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EFFECTS OF VARIETY AND FERTILIZER TYPE ON PHYSICO-CHEMICAL COMPOSITION OF SWEET CORN (*Zea mays* L. saccharata Sturt) KERNEL

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ABSTRACT

The sugar content of sweet corn kernel is influenced by variety and harvest time. This research investigated the effects of variety and fertilizer type on the physico-chemical composition of sweet corn kernel. The field experiment was conducted between April and June, 2024 at Agricwas Farm, Aboke village, Lagelu Local Government Area, Oyo State, Nigeria, while the post field experiment was conducted at the Department of Horticulture Laboratory, Federal University of Agriculture, Abeokuta, Nigeria. There were two factors: variety (Sugar King F1 and Royal Hybrid) and fertilizer type of Poultry manure (40 t/ha), NPK 15:15:15 (100 kg N/ha), complimentary poultry manure and NPK fertilizer (½ NPK 15:15:15 + ½ poultry manure) and No fertilizer. The experiment was arranged in Randomized Complete Block Design fitted into split plot arrangement, with three replicates. Sweet corn harvested at milk stage (65 days after planting) were placed in a plastic crate and taken to the laboratory for physico-chemical analysis. Sugar King F1 and Royal Hybrid variety of sweet corn kernel had similar moisture, dry matter, fat, ash, crude fiber, crude protein and carbohydrate contents. However, Sugar King F1 had higher total soluble solids, total Sugar and starch contents when compared with Royal Hybrid variety of sweet corn. Sweet corn kernel fertilized with ½ NPK 15:15:15 + ½ Poultry manure had the highest dry matter, crude protein, and carbohydrate contents when compared with sweet corn kernel fertilized with sole poultry manure, sole NPK 15:15:15 and no fertilizer treatments. Sweet corn kernel treated with sole poultry manure had higher total soluble solids and total sugar while the unfertilized sweet corn had the highest starch content. Variety and fertilizer type had no influence on the Light, Hue and Chroma colour values of the sweet corn kernel. Sugar King F1 kernels were sweeter than Royal Hybrid kernel; both varieties had similar colour at harvest; Sugar King F1 variety of sweet corn fertilized with 40 t/ha poultry manure were the sweetest.

Keyword: *Zea mays* var, fertilizer treatment, sweet corn kernel quality, sweetness

INTRODUCTION

Sweet corn (*Zea mays* L. saccharata Sturt.) also known as sugar corn, is a hybrid of maize (*Zea mays* L.) specifically bred to increase the sugar content (Lahay *et al.,* 2019). It originated from the United States of America and has since been introduced into many countries around the world, with increasing popularity as a favored vegetable choice. Sweet corn is consumed raw or processed (Swapna *et al.*, 2020) and considered more beneficial than field maize production due to shorter growing periods and higher cropping index which suppresses production costs and increases farmers income (Ajibola *et al.,* 2020). It differs genetically from the field maize which could be harvested when the kernels are matured and dry. However, sweet corn must be picked at the immature stage, prepared and eaten as a vegetable rather than a grain (Kumar *et al.,* 2016). It is rich in carbohydrate and sugars and contains tangible amounts of vitamins A and B3, which supports metabolism in the body as well as the nervous and digestive system. It also contains vitamin C (Kumar *et al*., 2016). Sweet corn contains ferulic acid which is an antioxidant found in the cell walls and insoluble parts of sweet corn (Swapna, 2020). Recent studies revealed that the ferulic acid can ward off diseases, cancer, diabetes, heart diseases and neurodegerative diseases such as Alzhemier (Arakelyan, 2019).

The market value of sweet corn is determined by the quality of harvest. The quality of sweet corn is decided by the contents of protein, sugar and starch in the kernels (Sahoo and Mohanty, 2020). Sweet corn is harvested at the immature milk stage of the endosperm development (18 -21 days after the initial emergence of silks, depending on environmental condition) when the kernel is soft, succulent and sweet (Abendroth *et al*., 2011; Pacjic *et al.,* 2004). It has a sugary rather than a starchy endosperm and a creamy texture. The low starch level makes the kernels wrinkled rather than plumpy (Lahay *et al.,* 2019). The cob can either be used immediately or frozen for later use since its sugar content turns quickly to starch (Pacjic *et al.,* 2004; Tracy, 2019). The sweetness of sweet corn is due to spontaneous mutation in the su ('sugary') gene of the field corn which controls the conversion of sugar into starch inside the endosperm of the corn kernel (Ramachandrappa and Nanjjapa, 2006; Swapna *et al.,* 2020). The sugar content is greater than 25% during the milking stage which has a total sugar content that ranges from 25-30% (Ramachandrappa and Nanjjapa, 2006). The local varieties have a sugar content of 9% - 11% while the hybrid varieties have a sugar content of 16 - 18% (Znidarcic, 2012). Kernels of the sweet corn taste sweeter, especially at 18 to 21 dayts after pollination (Swapna *et al.,* 2020).

The genetic make-up of the sweet corn varieties plays an important role in determing their quality at harvest. Different varieties have been bred for specific traits such as sweetness, colour and nutritional content. According to Azanza *et al.,* (2008), high sugar varieties also exhibit increased levels of certain antioxidants, contributing to their nutritional value. Yellow variety of sweet corn is typically higher in carotenoids such as lutein and zeaxanthin which are beneficial to the eye while white varieties on the other hand are preferred for their tenderness and delicate flavor (Azanza *et al.,* 2008). Application of fertilizer can impact the nutritional composition of sweet corn by influencing factors such as nutrient content, sugar levels and moisture content (Mosier *et al.,* 2004). It is therefore important to ensure balanced fertilizer application during cultivation period to enhance yield and quality. In Nigeria, it is observed that sweet corn production is very low due to low soil fertility and the optimum rate of an amendment needed to be applied (Ajibola *et al.,* 2019). Orosz *et al.,* (2009), also reported low yield in sweet corn production when no fertilizer was applied. However, the demand for sweet corn has been rising on a yearly basis due to enhanced consumption and increasing availability of food processing industries. One way of improving soil fertility and agricultural quality and quantity that is beneficial is by supplementing soil nutrient supply from organic and inorganic fertilizers, either solely or complimenrarily (Pangaribuan and Hendarto, 2018).

This study was therfore conducted to determine the effects of application of different fertilizers on the physical and chemical composition of Sugar King F1 and Royal Hybrid sweet corn varieties.

MATERIALS AND METHODS

Field management and source of plant materials

The field experiment was conducted at Agricwas Farm, Aboke village, Ibadan, Lagelu Local Government Oyo State Nigeria (Longitude 4^{o} 46'E and Latitude 7^{o} 28'N). Two varieties of sweet corn: Sugar King F1 and Royal Hybrid were used. The experimental field was ploughed, harrowed and mulched with mulching film to prevent frequent weeding. During the nursery operation, the sweet corn seeds were sown into cocoa peat in a plastic tray. The cocoa peat was soaked in water for some minutes and washed thoroughly before use. The seedlings were adequately irrigated and fertigated with Urea. At ten days after planting, the seedlings were transplanted unto the main field at a sowing depth of 50-60 cm. There were 12 experimental plots, with plot size of 5m by 4m. Spacing was 70 cm between rows and 30 cm within rows.

Four fertilizer types were utilized for the experiment: NPK 15:15:15 (100 kg N/ha) (Ajibola *et al.,* 2020), Poultry manure (40 t/ha), complimentary poultry manure and NPK fertilizer (½ NPK 15:15:15 + ½ poultry manure), no fertilizer (control). Poultry manure utilized for the experiment was obtained from a battery cage system and cured before application on the field. It was applied two weeks before planting. The first dose of NPK 15:15:15 was applied immediately after sweet corn was transplanted into the field at three weeks and the remaing half dose was applied in two equal splits at four and six weeks after transplanting (three application splits). The field was irrigated and insects were controlled with the use of Lancer®750DF (active ingredient: Acephate). The experiment was set in a Randomized complete block design fitted into split block, with three replicates. Variety was assigned to the main plot; fertilizer type assigned to sub plots.

Sample collection

Sweet corn was harvested at the milk stage (65 days after planting), early in the morning from all the treatments on the field and labelled. Harvesting was carried out in the early morning to reduce the field heat which reduces the rate of deterioration and ensures good quality of sweet corn kernels. The harvested cobs were placed in a plastic crate and transported in coolers to the Department of Horticulture Laboratory, Federal University of Agriculture, Abeokuta..

Data collection

Moisture content: Measured using air-oven following methods of Association of Official Analytical Chemists (AOAC, 2000). A material test chamber M720 (Labotec, South Africa) was used to dry an empty weighing vessel at 105 °C for 1 h (W1) and weighed (W2). The dry sample (5 g) was then poured into the vessel, oven dried at 105 ± 1 °C until constant weight was attained. This was then cooled in a desiccator, after which it was weighed (W3). The percentage moisture was calculated as:

$$\% \text{ Moisture content} = \frac{W2-W3}{W2-W1} \times 10$$

Where W1 = weight of the empty vessel. W2 = weight of the vessel + sample. W3 = weight of vessel + dried sample.

Dry matter content: 100 - moisture content. *Fat content*: Determined using Soxhlet extraction techniques (AOAC, 2005).

Ash content: Determined using a dry ashing method (Agrilasa, 2007). A porcelain crucible was dried at 105 °C for 1 h, after cooling in a desiccator, and then weighed (W1). The samples (2 g) were placed in the previously weighed crucible and reweighed (W2).The crucible with its content was then ashed first at 250 °C for 1 h at 550 °C for 5 h. (Furnace E-Range, E300-P4, MET-U-ED South Africa) and allowed to cool and the weight was taken (W3). The percentage ash was calculated as:

$$\%\text{Ash content} = \frac{W2W3}{W2W1} \times 100$$

Where W1 = weight of a dried porcelain crucible. W2= weight of the crucible + sample. W3= weight of the crucible + ashed sample.

Crude Fibre: a modification of the acid/base digestion method described by Aina *et al.* (2012) was used to determine the dietary fibre. A 5 g of sample was digested with 100 mL of 0.25 M sulfuric acid solution by boiling under reflux for 30 min and quickly filtered. The insoluble matter was rinsed four times with boiling water to remove the remaining acid. This process was repeated on the residue using 100 mL of 0.31 M sodium hydroxide solution. The final residue was washed with water until it was free of base. It was then oven-dried at 100 °C, cooled in adesiccator and weighed (C1). The weighed sample was incinerated in a muffle furnace at 550°C for 5 h, transferred to cool in a desiccator and weighed (C2). The percentage crude fiber was calculated as:

$$\%\text{ Crude fibre} = \frac{C2-C1}{\text{Weight of sample}} \times 100$$

Crude Protein: The total nitrogen amount in the sample was determined following the micro kjedahl method (AOAC, 2005).

Total Carbohydrate: Estimated by deducting the total crude protein, crude fibre, ash and lipid from the total dry matter as: %Total carbohydrate = 100 – (% Moisture content + % Total Ash + % crude fat + % crude fibre +% crude protein). Total soluble solid was measured with the use of Digital Refractometer (Model GY-1, capacity 15 x 10^5pa).

Total Sugar: 0.2 g of sweet corn flour sample was weighed into a centrifuge tube, 1 ml of 100% ethanol, 2 ml of distilled water and 10 ml of hot ethanol was added. The mixture was vortexed and centrifuge for 10 mins at 200 rpm. The supernant (sugar portion) was pipette into a test tube, 9.8 ml of the distilled water, 0.5 ml of phenol and 2.5 ml of concentrated H_2SO_4 was added and vortexed. The absorbance was read in a spectrophotometer at 490nm wave length.

$$\%\text{ Sugar} = \frac{\text{absorbance} - \text{intercept x dilution factor} \quad \text{x volume}}{\text{Weight of the sample x slope x 10,000}}$$

Total Starch: 7.5 perchloric acid was determined by added to the sediment and it was be allowed to stand for 1hr, 17.5ml of distilled water was added to it and vortexed. 0.5 ml of the solution was pipette into a test tube, 0.95 ml of distilled water, 0.5 ml of phenol and 25 ml of H_2SO_4 was added and vortexed, allowed to cool down then the absorbance was read at 490 nm in a spectrophotometer.

$$\% \text{ Total Starch} = \frac{\text{Absorbance} - \text{intercept x dilution factor x volume x 0.9}}{\text{Weight of sample x slope x 10,000}}$$

Colour: Determined with the use of colorimeter (Konica Minolta R, model CR-400/410, Netherlands) to measure colour coordinates in hunter's L*, a* and b* units. The L* represents the lightness (0 -100), black to white), a* indicates the redness (+a*) or greenness (-a*), and b* indicates the yellow (+b*) or blue (-b*) of the sweet corn kernel.

Statistical analysis

The data were subjected to analysis of variance using R Statistical Software (R Core Team, 2024) and significantly different means were separated using least significant difference (LSD) at 5% level of probability.

RESULTS

Proximate composition of sweet corn kernel as influenced by variety

The range of moisture (82.28 % to 83.22 %), dry matter (12.12 % to 17.71 %), fat (1.27 % to 1.31 %), ash (0.45 % to 0.48 %), crude fibre (1.62 % to 1.76 %), crude protein (2.52 % to 2.64 %) and, carbohydrate (11.27 % to 11.52 %) contents of Sugar King F1 and Royal Hybrid variety, respectively, were not significantly different (Table 1).

Table 1: Proximate composition (%) of sweet corn kernel as influenced by variety

Variety	Moisture	Dry matter	Fat	Ash content %	Crude fiber	Crude protein	Carbohydrate
-							
Sugar king F1	82.28	17.71	1.31	0.48	1.76	2.64	11.52
Royal Hybrid	83.22	17.12	1.27	0.45	1.62	2.52	11.27
LSD ($p<0.05$)	ns	ns	ns	Ns	Ns	Ns	Ns

Biochemical composition and colour of sweet corn kernel as influenced by variety

Sugar King F1 variety of sweet corn recorded a higher total soluble solids, total sugar and total starch contents (Table 2) when compared with the Royal Hybrid variety of sweet corn. However, the L*, a* and b* colour values of Sugar King F1 and Royal Hybrid sweet corn varieties were similar (Table 3).

Table 2: Biochemical composition of sweet corn kernel as influenced by variety

Variety	Total soluble solids (%)	Total Sugar (mmol/L)	Total Starch (g)
Sugar King F1	14.0	19.16	20.0
Royal Hybrid	13.50	17.66	18.91
LSD ($p<0.05$)	0.41	0.26	0.36

Table 3: Colour of sweet corn kernel as influenced by variety

Variety	L*	a*	b*
Sugar King F1	46.74	1.93	35.51
Royal Hybrid	46.21	1.71	33.82
LSD ($p<0.05$)	Ns	Ns	Ns

Note: L-lightness of the sweet corn kernel (0-100), a –redness (+ve) or greenness (-ve) of sweet corn, b- blueness (-ve) or yellowness (+ve) of sweet corn.

Proximate composition of sweet corn kernel as influenced by fertilizer type.

Sweet corn fertilized with complimentary poultry manure (PM) and NPK fertilizer had the highest Dry matter and Carbohydrate contents which were similar with contents from sole PM and from the unfertilized plants. Crude protein content of sweet corn fertilized with complimentary PM and NPK was also similar with sweet corn fertilized with sole PM. Dry matter and Carbohydrate contents of sweet corn fertilized with NPK when compared with other treatment combination were as lower, but the Crude protein content was only similar with contents from the unfertilized plants (Table 4).

Table 4: Proximate composition (%) of sweet corn kernel as influenced by fertilizer type

Fertilizer type	Moisture	Dry matter	Fat	Ash	Crude fiber %	Crude protein	Carbohydrate
NPK 15:15:15	84.09	15.91	1.21	0.41	1.65	2.41	10.24
PM 40 t/ha	82.15	17.86	1.35	0.49	1.73	2.59	11.70
½ NPK 15:15:15+ PM 40 t/ha	82.11	18.57	1.36	0.50	1.76	2.84	12.14
No fertilizer	82.66	17.34	1.26	0.45	1.62	2.49	11.51
LSD (p<0.05)	ns	1.69	Ns	ns	Ns	0.25	1.08

Note : Complimentary PM and NPK fertilizer (½ NPK 15:15:15+ PM 40 t/ha)

Biochemical composition and colour of sweet corn kernel as influenced by fertilizer type

Sweet corn fertilized with sole PM had the highest total soluble solids and total sugar when compared with sweet corn fertilized with sole NPK, complimentary PM and NPK, as well as the unfertilized plants. However, sweet corn fertilized with sole PM and unfertilized sweet corn kernel had the highest total starch contents when compared with sweet corn fertilized with NPK, and complentary PM and NPK (Table 5). The L* value ranged between 47.48 and 44.63), +a* (1.09 and 2.54) and b* (31.15 and 37.17) in the sweet corn kernel colour and were not significantly influenced by fertilizer type (Table 6).

Table 5: Biochemical composition of sweet corn kernel as influenced by fertilizer type

Fertilizer type	Total soluble solids (%)	Total Sugar (mmol/L)	Total Starch (g)
NPK 15:15:15	12.90	17.99	18.35
PM 40 t/ha	14.47	19.0	19.64
½ NPK 15:15:15+ PM 40 t/ha	13.75	18.21	18.68
No fertilizer	13.91	18.21	19.73
LSD (p<0.05)	0.38	0.22	0.33

Note : Complimentary PM and NPK fertilizer (½ NPK 15:15:15+ PM 40 t/ha)

Table 6: Colour of sweet corn kernel as influenced by fertilizer type

Fertilizer type	L*	a*	b*
NPK 15:15:15	44.63	1.09	31.15
PM 40t/ha	46.51	1.99	35.79
½ NPK 15:15:15+ PM 40t/ha	47.30	2.54	37.17
No fertilizer	47.48	1.25	34.53
LSD (p<0.05)	Ns	Ns	ns

Note: L- Lightness of the sweet corn (0-100), a –redness (-ve) or greenness (+ve), b –blueness (-ve) or yellowness (+ve) of the sweet corn. Complimentary PM and NPK fertilizer (½ NPK 15:15:15+ PM 40 t/ha)

Proximate composition (%) of sweet corn kernel as influenced by variety and fertilizer type

Royal Hybrid variety of sweet corn fertilized with NPK had the highest moisture content when compared with other treatment combination. Sugar King F1 sweet corn variety fertilized with complimentary PM and NPK fertilizer had the highest crude fiber content with other treatment combinations except Royal Hybrid sweet corn fertilized with NPK which recorded the least significant value. Sugar King F1 sweet corn variety fertilized with sole NPK and complimentary PM and NPK fertilizers had similar high crude protein contents with Royal Hybrid sweet corn variety fertilized with sole PM and complimentary PM and NPK fertilizers. Sugar King F1 sweet corn fertilized with sole PM recorded the highest carbohydrate content when compared with other treatment combinations. There were no significant differences in the fat, ash and crude fibre content of sweet corn as influenced by variety and fertilizer type. (Table 7).

Table 7: Proximate composition (%) of sweet corn kernel as influenced by variety and fertilizer type

Variety	Fertilizer	Moisture	Dry matter	Fat	Ash content %	Crude fiber	Crude protein	Carbohydrate
Sugar King F1	NPK 15:15:15	82.22	17.78	1.35	0.46	1.82	2.71	11.43
	PM 40 t/ha	82.93	17.07	1.34	0.51	1.76	2.47	19.98
	½ NPK 15:15:15+PM 40 t/ha	81.10	18.91	1.35	0.53	1.82	2.89	12.30
	No fertilizer	82.88	17.12	1.22	0.42	1.62	2.48	11.38
Royal Hybrid	NPK 15:15:15	85.97	14.03	1.06	0.35	1.48	2.10	9.04
	PM 40t/ha	81.36	18.64	1.36	0.49	1.70	2.71	12.43
	½ NPK 15:15:15+ PM 40t/ha	83.12	18.25	1.36	0.48	1.70	2.78	11.98
	No fertilizer	82.44	17.56	1.30	0.48	1.62	2.52	11.63
LSD (p<0.05)		2.62	2.39	Ns	Ns	Ns	0.36	1.52

Note : Complimentary PM and NPK fertilizer (½ NPK 15:15:15+ PM 40 t/ha)

Biochemical composition of sweet corn kernel as influenced by variety and fertilizer type

Sugar King F1 sweet corn fertilized with sole PM and those that received no fertilized had comparable high total soluble solids contents with Royal Hybrid sweet corn fertilized with sole PM and those that received complimentary PM and NPK fertilizers. However, Sugar Kind F1 sweet corn kernel fertilized with sole NPK, complimentary PM and NPK and Royal Hybrid sweet corn fertilizer fertilized with sole NPK and those that received no fertilized had low total soluble sugar However Sugar king F1 variety of sweet corn that receive no fertilizer had the highest total sugar and total starch content when compared with other treatment combination (Table 8).

Table 8: Biochemical composition of sweet corn kernel as influenced by variety and fertilizer type

Variety	Fertilizer	Total Soluble solid (%)	Total Sugar (mmol/L)	Total Starch (g)
Sugar King F1	NPK 15:15:15	13.60	18.94	19.23
	PM 40t/ha	14.73	18.95	20.31
	½ NPK 15:15:15+PM 40t/ha	13.20	18.45	18.95
	No fertilizer	14.40	19.41	21.54
Royal Hybrid	NPK 15:15:15	12.20	17.04	17.48
	PM 40t/ha	14.20	18.15	18.96
	½ NPK 15:15:15+ PM 40t/ha	14.30	17.98	18.42
	No fertilizer	13.33	17.50	17.92
LSD (p<0.05)		0.53	0.32	0.47

Note : Complimentary PM and NPK fertilizer (½ NPK 15:15:15+ PM 40 t/ha)

DISCUSSION

Application of fertilizers had positive effect on the growth and development of sweet corn. Nutrient release by applied fertilizers on crops depend on the type and rate of application (Mosier *et al.,* 2004). Nitrogen is a very important nutrient in the cultivation of sweet corn which influences both the yield, amino acids and determine the taste and nutrient value (Abendroth *et al.,* 2011; Abuduliah and Obaidy, 2024). Ajibola *et al.*, (2020) in their study concluded that application of NPK 100 kg/ha fertilizer type and level significantly influenced the total sugar concentration and the ether extract of sweet corn. However, sweet corn fertilized with 40 t/ha PM in this experiment recorded the highest total soluble solids, sugar content and starch. This was similar to the findings of Khandeker *et al.,* (2018) who reported that organic manure significantly increased the levels of soluble sugar, vitamin C and phenolic compounds in sweet corn kernel. Kumar *et al.,* (2016) also reported that combined application of organic fertilizer with greater nutrient release pattern and liquid organic spray provided better availability of nutrients at different stages of crop growth, with higher efficiency enhanced the growth, yield and yield components resulted in increased uptake of nutrients.

Shah *et al.,* (2017) also reported that application of nitrogen-based fertilizer increased the starch content but reduced the sugar content of sweet corn, affecting its sweetness and overall taste. In-organic fertilizers which include compounds such as urea, ammonium nitrate and superphosphate are commonly used for their immediate availability of nutrients. Sugar King F1 variety of sweet corn fertilized with complimentary PM and NPK fertilizer (½ NPK 15:15:15+ PM 40 t/ha) had the highest dry matter content and crude protein. This align with Singh *et al., (*2019) who reported that fertilizer used can also affect the soil physical and chemical properties which in turn impacts the sweet corn nutritional composition. Organic fertilizer gradually releases nutrient into the soil without been washed away by runoff or erosion while NPK fertilizers combined effect to form a nutrient amendment. The sweetness in the Sugar King F1 variety could be as a result of the breeders prefernce

Sugar King F1 and Royal Hybrid variety of sweet corn had similar moisture, dry matter, fat, ash, crude fibre, crude protein and carbohydrate contents and kernel colour which indicated that they may behave similarly during handling processes. The identical nutrient composition implies these varieties would provide same energy, macro nutrients and likely similar micronutrients, which is an important fact for dietitians, nutritionist and consumers who rely on the nutritional information for meal planning or dietary management that they are similar in nutritional compostion. However, Sugar King F1 was sweeter than Royal Hybrid which may have influence on consumers choice and marketing opportunity.

CONCLUSION

Sugar King F1 kernel were sweeter than Royal Hybrid kernel but both had similar kernel colour and proximate composition; application of 40 t/ha poultry manure produced the sweetest sweet corn kernel. Sugar King F1 variety of sweet corn fertilized with 40 t/ha poultry manure were the sweetest.

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