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Varietal and harvesting time effects on physical characteristics and sensory attributes of boiled fresh yellow maize hybrids

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ABSTRACT
Objective: The present study evaluated the effect of varieties and harvesting time on the physical characteristics and acceptability of boiled fresh yellow maize hybrids.
Methodology and Results: Freshly harvested cobs from eight biofortified yellow maize hybrids, at three harvesting time (20, 27 and 34 days after pollination (DAP)), were used for the present study. The fresh yellow maize ears at each of the harvesting time were boiled without husk in water at 100°C for averagely 15mins (20DAP), 25mins (27DAP) and 32mins (34DAP) respectively using atmospheric cooking method. Sensory evaluation was carried out on the boiled fresh yellow maize samples within 24 hours after harvesting. The physical characteristics of the fresh maize grains were also determined. Variety and harvesting time had significant effects ($P \leq 0.001$) on most of the physical properties, except porosity. The optimum harvest maturity stage to consume boiled maize hybrids was found to be 20DAP. There was negative but significant correlation between the physical characteristics and the sensory properties except colour that showed positive correlation.
Conclusions and application of findings: Differences in kernel characteristics caused by genetic inheritance and harvesting time can influence the processing, utilization and consumer appreciation of maize. The information from this study could used by the Maize breeders to further improve the physical characteristics of the maize hybrids and by the maize consumers to know the best harvest time to consume boiled maize hybrids
Keywords: yellow maize, hybrids, harvesting time, boiled, physical characteristics acceptability

INTRODUCTION

Even though the first hybrid maize varieties were released in sub-Saharan Africa (SSA) more than 40 years ago, less than 30% of the maize area in SSA is planted with hybrid seed (Hassan *et al.* 2001) The remaining area is planted with recycled hybrid grain, improved open–pollinated varieties (OPVs) or local varieties (Morris, 2001). The hybrid maize was well received by the farmers and they swiftly substituted the OPVs with hybrid maize in the main maize growing areas (Duvick, 1999). In recent times, hybrid maize production has been given widespread support among farmers in Nigeria (Ayinde *et al.* 2011). Nigeria produces over 700,000 metric tonnes (FAOSTAT, 2011) of green maize per annum which is mainly consumed fresh on the cob as either boiled or roasted. However, in many developing countries little attention is paid to this form of maize utilization. Yellow maize is produced in at least one of the major maize production zones in the various countries in West Africa (CIMMYT, 1988) and maize grain is converted into well-accepted local food products including gruels, porridges, pastes, and infant weaning food. Yellow maize is preferred as green maize and consumed boiled or roasted on the cob to bridge the hunger gap after a long dry season(Osanyintola,1995) Efforts to develop maize "biofortified" with increased concentrations of important micronutrients, including provitamin A carotenoids, however, have only recently begun. There are many biofortified yellow maize lines that have just been developed by the maize breeders (Menkir and Maziya-Dixon, 2004; Menkir et al. 2008) and are in the markets today.Biofortifying cassava with provitamin A (converted in the body to vitamin A) could significantly improve nutrition and overall health, especially among poorer communities.

Yellow maize on cobs

Dehusked boiled yellow maize on cobs

Kernel hardness, moisture and sugar/starch ratio were the quality attributes of raw green field maize, which determined the acceptability of the product in either boiled or roasted form (Osanyintola, 1995). Sugar/starch ratio, rate of change of moisture and rate of change of hardness were identified as indices for green field maize quality and were proposed as quality control standards to monitor green field maize crop quality. Corn with low-test weight (bulk density) contained lower percentages of hard endosperm, and produced lower yields of prime grits when milled dry (Rutledge, 1979). Kirleis and Stroshine (1990) reported that the tests were positively and significantly correlated with the milling evaluation factor (MEF) determined by a short-flow milling process. Mestres *et al.* (1991) found that chemical composition (ash and protein contents) and physical properties (sphericity or dent kernel percentage) could be used to predict dry–milling characteristics of different yellow dent corn hybrids. Differences in kernel characteristics caused by genetic inheritance, environment, or handling can influence the processing and utilization of crop (Peplinski, 1992). Breeding efforts to enhance physical or compositional end-use characteristics of maize require effective and expedient assessments of phenotypic traits and may be optimized when genetic control of the traits is understood. The effectiveness of a biofortification strategy is largely depending on how traditional processing will impact the overall acceptability, not only nutritional value of maize grain. There is little information on the effects of varieties and harvesting time on the physical characteristics and sensory attributes of boiled fresh yellow maize hybrids. The objectives of this present study therefore evaluated the effect of physical characteristics and harvesting time on the acceptability of boiled fresh yellow maize hybrids ready to be released are:

(i) to evaluate the physical characteristics of the newly developed yellow maize hybrids and establish the effects of harvesting time on their physical characteristics

(ii) to identify the most acceptable maize hybrids among the newly developed yellow maize hybrids.
(iii) to establish the optimum harvesting time to boil maize hybrids.
(iv) to establish the correlation between physical characteristics and sensory properties.

The information from this study could used by the Maize breeders to further improve the physical characteristics of the maize hybrids and by the maize consumers to know the best harvest time to consume boiled maize hybrids.

MATERIAL AND EXPERIMENTAL METHODS

Genetic Material: Freshly harvested cobs from eight biofortified yellow maize hybrids with varying endosperm texture were used for this study. They were obtained from the research farms of International Institute of Tropical Agriculture (IITA). The viable seeds of eight selected orange maize hybrids were planted in two separate trials at Ibadan (7°22' N, 3° 58'E, altitude 150m) and Ikenne (10°40' N, 8° 77'E, altitude 730m) with different and known meteorological information, in early seasons of April to August 2010 and 2011. The hybrids were arranged in a randomized complete block design (RCBD) with three replications. Cobs of each hybrid were self pollinated to minimize contamination from other pollen sources. The names of these varieties and their respective entry numbers are given in Table 1.

Table 1: Genotype name of selected yellow hybrid maize trial

Hybrid	Pedigree	Source
1	ACR97TZL-CCOMP1-Y-S3-13-1-B-B-B-B-B-B-B/9450xKI 21-3-2-2-1-3-B-B-B-B-B-B-B-B-B	09C8073B
2	(GT-MAS:Gk x BABANGOYO x GT-MAS:Gk)-2-1-3-1-B-B-B-B-B-B-B-B-B-B/(MP420 x 4001 x MP420)-3-1-2-1-B-B-B-	09C8075B
3	(KU1409/KU1414-SR/KVI43)-S2-4-1-BB/4001xB73LPAx4001-33-2-1-B*4	09C8087B
4	(KU1409/KU1414-SR/NC298)-S2-8-1-BB/9450xKI21-1-5-3 2-2-B*5	09C8089B
5	(KU1409/KU1414-SR/NC298)-S2-7-1-BB/9450xKI21-7-3-1-2-4-B*4	09C8095B
6	(KU1409/KU1414-SR/KUI2007)-S2-3-2-BB/9450xKI21-1-5-2-1-2-B*5	09C8097B
7	9450xKI21-7-2-1-2-B*4/KU1409xMO17LPAxKU1409-27-3-1-1-B*7	09C8099B
8	Oba Super-II	

Field Sampling : Plants were randomly prelabelled on the field for the three harvest maturity stages of 20, 27 and 34 days after pollination (DAP) (The day after pollination started from 50% anthesis or 50% silk emergence which was 57 days after planting) for each hybrid. They were harvested at 08.00hrs on the relevant dates. A total of 10 selected cobs of each hybrid were harvested from each plot and these were pooled to give 30 cobs per hybrid per harvest. They were packed in sacks and conveyed to the laboratory as soon as possible (Osanyintola, 1992). In the laboratory, each hybrid was divided into 2 sets for physical characteristics measurements and for processing into boiled maize without husk (dehusked cobs) respectively. All the selections and divisions were strictly randomised.

Processing of freshly harvested orange maize: The 15 selected harvested cobs of each hybrid were dehusked and boiled at 100 °C in stainless steel pots on domestic gas cookers in 2L water according to the local practice (Osanyintola, 1992). The cooking time varied with harvest time. Dehusked cobs from 20, 27 and 34 DAP harvests cooked at 25, 35 and 45mins respectively. Salt was not added to samples that were boiled as suggested by Osanyintola *et al.* (1995). All the harvested cobs were processed within 12 hours after harvesting. The samples for sensory evaluation were kept warm in a cooler equipped with Styrofoam.

Sensory properties evaluation: Sensory evaluation was carried out on the boiled fresh yellow maize samples within 24 hours after harvesting. The samples were first evaluated by 10 trained panellists on a hedonic scale of 1 to 9, where 1 = dislike extremely and 9 = like extremely for colour, aroma, chewiness, appearance, taste and overall acceptability. The selected panellists were screened for 'normal' sensory acuity through taste, aroma and texture/chewiness identification tests. Basic taste recognition test was conducted using solution of sucrose, sodium chloride, citric acid and quinine sulphate. Aroma and texture recognition tests were done following the method recommended by Watts *et al.* (1989). Panellists started with the selection of important quality attributes of boiled fresh maize following by technique of evaluation and the use of standard rating scale. Panellists selected colour, aroma, chewiness, appearance, taste, and overall acceptability as the most important quality attributes of cooked maize. Panellists were served with the boiled samples in duplicate while they were still warm to touch.

Physical characteristics determinations

Test weight or bulk density of grain: The test weight or bulk density was determined using method described by Paulsen and Hill (1985). A 200ml measuring cylinder or a suitable calibrated beaker of known weight (W_1) was filled to the mark with grains. The weight was recorded (W_2) and the weight of the grain was obtained by difference. The bulk density was calculated as weight per unit volume using the equation below:

$$\text{Density} = \frac{(W_2 - W_1)\ g}{\text{Volume of container (ml)}}$$

Kernel weight volume and true density: Method described by Arnold *et al.* (1977) and Adeyemi *et al.* (1987) was used. 25 randomly selected whole seeds were weighed and transferred into a graduated measuring cylinder containing a known volume of 50% absolute ethanol (maximum volume of 20ml). The volume of the kernel was recorded. The data were used for the computation of density and 1000 kernel weight.

Porosity: Porosity of the grain reflects the fraction of void space in a bulk of grain and was determined by the method described by Bhattacharya *et al.* (1972). The bulk density (db) and kernel true density (d) were determined as described above and from the data, the porosity is calculated thus:

$$\%\ \text{Porosity (P)} = \frac{(d - db)}{d} \times 100$$

Kernel size (dimensions): Kernel size was evaluated by randomly selecting 20 kernels and measuring the three major axes namely length (mm) breadth (mm) and thickness or depth (mm) with a vernier calliper (Martinez-Herrera and Lachance, 1979).

Kernel shape factor (sphericity): The kernel shape factor (sphericity) was determined using the method described by Pomeranz *et al.* (1985). The kernel length (a), width (b) and thickness (c) were determined as described by Pomeranz et al.(1985) above and using the data to determine the sphericity thus:

$$\text{Kernel shape factor (sphericity)} = \frac{(abc)^{1/3}}{a}$$

Hardness test: A hardness tester, Kiya M. 174856 of the Kiya Seisakutcho Limited, Japan was used to measure rigidity or hardness of grains. It measures the peak compression force which corresponds to the bioyield point in kilogram force units of the kernel. It delivers a uniaxial compression force on the kernel units' cell; hence if the grain is placed uniformly as described by Martinez–Herrera and LaChance (1979) it would give results similar to the Instron instrument. The peak force in the deformation of the kernel was used as a measure of hardness.

Statistical analysis: All measurements were done in duplicate. Data generated were subjected to analysis of variance (ANOVA) and descriptive statistics using statistical analysis system (SAS) software package 9.2. Least significant difference (LSD) test was used for mean comparison.

RESULTS AND DISCUSSION

The combined analysis of variance (ANOVA) for the physical characteristics of fresh yellow hybrid maize is presented in Table 2. Variety (hybrids) and maturity (harvesting time) had significant effects ($P \leq 0.001$) on most of the physical characteristics except porosity. Kernel weight, kernel volume, bulk density (BD) and kernel size index (KSI) were significantly ($P \leq 0.05$) affected by location. There was significant location x maturity interaction mean squares (MS) for all characteristics except porosity and shape factor. Only kernel weight, kernel volume, true density and bulk density showed significant ($P \leq 0.05$) variety x maturity interaction mean squares. Tables 3 and 4 showed the summary of descriptive statistics and the mean results for physical characteristics of unprocessed fresh yellow maize hybrids. There was general increase in the mean values of all physical parameters as the harvesting time increased except porosity, depth and sphericity that showed a decrease at 34DAP.There were significant differences in the mean values across harvest maturity stages for Kernel weight, kernel TD, kernel size index (KSI) and hardness test. The mean values of kernel true density (Kernel TD) for all varieties across the two locations were found to be 1.09g/ml at 20DAP, 1.12g/ml at 27DAP and 1.15g/ml at 34DAP. This could be attributed to the high moisture content that increases the weight and increases the density (Arnold et al.1977). The kernel weight mean values for all varieties across the two locations were found to be 278g at 20DAP, 325g at 27DAPand 350g at 34DAP. The 1000 kernel weight was highly influenced by variety and maturity and the results found in the present study are in agreement with the findings of Moenteno (1985), Weller *et al.* (1988) and Osanyintola (1995) .They are also similar to values reported for sweet and field corn by Birchler and Hart (1985), Kang and Zuber (1989) and Osanyintola (1995). The observed varietal and maturity effects could be attributable to differential rate of accumulation of dry matter (Ingle *et al.* 1965). However, during maturity Singh *et al.* (2009) reported for dry maize that dent corn showed the highest 1000 kernel weight of 34g followed by sweet corn (21.5g), white corn (18.6g) and pop corn (16.6g). It has been observed that kernel weight peaks at 28DAP (Ingle *et al.* 1965) and 30DAP (Osanyintola, 1995) which are in close agreement with the results of this study that found kernel weight to peak at 34DAP. Kernel hardness increased with maturity and there were significant differences in the mean values for kernel hardness across the harvest maturity stages. This must be due to difference in corneous endosperm and Szaniel *et al.* (1984) indicated that the cell sizes, cell wall thickness, apart from the compactness of the cellular components, create differences observed in kernel hardness. The mean results of Kernel TD and KSI obtained for the unprocessed fresh yellow maize hybrids at different harvest maturity stages at two locations could be summarized as follows:

(i) Variety 6 had the highest kernel TD of 1.22±0.096 and KSI of 22.9±0.97 at 20DAP.

(ii) Variety 7 had the highest kernel TD of 1.16±0.042 and variety 2 had the highest KSI of 24.5±2.15 at 27DAP.

(iii) Variety 7 had the highest kernel TD of 1.21±0.024 and variety 4 had the highest KSI of 25.3±0.832 at 34DAP.

Variety 6 at 20DAP and variety 7 at 27DAP and 34DAP were the best hybrids if kernel TD is considered as an important characteristic. Variety 6 at 20DAP, variety 2 at 27DAP and variety 4 at 34DAP were the best hybrids if KSI is considered as the key physical characteristic. Endosperm texture may be responsible for the density differences of maize kernel. The data presented in this study suggest that kernel growth in maize occurs along the length and breadth axes of the kernels but not much in depth, as inferred from the steady increase in length and breadth with maturity, while depth more or less remained constant. Kernel dimensions could become simple physical characteristics enabling the identification and providing some numeric descriptors for green maize. Kernel size was reported to be an important factor of quality in sweet corn independent of succulence or solid content (Kramer, 1952). Ilori (unpublished, 1989) also reported some correlation of kernel size index with bulk density and 1000 kernel weight in sorghum. The results of kernel dimensions from the present study are important because they can be used as maturity indicator for developing maize.

Table 2: Mean squares from the analysis of variance for the physical characteristics of fresh yellow maize hybrid evaluated at two locations for two years.

	DF	kernel wt MS	Kernel vol MS	kernel TD MS	bulk density MS	porosity MS	length MS	breadth MS	depth MS	shape MS	KSI MS	hardness test MS
Location	1	5212*	2.09*	0.000	0.004**	29.5	7.68***	2.28**	0.291	0.002	23.2***	5.33
Hybrid	7	3851***	1.17**	0.011***	0.002**	38.7	1.35***	1.09**	0.684**	0.007***	3.48*	6.06***
Maturity	2	42792***	12.6***	0.029***	0.019***	32.3	16.2***	9.23***	1.27**	0.012***	57.9***	128***
Location * variety	7	531	0.157	0.002	0.003***	42.2	0.100	0.484	0.246	0.002	0.779	2.35
Location * maturity	2	9377***	2.27**	0.010**	0.007***	31.0	0.548	2.46***	0.189	0.003	5.34*	11.8***
variety *maturity	14	2218*	1.47***	0.007***	0.002**	24.6	0.143	0.252	0.322	0.001	1.07	1.66
Location * variety *maturity	14	517	0.266	0.001	0.003***	23.3	0.234	0.334	0.2111	0.001	1.13	1.16
Error		912	0.355	0.002	0.001	12.0	0.320	0.307	0.223	0.001	1.28	1.44

* * *, * *, * - Significant at P<=0.001, P<=0.01 and P<=0.05, respectively, ns -Not significant P>0.05, MS =Mean Square, DF = Degree of Freedom
Kernel TD =kernel true density, KSI = kernel size index, Kernel wt = Kernel weight, Kernel vol = Kernel Volume

Table 3: Descriptive statistics of physical characteristics of unprocessed fresh yellow hybrid maize at different harvesting time evaluated at two locations for two years.

Maturity		kernel wt g	kernel vol ml	kernel TD g/ml	bulk density g/ml	porosity	length mm	breadth mm	depth mm	shape	KSI	hardness test kg/f
20DAP	**Mean**	278c	6.40c	1.09c	0.540b	50.5a	9.21c	8.25c	4.35b	0.750a	21.8	5.28c
	Min	240	5.33	1.03	0.510	46.5	8.63	7.76	4.11	0.710	4.01	240
	Max	309	7.47	1.22	0.560	57.7	9.64	8.76	4.58	0.780	6.38	309
	LSD(0.05)	25.0	0.529	0.040	0.027	3.16	0.415	0.438	0.362	0.028	0.930	0.970
	SE	2.93	0.074	0.008	0.002	0.431	0.045	0.038	0.022	0.003	0.076	0.098
	CV (%)	1.05	1.15	0.707	0.373	0.852	0.490	0.459	0.515	0.397	0.349	1.85
27DAP	**Mean**	325b	7.26b	1.12b	0.580a	48.5b	9.77b	8.76b	4.75a	0.760a	23.3	6.95b
	Min	294	6.40	1.05	0.530	45.6	9.10	8.40	4.18	0.710	5.83	294
	Max	356	8.00	1.16	0.630	52.0	10.4	9.28	5.19	0.810	8.44	356
	LSD(0.05)	25.0	0.529	0.040	0.027	3.16	0.415	0.438	0.362	0.028	0.930	0.970
	SE	2.80	0.060	0.005	0.004	0.315	0.048	0.044	0.044	0.004	0.087	0.120
	CV (%)	0.862	0.829	0.412	0.690	0.648	0.487	0.506	0.937	0.486	0.372	1.73
34DAP	**Mean**	350a	7.62a	1.15a	0.580a	49.5ab	10.6a	9.32a	4.55ab	0.720b	24.5	9.26a
	Min	305	6.72	1.11	0.560	45.4	10.1	8.75	4.05	0.680	8.13	305
	Max	401	8.46	1.21	0.60	51.4	11.2	9.85	5.41	0.780	11.3	401
	LSD(0.05)	25.0	0.529	0.040	0.027	3.16	0.415	0.438	0.362	0.028	0.930	0.970
	SE	3.99	0.083	0.004	0.002	0.242	0.046	0.053	0.052	0.004	0.093	0.113
	CV (%)	1.14	1.09	0.362	0.339	0.489	0.430	0.572	1.14	0.508	0.380	1.22

Values with similar letters in column do not differ significantly ($p < 0.05$).
Kernel TD =kernel true density, KSI= kernel size index

Table 4: Means table of the physical characteristics of unprocessed fresh yellow hybrid maize at different harvesting time evaluated at two locations for two years.

Hybrid	maturity	kernel wt	kernel vol	kernel TD	bulk density	porosity	length	breadth	depth	shape	KSI	hardness test
		g	ml	g/ml	g/ml		mm	mm	mm			Kg/F
1	20DAP	276±15.8	6.35±0.700	1.09±0.066	0.561±0.030	48.6±4.91	9.56±0.334	8.57±0.595	4.17±0.425	0.730±0.425	22.3±0.967	6.38±0.922
2	20DAP	309±0.000	7.47±0.000	1.04±0.000	0.555±0.001	46.5±0.143	9.64±0.872	8.11±1.27	4.11±0.479	0.709±0.479	21.9±2.53	4.43±2.00
3	20DAP	287±26.2	6.51±0.564	1.10±0.030	0.535±0.027	51.5±2.39	9.11±0.573	8.25±0.783	4.45±0.167	0.763±0.167	21.8±1.00	5.83±2.31
4	20DAP	263±22.6	6.27±0.231	1.05±0.051	0.531±0.057	49.2±6.86	8.87±0.570	8.22±0.534	4.54±0.095	0.781±0.095	21.6±1.12	5.12±1.01
5	20DAP	286±0.000	6.73±0.000	1.06±0.000	0.536±0.002	49.6±0.178	9.15±0.530	8.08±0.203	4.25±0.362	0.743±0.362	21.5±0.915	5.17±0.918
6	20DAP	305±54.0	6.26±0.924	1.22±0.096	0.510±0.056	57.7±8.02	9.57±0.457	8.76±0.584	4.58±0.333	0.759±0.333	22.9±0.947	5.47±1.34
7	20DAP	261±34.7	6.30±0.467	1.03±0.056	0.525±0.012	48.7±3.93	9.14±0.891	8.24±0.246	4.23±0.070	0.766±0.070	21.6±0.921	5.87±1.91
8	20DAP	240±0.000	5.33±0.000	1.13±0.000	0.535±0.001	52.7±0.122	8.63±1.06	7.76±1.30	4.44±0.601	0.772±0.601	20.8±2.92	4.01±1.06
1	27DAP	300±31.6	7.10±0.333	1.05±0.060	0.561±0.006	46.7±2.67	9.92±0.212	8.40±0.315	4.18±0.120	0.710±0.120	22.5±0.161	7.91±0.754
2	27DAP	325±0.000	7.23±0.000	1.13±0.000	0.595±0.088	47.2±7.84	10.4±0.458	9.01±0.674	5.12±1.17	0.746±1.17	24.5±2.15	7.48±1.51
3	27DAP	311±25.4	7.15±0.346	1.09±0.062	0.575±0.056	46.9±7.74	9.10±0.423	8.50±0.099	5.19±0.611	0.810±0.611	22.8±0.852	6.78±1.23
4	27DAP	333±16.6	7.43±0.308	1.12±0.010	0.553±0.036	50.5±3.34	9.66±0.181	9.28±0.336	4.62±0.146	0.772±0.146	23.6±0.398	8.44±1.97
5	27DAP	294±0.000	6.40±0.000	1.15±0.000	0.626±0.064	45.6±5.59	9.67±0.347	8.48±0.126	4.42±0.153	0.738±0.153	22.6±0.449	5.99±0.695
6	27DAP	356±12.7	7.73±0.271	1.15±0.008	0.605±0.057	47.4±4.77	9.83±0.650	8.93±1.161	4.76±0.159	0.759±0.159	23.5±1.59	7.10±1.93
7	27DAP	328±45.3	7.05±0.712	1.16±0.042	0.558±0.012	51.9±2.25	10.0±0.536	9.11±0.614	4.63±0.328	0.750±0.328	23.7±1.12	5.83±0.591
8	27DAP	351±0.000	8.00±0.000	1.10±0.000	0.528±0.066	51.9±6.03	9.55±0.498	8.40±0.704	5.05±0.480	0.773±0.480	23.0±1.26	6.06±0.105
1	34DAP	354±21.4	8.02±0.599	1.11±0.018	0.603±0.031	45.4±3.56	11.2±0.651	9.51±0.337	4.05±0.162	0.677±0.162	24.7±0.509	11.3±1.32
2	34DAP	345±66.2	7.62±1.26	1.13±0.03	0.559±0.01	50.5±1.94	10.9±0.86	9.71±0.41	4.50±0.30	0.717±0.30	25.1±0.89	9.22±0.667

				5	3		1	4	3	3	8	
3	34DAP	309±59.3	6.72±1.45	1.16±0.054	0.562±0.039	51.4±3.52	10.1±1.11	8.92±0.353	4.34±0.225	0.727±0.225	23.4±1.19	8.81±0.673
4	34DAP	373±46.1	8.12±0.917	1.15±0.049	0.579±0.035	49.6±1.33	10.3±0.509	9.53±0.322	5.41±1.33	0.777±1.33	25.3±0.832	9.29±1.47
5	34DAP	305±66.7	6.72±1.14	1.13±0.052	0.589±0.021	48.1±0.542	10.5±0.498	8.75±0.939	4.34±0.052	0.701±0.052	23.6±1.19	8.98±1.05
6	34DAP	401±13.3	8.46±0.166	1.19±0.036	0.589±0.020	50.4±1.03	10.9±0.756	9.85±0.301	4.45±0.109	0.720±0.109	25.2±0.845	9.22±1.17
7	34DAP	350±29.1	7.23±0.514	1.21±0.024	0.593±0.020	51.0±0.900	10.8±0.394	9.49±0.512	4.41±0.059	0.711±0.059	24.7±0.877	9.16±0.659
8	34DAP	367±9.08	8.10±0.038	1.13±0.023	0.569±0.032	49.9±1.82	10.3±0.364	8.82±0.404	4.87±0.234	0.740±0.234	24.0±0.557	8.13±1.88

[a] Parameter mean value± SD

Sensory characteristics of boiled fresh yellow hybrid maize: Table 5 showed the summary of mean ratings for sensory characteristics of boiled fresh yellow maize hybrids. There was general decrease in the mean ratings for all sensory parameters across the harvest maturity stages except colour rating that increases across the harvest maturity stages. There were no statistical significant differences in the mean ratings for colour and appearance across the maturity stages. However, aroma, chewiness and taste showed significant differences in the mean ratings across the maturity stages. The overall acceptability rating showed significant difference at 20DAP and 27DAP but no differences between samples at 34DAP. Samples at 20DAP showed the highest ratings for all sensory parameters except colour. This observation suggested that the optimum harvest maturity stage to consume boiled maize hybrids is 20DAP and the overall acceptability rating was found to be 6.85, which is approximately 7 on the 9-point hedonic scale which was described as "like moderately".

Data in Table 6 showed the mean ratings of the sensory properties of boiled fresh yellow maize hybrids at different harvest maturity stages at two locations. It could be summarized as follows:

(i) Varieties 1, 3 and 5 showed higher overall acceptability ratings than the grand mean rating of 6.85 at 20DAP. Variety 1 had the highest value of 7.40±0.68.

(ii) Varieties 1, 2, 3, 6 and 7 showed higher overall acceptability ratings than the grand mean rating of 6.13 at 27DAP. Variety 1 had the highest value of 6.85± 0.93.

(iii) Varieties 1, 2, 5 and 7 showed higher overall acceptability ratings than the grand mean rating of 5.86 at 34DAP. Variety 2 had the highest value of 6.20± 1.32.

It could be concluded that variety 1 showed higher overall acceptability ratings at the three maturity stages and it is the most acceptable variety for boiled fresh yellow maize hybrids. The optimum overall acceptability for variety 1 was found to be at 20DAP. However, variety 2 had higher overall acceptability rating at 27DAP and 34DAP and the optimum overall acceptability was found to be at 27DAP.

Table 5: Descriptive statistics of sensory properties of boiled yellow hybrid maize without husk at different harvesting time evaluated at two locations for two years.

MATURITY		colour	aroma	Chewiness	taste	appearance	acceptability
20DAP	**Mean**	6.44a	6.59a	6.56a	6.83a	6.78a	6.85a
	Min	5.20	6.30	6.30	6.55	6.10	6.40
	Max	7.05	6.90	7.00	7.45	7.50	7.40
	LSD(0.05)	0.268	0.256	0.321	0.333	0.226	0.282
	SE	0.078	0.027	0.033	0.036	0.060	0.036
	CV (%)	1.21	0.410	0.498	0.524	0.883	0.532
27DAP	**Mean**	6.49a	6.21b	5.67b	5.78b	6.57ab	6.13b
	Min	5.65	5.60	5.10	5.05	6.30	5.50
	Max	7.25	6.55	6.45	6.80	6.90	6.85
	LSD(0.05)	0.268	0.256	0.321	0.333	0.226	0.282
	SE	0.063	0.040	0.051	0.082	0.028	0.061
	CV (%)	0.973	0.645	0.898	1.43	0.422	0.991
34DAP	**Mean**	6.55a	5.84c	5.19c	5.27c	6.44b	5.86b
	Min	6.00	5.35	4.80	4.55	6.10	5.45
	Max	6.90	6.40	5.95	6.20	6.80	6.70
	LSD(0.05)	0.268	0.256	0.321	0.333	0.226	0.282
	SE	0.044	0.050	0.052	0.070	0.026	0.052
	CV (%)	0.667	0.853	1.00	1.33	0.408	0.888

Values with similar letters in column do not differ significantly ($p < 0.05$).

Table 6: Means table of the sensory properties ratings of boiled yellow hybrid maize at different harvesting time evaluated at two locations for two years.

Hybrid	maturity	[a] colour	aroma	chewiness	taste	appearance	acceptability
1	20DAP	6.95±1.23	6.90±1.02	7.00±1.59	7.45±0.826	7.50±0.607	7.40±0.680
2	20DAP	5.20±1.51	6.45±1.00	6.70±1.53	6.75±1.48	6.10±1.07	6.40±1.23
3	20DAP	7.05±0.759	6.80±0.894	6.35±1.23	6.85±0.875	7.30±0.801	7.05±0.760
4	20DAP	6.65±1.18	6.30±1.08	6.35±1.31	6.55±1.28	6.80±0.951	6.80±1.01
5	20DAP	6.85±0.875	6.45±1.00	6.35=1.66	6.70±1.38	6.90±1.07	6.70±1.17
6	20DAP	6.30±1.13	6.45±1.10	6.3±1.42	6.75±0.967	6.55±0.759	6.90±1.12
7	20DAP	5.90±1.45	6.60±1.27	6.80±1.24	7.00±1.17	6.25±1.37	6.70±1.45
8	20DAP	6.65±1.46	6.80±0.834	6.65±1.09	6.60±1.39	6.85±0.745	6.85±0.930
1	27DAP	7.25±0.851	6.55±1.10	5.80±1.32	6.60±1.05	6.90±0.912	6.85±0.930
2	27DAP	5.65±1.39	6.50±0.889	6.45±1.10	6.80±0.834	6.35±0.933	6.65±0.75
3	27DAP	6.85±1.18	6.05±1.05	5.55±1.54	5.65±1.46	6.65±1.14	6.20±1.36
4	27DAP	6.80±0.951	5.60±1.47	5.25±1.80	5.05±1.70	6.55±1.36	5.50±1.57
5	27DAP	6.65±1.09	6.15±1.31	5.70±1.49	5.20±2.02	6.65±1.23	5.85±1.53
6	27DAP	6.05±1.47	6.50±1.43	5.80±1.36	6.00±1.78	6.35±1.14	6.25±1.59
7	27DAP	6.30±1.72	6.30±1.22	5.70±1.72	5.75±1.65	6.80±1.15	6.15±1.42
8	27DAP	6.35±1.09	6.05±1.00	5.10±1.71	5.15±1.76	6.30±1.22	5.53±1.22
1	34DAP	6.90±1.17	6.00±1.26	4.90±1.17	5.00±1.69	6.65±0.875	5.70±1.30
2	34DAP	6.00±1.69	6.40±0.995	5.50±1.36	5.85±1.53	6.45±1.23	6.20±1.32
3	34DAP	6.90±0.788	5.80±1.15	4.85±1.53	5.10±1.80	6.35±1.31	5.65±1.27
4	34DAP	6.75±1.07	5.45±1.10	4.80±1.54	4.80±1.67	6.40±1.14	5.60±1.31
5	34DAP	6.70±1.17	5.90±1.48	5.50±1.61	5.60±1.90	6.40±0.821	6.00±1.56
6	34DAP	6.30±1.03	5.50±1.61	4.90±2.02	5.05±2.09	6.35±1.04	5.60±1.96
7	34DAP	6.70±1.34	6.35±1.09	5.95±1.10	6.20±1.28	6.80±0.951	6.70±1.17
8	34DAP	6.15±1.27	5.35±1.76	5.10±1.55	4.55±2.21	6.10±1.02	5.45±1.93

[a] Parameter mean ratings ± SD

Pearson correlation results between Physical characteristics and Sensory properties: Table 6 showed the Pearson correlation coefficient between the physical characteristics and sensory properties of boiled fresh yellow maize hybrids. There was negative correlation between the physical characteristics and the sensory properties except colour that showed positive correlation. There was no significant (P≤0.05) correlation (P≤0.05) between all the physical characteristics and colour and appearance. This result suggested that physical characteristics showed little or no effect on the sensory ratings of colour and appearance of boiled maize hybrids but they played a key role in the ratings of aroma, chewiness, taste and overall acceptability. Kernel TD showed highly significant (P≤0.001) but and negative correlation with aroma (r= -0.56), chewiness (r = -0.675), taste (r= -0.691) and overall acceptability(r =-0.628). Kernel size index (KSI) which is an index of length, breadth and depth showed highly significant (P<0.001) and negative correlation with aroma (r= -0.496), chewiness (r= -0.678), taste (r=-0.715) and overall acceptability(r= -0.644).The highest negative correlation (r=-0.715) between KSI and taste suggested that as the length, breadth and depth increase the taste of the boiled fresh maize hybrids decreases. This might be due to decrease in total free sugars and increase in starch content as the harvesting time increases. Breadth was the key kernel dimension that mostly affected the sensory ratings of chewiness, taste and hence overall acceptability of boiled fresh cobs of yellow maize hybrids. Hardness test also showed highly significant (P≤0.001) but negative correlation with aroma (r= -0.520), chewiness (r= -0.692), taste (r= -0.736) and overall acceptability (r= -0.645).This observation suggested that as hardness increases the sensory ratings of aroma, chewiness, taste and overall acceptability decrease. It could concluded that the key sensory properties that affected by the physical characteristics were aroma, chewiness and taste. These three identified sensory properties played key role on overall acceptability of boiled fresh yellow maize hybrids.

CONCLUSION

It could be concluded that the kernel size index (KSI) increased as the maize matured for hybrid varieties and kernel growth in maize occurs along the length and breadth axes of the kernels but not much in depth. Kernel hardness increased with maturity for fresh yellow hybrid maize. The endosperm texture and composition contributed more significantly to kernel hardness and density differences in maize kernels. Variety 6 at 20DAP and 34DAP and variety 7 at 27DAP were heavier and denser kernels. Varieties 1 and 2 were the most acceptable varieties for boiled fresh yellow hybrid maize and the best harvesting time was found to be 20DAP.

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