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ASSESSMENT OF PROXIMATE AND CURCUMIN CHEMICAL COMPOSITION OF NIGERIAN TURMERIC (*CURCUMA LONGA* L.*)* GERMPLASM

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ABSTRACT

The present research work assessed the proximate and curcumin chemical composition of 47 Turmeric accessions in the laboratory, using standard methods. Finger rhizomes samples were collected dried and grind into powder from the three replicates at harvest. This was laid out in a randomized complete block design (RCBD) on the field experiment at Nsukka, Nigeria. The results showed that Turmeric powder contains high content of total carbohydrate (68.16%), low contents of ash (2.65%), fat (5.48%), fibre (3.63%) and moisture (10.72%). Turmeric accessions NCL 58, 52, 50 and 41, differed in protein content, which ranged from 11.12 – 13.57%. Accessions NCL 32, 48, 59, 43, 46 and IBF 222, recorded the highest curcumin content, which ranged from 6.67 – 6.90% with water as solvent. Likewise, with ethanol as solvent, Turmeric accessions NCL 49, 18, 50 and 46, had high curcumin content, ranging from 6.43 – 6.67% when assayed. Fibre (-0.181*) and moisture content, had significant and negative correlation with ash and carbohydrate (-0.953**). Conclusively, Turmeric is highly nutritious and serves as a good source of value addition to food products. And, curcumin are natural phenolic compounds with potent antioxidant properties.

Key words: Turmeric, curcumin, proximate, ethanol, water, germplasm and NCL with IBF.

INTRODUCTION

Turmeric (*Curcuma longa* Linn.) is a tropical perennial monocotyledonous herb, belonging to the family Zingiberaceae (Ravindran *et al.* 2007). It's importance lie in its underground rhizome, which contains yellow coloured phenolic pigment known as Curcuminoids. This active ingredient includes curcumin – diferulylmethane, demethoxycurcumin and bismethoxycurcumin (Chaini – Wu, 2003). Curcumin is an important compound, which is responsible for the biological activities of Turmeric. And posses medicinal properties such as chemo preventive activity, cholesterol lowering and as antioxidant, anti-inflammatory, anti fungal and anti bacterial effects (Peter, 2000; Olojede *et al.,* 2009). The melting point of curcumin (C2H52OO6) is 184.2 ^{0}c. It dissolves in ethanol but insoluble in water (Joe, *et al.,* 2004). Turmeric nutrients boost the body immune system against diseases, and has high nutritional potential that has not been fully exploited (Ikpeama *et al., 2014*). Turmeric is being consumed in Africa and sub – Saharan countries, as a good source of spice and natural colouring agent for food, cosmetics and dye. Yet, the curcuma species are neglected, underutilized and termed minor root crop, grown mostly at the homestead gardens in Nigeria and wild in the Asian forests, for myriad of uses. The leaves are rich in vitamin and minerals (Chattopadhyan *et al.,* 2004). Turmeric is been use traditionally as household remedy in curing various ailments, such as anorexia, cough, rheumatism and intestinal disorder (Ikpeama *et al., 2014*). There is need to characterized the biochemical properties of Nigerian Turmeric germplasm scientifically, for industrial food and drug production. Since there is a general shift of consumer and patience preference away from synthetic / orthodox medicine to natural herbal plant, for the treatment of human ailments (Adeniji, 2004).

This study will reveal the nutritional values and curcumin content of Turmeric plant, which would be of immense benefits for captain of industries and medical practitioner to explore.

The specific objectives of this work are to:

1. Evaluate the proximate composition of 47 Nigerian Turmeric germplasm, and
2. Determine the curcumin content of the 47 Nigerian Turmeric accessions.

MATERIALS AND METHODS

A Field to Laboratory trial was established and the biochemical properties of Turmeric rhizomes were analyzed at harvest in 2013, after evaluating the yield parameters. Samples were collected at harvest from the 47 Turmeric accessions, which was laid out in a Randomized Complete Block Design (RCBD) and replicated four times. Each block contained 47 plots with 47 Turmeric accessions which gave 188 experimental plots. Proximate properties and Curcumin content were characterized in the Laboratory, according to the methods of (Pearson, 1976, A.O.A.C. 2000).

Ash content

Ash is the inorganic residue obtained by burning off the organic matter of sample at 400 - 600 ^{0}C in muffle furnace for 4 hrs. Two grammes (2 g) of the sample were weighed into a platinum crucible. The crucible was placed into muffle furnace at 400 - 600 ^{0}C for 4 h, until whitish - grey ash were obtained. The crucible was then placed in the desiccator and weighed.

$$\% \text{ Ash} = \frac{\text{wt of the ash}}{\text{wt of the sample}} \times 100$$

Moisture content

Principle

This is based on an indirect distillation method (evaporation of moisture). The amount of moisture in the sample is the loss in weight after drying in the oven at 105^{0}C until a constant weight is recorded.

Procedure

Sample (2 g) was weighed and dried in the oven at 105 ^{0}C to a constant weight. The dishes and sample were cooled and weighed. The moisture content was then calculated from the equation below.

$$\%\text{Moisture} = \frac{\text{wt of sample + dish before drying} - \text{wt of sample + dish after drying}}{\text{wt of sample taken}} \times 100$$

Fat determination

Principle

The sample was continuously extracted with petroleum ether, using an extraction apparatus. After extraction, the petroleum ether was evaporated to dryness and the residue designated the petroleum ether extract. This was referred to as the fat portion of the sample. Procedure An anhydrous diethyl ether (petroleum ether) (150 ml) of boiling point of 40 - 60 ^{0}C was placed in the flask. Sample (2 g) was weighed into a thimble and the thimble was plugged with cotton wool. The thimble with content was placed into the extractor; the ether in the 2 flasks was then heated. As the ether vapour reached the condenser through the side arm of the extractor, it condensed to liquid form and drop back into the sample in the thimble, the ether soluble substances were dissolved and were carried into solution through the siphon tube back into the flask. The extraction continued for 4 h. The thimble was removed and most of the solvent was distilled from the flask into the extractor. The flask was then disconnected and placed in an oven at 65 ^{0}C for 4 h, cooled in a desiccator and weighed.

$$\%\text{Fat} = \frac{\text{wt of flask + extract} - \text{tare wt of flask}}{\text{Wt of sample}} \times 100$$

Crude fibre

Principle

This is insoluble and combustible organic residue which remains after the sample has been treated under prescribed condition. The most common conditions are consecutive treatments with light petroleum ether boiling dilute sulphuric acid, boiling dilute sodium hydroxide, dilute hydrochloric acid, alcohol and ether. This treatment provides a crude fibre consisting largely of the cellulose content together with a proportion of the lignin and hemicelluloses content of the sample.

Procedure

The defatted sample (2 g) was transferred into 500 ml flask / beaker and 200 ml of pre - heated 1.25 % H_2SO_4 was added and the solution was gently boiled for 30 mins, maintaining constant volume of acid by the addition of hot water. Residue was washed three times with hot water and returned to the beaker. Then 200 ml of pre - heated 1.25 % Na_2OH was added and boiled for another 30 min. This was filtered under suction and washed thoroughly with hot water and twice with ethanol. The residue was dried at 65 ^{0}C for about 24 h and weighed. The residue was transferred into a crucible and placed in muffle furnace (400 - 600 ^{0}C) and ashed for 4 h. It was then cooled in a desiccator and weighed.

$$\%\text{Crude fibre} = \frac{\text{Dry wt of residue before ashing} - \text{wt of residue after ashing}}{\text{wt of sample}} \times 100$$

Protein determination

Principle

The crude protein content was determined using the micro - Kjeldhal method. The method is based on the wet combustion of the sample by heating with concentrated sulphuric acid in the presence of metallic and other catalysts to effect the reduction of organic nitrogen in the sample to ammonia, which is retained in solution as ammonium sulphate. The digest having been made alkaline, is distilled to remove ammonia which is trapped and titrated.

Procedure: This involves three major steps.
Digestion: sample (2 g) was weighed inside Kjeldhal digestion flask and 25 ml of concentrated sulphuric acid, 0.5 g of copper sulphate, 5 g of sodium sulphate and a speck of selenium tablet was added. Heat was applied in a fume cupboard slowly at first to prevent undue frothing. Digestion continued for 45 min until the digest became clear pale green. This was left until completely cool. Distilled water (100 ml) was added.

Distillation: Markham distillation apparatus was used for distillation. The distillation apparatus was heated and 10 ml of the digest was added into the apparatus via a funnel and allowed to boil. Sodium hydroxide (10 ml) of 50 % was added from the measuring cylinder so that ammonia was not lost. This was distilled into 50 ml of 2 % boric acid containing screened methyl red indicator.

Titration: The alkaline ammonium borate formed was then titrated directly with 0. 01N HCl. The titre value which is the volume of acid used was recorded.

$$\% \text{ protein} = \frac{\text{Titrex 0.01N HCl x 14.01(At.utN)}}{\text{x100 x 50 x 100}} \over \text{1000 x 0.5 g x 10}$$

Carbohydrate determination
Carbohydrate was determined by mathematical calculation. It was obtained by subtracting the sum of percentages of all the nutrients already determined from 100.
% Carbohydrate = 100 - (% Ash + % Moisture + % Fat + % Protein + % Fibre)
Carbohydrate is an easily utilizable non-nitrogenous substance in sample.

Determination of curcumin (%) using visible spectroscopic method - by Soni, *et al.,* (2011).
0.1 gm of dried extract was dissolved in 25 ml of ethanol. This solution was filtered and volume made upto 100 ml. Then 10 ml of above solution was taken in volumetric flask and again volume made upto 100 ml with ethanol. The absorbance was measured at 425 nm and curcumin was determined.
A standard curcumin 0.25 g litre^{-1} give absorbance at 425 nm = 0.42.
Absorptivity of curcumin (A) = 0.42 / 1 x 0.025 = 16.8
% Curcumin = a x 100 / L x A x W
Where, a = absorbance of sample at 425 nm
L = path length (1cm)
A = Absorptivity

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determine the Means and Percentages. Also, analysis of variance (ANOVA), is done to identify differences between means, according to the procedure outlined for RCBD experiment, using GenStat Release 7.22 Discovery Edition 3(2008). The treatment Means was compared using Fisher's protected Least Significant Difference (F-LSD) test at the 5% level of probability as outlined by Obi (2002).

RESULTS

Proximate composition (%) of 47 Turmeric accessions in Nigeria
The characteristics of 47 Turmeric characters evaluated based on chemical composition is shown in Table 1. Characters such as ash, with the highest mean value of 3.15%, carbohydrate (71.44%), and fat (6.03%), differed non significantly ($p > 0.05$) among the accessions. Fibre differed significantly ($p < 0.01$) among the accessions. With accession NCL 26 recording the highest mean value of 3.64%, this is similar statistically with NCL 63 and 30 (3.39% and 3.35%). But, NCL 27 recorded the least mean value of 2.63%. Also, protein differed significantly ($p < 0.01$) among the accessions. Accessions NCL 44, 30 and 50, which ranged from 13.28 – 13.58% had the highest mean values, while accessions NCL 21 and 22 recorded the lowest mean value of 10.95%. Coefficient of variation was 10.10%.

Characterization of 47 Turmeric accessions for Curcumin content at Nsukka
The evaluation for curcumin content of 47 Turmeric rhizome accessions in Table 1, revealed that Curcumin in ethanol differed non significantly ($p > 0.05$) among the accessions. However, accessions NCL 49, 18, 50 and 46 recorded the highest curcumin values range of 6.43 – 6.67%. But, NCL 61 and 37 had lower curcumin content of 5.12 – 5.20. Also, curcumin in water did not differ significantly ($p > 0.05$) among the accessions. However, accessions NCL 32, 48, 59, 43, 46 and 1BF 222, recorded the highest curcumin values. This range from 6.67 – 6.90%, while NCL 12, 25, 14, 20 and 28, which ranged from 5.00 – 5.25% had lower curcumin content values.

Linear correlation matrix for proximate qualities of 47 Turmeric accessions at Nsukka
Correlation studies on six biochemical properties in Table 2 revealed that ash had a significant and negative relationship with fibre (-0.181*), but non significant with fat (-0.040), moisture (-0.116) and protein (-0.156), while positively correlated with carbohydrate (0.102).

Table 1: Proximate and Curcumin chemical composition (%) of 47 Turmeric accessions in Nigeria

Accession	Ash	Carbohydrate	Fat	Fibre	Moisture	Protein	Curcumin	
							Water	**Ethanol**
NCL30	2.71	72.93	5.97	4.03	9.57	9.59	6.31	5.42
IBF222	2.79	68.08	5.65	3.03	10.58	9.86	6.79	5.87
NCL37	2.74	68.75	5.43	3.74	10.25	9.09	5.95	5.20
NCL60	2.43	68.57	5.49	3.61	10.24	9.65	6.67	5.60
NCL4	2.50	67.82	5.60	3.33	0.42	10.32	5.95	5.95
NCL41	2.60	67.42	5.49	3.54	9.84	11.12	5.95	6.28
NCL23	2.56	67.63	5.42	3.83	10.86	9.70	5.95	5.78
NCL48	2.63	68.70	5.52	3.66	9.67	9.82	6.43	5.60
NCL17	2.66	70.55	5.55	3.74	10.74	10.15	6.55	5.72
NCL14	2.59	71.08	5.54	4.02	9.77	10.50	5.24	5.79
NCL38	2.47	67.40	5.27	3.40	10.29	10.17	6.55	6.15
NCL50	2.73	67.05	5.50	3.75	9.50	11.47	6.19	6.35
NCL63	2.58	68.22	5.38	4.70	9.54	10.17	5.95	5.66
NCL35	2.58	69.17	5.27	3.14	10.43	9.41	6.19	5.55
NCL20	2.42	68.07	5.20	3.61	10.83	9.88	5.24	5.59
NCL6	2.80	68.50	5.47	3.54	8.96	10.71	6.55	5.44
IBF111	2.62	68.73	5.66	3.36	3.36	9.84	6.55	6.19
NCL27	2.71	70.01	5.39	2.94	9.17	9.19	5.71	5.83
NCL19	2.68	66.96	5.89	3.92	10.44	10.10	5.36	5.54
NCL34	2.79	67.93	5.62	3.49	10.86	9.31	6.43	6.23
NCL49	2.59	67.17	5.57	4.06	10.61	10.00	6.19	6.35
NCL55	2.71	71.88	4.77	3.78	10.37	9.74	5.95	5.91
NCL39	2.69	66.83	6.03	3.70	10.66	10.09	5.71	5.40
NCL13	2.65	67.66	5.83	3.52	10.57	9.77	5.48	6.27
NCL43	2.62	71.76	5.48	4.11	9.45	9.86	6.79	5.60
NCL61	2.31	68.53	5.33	3.72	10.31	9.80	6.07	5.12
NCL46	2.80	69.35	5.42	3.43	9.36	9.65	6.90	6.67
NCL16	2.76	67.68	5.40	3.95	10.67	9.54	5.95	5.79
NCL28	2.59	67.88	5.93	3.70	10.38	9.52	5.24	5.99
NCL32	2.57	68.04	5.43	3.33	10.89	9.74	6.67	5.95
NCL12	2.76	69.78	5.38	3.54	8.88	9.67	5.00	6.07
NCL44	2.56	78.21	5.06	3.79	10.39	9.58	5.95	5.79
NCL26	2.33	67.40	5.39	4.45	10.98	10.20	6.31	5.91
NCL5	2.63	67.16	5.80	3.88	10.57	9.96	5.95	5.71
NCL59	3.10	68.97	5.70	3.19	9.42	9.62	6.67	5.60
NCL47	2.86	69.19	5.37	3.81	9.35	9.41	6.43	5.60
NCL24	2.62	67.20	5.74	3.76	11.38	9.31	5.60	5.42
NCL25	2.55	72.18	5.08	2.98	10.46	10.13	5.00	5.60
NCL42	2.55	68.07	5.53	3.90	10.15	9.81	5.60	6.07
NCL29	2.54	68.13	5.37	4.00	9.84	10.35	5.48	6.19
NCL45	2.61	68.50	5.44	3.63	10.00	9.82	6.19	5.56
NCL18	3.19	66.70	5.58	3.17	11.24	10.12	5.95	6.43
NCL36	2.66	67.77	5.92	3.61	10.55	9.49	6.19	5.64
NCL52	2.50	70.00	4.00	2.95	7.40	12.00	6.19	5.84
NCL22	2.63	68.01	5.26	3.94	11.09	9.07	5.60	5.95
NCL58	2.76	63.40	5.53	3.63	11.12	13.57	5.89	5.52
NCL21	2.70	67.24	5.92	3.35	10.88	9.51	6.55	5.96
Mean	2.65	68.16	5.48	3.63	10.72	9.99	6.01	5.84
F-LSD	ns	ns	ns	***	ns	**	ns	ns
(p<0.05)				0.68		1.71		
C V (%)	10.50	13.50	9.10	11.60	81.60	10.50	-	12.97

Note: ***, ** Significant at 1% and 5% level of probabilities, ns = not significant at (P > 0.05). NCL = Nigerian Curcuma longa accession number, was named by the National Root Crop Research Institute (NRCRI), Umudike. IBF = Ibadan Finger.

Table 2: Linear correlation matrix among proximate composition of 47 Turmeric accessions

Traits	**Ash**	**Carbohy drate**	**Fat**	**Fibre**	**Moisture**	**Protein**
sh	1	.102	-.040	-.181*	-.116	-.156
Carbohydrate		1	-.038	.077	-.953**	-.155
Fat			1	.011	-.042	.091
Fibre				1	.005	.055
Moisture					1	.046
Protein						1

Note: *, ** = Significant @ p< 0.05 and 0.01 levels (2 - tailed) respectively. n = 47.

Moisture content had a highly significant and negative relationship with carbohydrate (-0.953**), but insignificant with ash (-0.116) and fat (-0.042). But, it had a positive correlation with fibre (0.156).

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with ash (-0.156) and carbohydrate (-0.155). While positive correlation existed with fat (0.091), fibre (0.055) and moisture content (0.046).

DISCUSSION

Proximate properties (%)

Turmeric contains good nutritional and chemical composition, which will be of immense benefit for value addition in food products needed for body growth, and boost the immune systems against various ailments. The results of the proximate analysis, implies that Turmeric is a rich source of protein (13.58%), carbohydrate (71.44%), ash (3.15%), fat (6.03%), fibre (3.64%) and moisture content of 9.72%. This work is in line with that of Ikpeama, *et al.* (2014), who reported 9.42% crude protein, carbohydrate (67.38%), ash (2.85), fat (6.85%), crude fibre (4.60%) and 8.92% moisture content. While, Mane, *et al.* (2018) in his studies, reported lower values of protein (1.20%), carbohydrate (9.10%), ash (0.66%), fat (1.08%), fibre (0.72%), but higher moisture content of 84.24%, with acidity (0.70%), pH (5.7) and high curcumin content of 5.1%, respectively. The carbohydrate content of 71.44% in this study corroborate with that of Ikpeama (67.38%), and is higher than that of *Acalypha racemosa* (45.26 %) and *Acalypha marginata* (38.24 %), which are known medicinal plants. However, the crude fibre, crude protein and ash (3.64%, 13.58% and 3.15%) of Turmeric, are lower than that of *Acalypha racemosa* (7.20 %, 16.19 % and 13.14 %) and *Acalypha marginata* (10.25 %, 18.15% and 10.32 %) respectively (Iniaghe *et al.*, 2009, Ikpeama, *et al.*, 2014). The ash content of 3.15% in Turmeric shows that it will contain reasonable amount of mineral. The 3.64% fibre presents in turmeric, will help the body to absorb excess cholesterol and cleanse the digestive tract of its consumer by removing potential carcinogens. Fibre also, adds bulk to the food and prevents the intake of excess starchy food. This could guard against metabolic conditions such as diabeties mellitus and hypercholesterdemic (Bamishaiye *et. al*., 2011, Ikpeama, *et al.*, 2014).

Curcumin content

The curcumin content in Turmeric leave and rhizome, are used widely for imparting aroma and yellow colourations in variety of food products. In this study, accessions NCL 49, 18, 50 and 46 recorded the highest curcumin values range from 6.43 – 6.67%, using ethanol as solvent. Work on curcumin content had been reported by several authors. Manjunathgoud, (2002) found that spacing of 30 x 45 cm enhanced maximum curcumin content. Chiu, *et al.* (1993) reported that curcumin content differed significantly in mother rhizomes (5.5%) as compared to 4.9% from finger rhizome. kha, *et al.* (2018) reported lower range of curcumin content of 3.76 – 5.05%. Higher curcumin content of 7.73% was extracted and reported by Vikramsinh, *et al.*(2013), while 9.3% came from two clones PTS - 10 and PTS - 24 released from India (FAO, 2014). And, Edapalayan cultivar recorded 10.9% (Zachariah, *et al.,* 1999). The relative reduction in curcumin content in some genotypes can be attributed to accumulation of starch and fibre (Zachariah, *et al.,* 1999). The linear correlation matrixes showed significant and negative correlation between the proximate parameters. The improvement of the biochemical characters, results in simultaneous high value of all the related characters.

CONCLUSION

The data recorded that Turmeric rhizomes had high amount of Protein (13.58%) and Curcumin content (6.67%). Turmeric contains good nutritional and chemical composition, which will be of immense benefit for value addition in food products needed for body growth. Curcumin, a potent antioxidant of the herb can be use in the development of pharmaceutical industries as a therapy against various diseases. The results of the study support the development of new drugs from the plant.

Recommendation

For Curcumin, Turmeric accessions NCL 49, 18, 50 and 46, which recorded the highest Curcumin contents of 6.43 – 6.67%. And, Protein with accessions NCL 44, 30 and 50, which had the highest mean values of 13.28 – 13.58%, are selected for commercial cultivation. The identified Turmeric accessions will be of immense benefits to medical health practitioners, nutritionists, researchers and captains of industries in drug production.

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REFERENCES

A.O.A.C. (2000). Official Methods of Analysis. Association of Official Analytical Chemists, Washington D.C. Adeniji M.O. (2004) Herbal Treatment of Human diseases. pp 82.

Bamishaiye E.I; Olayemi F.F, Awagu E.F. and Bamshaiye O.M. (2011). Proximate and phytochemical composition of moringa oleifera leaves at three stages of maturation. Advance Journal of Food Science and Technology **3(4),** 233 – 237.

Chainani-Wu, N. (2003). Safety and anti-inflammatory activity of curcumin : a component of turmeric (*Curcuma longa*). Journal of Alternative and Complement medicine **9,** 161-168.

Chattopadhyan L., Biswas K., Bandyo-Padhyay U. and Banerjee R.L. (2004). Turmeric and Curcumin: Biological Action and Medicinal Applications. Current Science **87,** 44 - 53.

Genstat (2005) Genstat 3.0 Release 4.23 DE. Discovery Edition, Iawes Agricultural Trust, Rothmanisted Experimental station, Nk.

Ikpeama *et al.* (2014). Nutritional composition of Turmeric (*Curcuma longa*) and its Antimicrobial properties. International Journal of Scientific and Engineering Research, **Vol. 5,** Issue 10.

Iniaghe O.M., Malomo S.O. and Adebayo J.O. (2009). Proximate composition and phytochemical constituents of leaves of some acalypha species. Pakistan Journal of Nutrition **8,** 256 - 258.

Joe B.M., Vijaykumar, M and Lokesh, B.R. (2004). Biological properties of curcumin- cellular and molecular mechanisms of action. Critical Reviews in Food Science and Nutrition **44,** 97:111

Pearson D. (1976). Roots and Rhizomes. The Chemical Analysis of Foods 7th Edition. Edinburgh Churchil living stone. p. 319-323.

Peter K.V. (2000). Informatics on Turmeric and Ginger. India Spices **36 (2 and 3),** 12 - 14.

Ravindran P.N, Nirmal, B.K, Sivaraman, K (2007). The golden spice of life. In: Turmeric. The Genus Curcuma. Boca Raton, FL, USA: CRC Press; p. 1-14.

Soni H, Patel Sita Shara (2011). Quantitative and Qualitative Profile of curcumin from ethanolic extract of *Curcuma longa*. International Research Journal of Pharmacy. **2 (4),** p. 180-184.

Lu Y.L.; Yan J., Guimarães C.T., Taba S., Hao Z., Gao S., Chen, S., Li, J., Zhang S., Vivek B.S., Magorokosho C., Mugo S., Makumbi D., Parentoni S.N., Shah, T., Rong T., Crouch J.H. and Xu Y. (2009). Molecular characterization of global maize breeding germplasm based on genome-wide single nucleotide polymorphisms. *Theoretical and Applied Genetics*, **120 (1),** 93-115.

Manggoel W. and Panwal E.F. (2009). Preliminary Evaluation of 20 Elite Varieties of Cowpea at Markudi, Nigeria. *Gindiri Educational Forum: Journal of COEASU*, 1, 105-116.

Manggoel W., Uguru M.I., Ndam O.N. and Dasbak M.A. (2012). Genetic variability, correlation and path coefficient analysis of some yield Components of ten Cowpea *(Vigna unguiculata* (L.) Walp*)* accessions. *Journal of Plant Breeding and Crop Science,***4 (5*), 80-86*** http://www.academicjournals.org/jpbcs

Obi I.U. (2002). *Statistical Methods of Detecting Differences Between Treatment Means and Research Methodology Issues in Laboratory and Field Experiments.* AP Express Publishers Ltd., Nsukka.117pp.

Olaiya A.O., Oyafajo A.T., Atayese M.O., Bodunde J.G. (2019).Field evaluation of extra early maize varieties in two agro ecological zones of Nigeria.*Biodiversity International Journal,* **3 (4),** 156–160

Sorsa Z. and Kassa M. (2015). Evaluation of Yield Performance and Variation on its Adaptation-Related Traits of Quality Protein Maize (QPM) (Zea mays L.) Varieties at Selected Woredas of Wolaita Zone, Ethiopia. *International Journal of Plant Breeding and Genetics* **9 (4),** 255-261

USDA (2015). Crop production historical track records. National Agriculture Statistics Service, Washington, DC.

WAAPP (2014). Extension Bulletin of Maize Production, Marketing, Processing and Utilization. Extension Bulletin No. 217. Published by National Agricultural Extension Research Liaison Services, pp.3.