preference	-0.125	-0.266	-0.680*	-0.747*	

*,**; Significant r values at 0.05 and 0.01 levels of probability respectively

Association between organoleptic properties and nutrient composition

The correlation coefficients between organoleptic properties and nutrient composition are presented in Tables 6 & 7 respectively. The relationship between the parameters and nutrient composition were nonsignificant except those of ash content with flavour, texture and likeness which were negative and significant at the milk stage (Table 6). This tends to corroborate the earlier observation that consumer acceptability may not necessarily be related to quality characteristics. At the physiological maturity, texture had a significant negative association with MC but was positively correlated with carbohydrate content (Table 7). Likeness on the other hand correlated positively and significantly with NFE and carbohydrate contents. All other associations at this stage were nonsignificant.

Table 6: Simple linear correlation coefficients between sensory parameters and nutrient composition in parents and the F_1 hybrids of a Field corn x Sweet corn cross at the milk stage.

	%MC	CP	NFE	Carbohydrate	CF	CLP	Ash
Flavour	-0.378	0.065	0.354	0.378	0.270	0.219	-0.659*
Sweetness	-0.198	0.222	0.183	0.226	0.144	0.382	-0.219
Texture	-0.141	0.222	-0.266	-0.173	0.158	0.200	-0.667*
Likeness	-0.300	-0.086	0.392	0.435	0.280	0.086	-0.714*
Preference	0.314	-0.307	-0.194	-0.189	0.080	-0.357	0.385

*; Significant r values at 0.05 level of probability.
MC = moisture content; CP = Crude protein; NFE = Nitrogen free extract; CF = Crude fibre; CLP = Crude lipid.

Table 7: Simple linear correlation coefficients between sensory parameters and nutrient composition in parents and F_1 hybrids of a Field corn x Sweet corn cross at physiological maturity.

	% MC	CP	NFE	Carbohydrate	CF	CLP	Ash
Flavour	0.378	0.065	-0.460	-0.406	-0.242	0.167	0.158
Sweetness	-0.105	-0.362	0.044	-0.031	-0.022	0.446	0.236
Texture	-0.571*	-0.027	0.547	0.708*	-0.257	0.034	-0.361
Likeness	-0.036	-0.206	0.647*	0.658*	-0.310	0.144	0.229
Preference	0.147	-0.278	-0.371	-0.343	-0.336	0.235	0.256

*; Significant r values at 0.05 level of probability.
MC = moisture content; CP = Crude protein; NFE = Nitrogen free extract; CF = Crude fibre; CLP = Crude lipid.

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