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PRINCIPAL COMPONENT ANALYSIS OF BODY MEASUREMENTS IN TWO GENOTYPES OF CHICKENS FED GRADED LEVELS OF *Moringa oleifera* SEED MEAL

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ABSTRACT

This study was conducted to explore the interrelationship among body measurements in two genotypes of chickens (Yoruba ecotype chickens and Marshall broiler chickens) fed graded levels of *Moringa oleifera* seed meal (MOSM) using principal component analysis with the view of identifying those components that drive body conformation in local and exotic chickens. A total of 192 birds were used, 96 birds per genotype. The parameters measured at 8 weeks of age were body weight, thigh length, wing length, shank length, body length, keel length and body girth. Principal component analysis with variance maximizing orthogonal rotation was used to extract the components. Six principal components were extracted when all the birds were considered irrespective of genotypes which explained 84.153% of the total variation in the original. Twelve principal components each were extracted for Yoruba Ecotype Chickens (YEC) and Marshall broiler chickens accounting for 85.029% and 82.523% of the total variance respectively. Generally, PC1 had the largest share of the total variance and correlated highly with body weight, thigh length, body girth, wing length, thigh length, shank length and body length. PC1 was termed the generalized form of broilers as it loaded heavily on body weight at weeks 4 and 8 while it loaded heavily on thigh length at weeks 4 and 8 for YEC. PC2 had its loadings in Marshall broilers on thigh length at week 8 while it loaded on body girth at weeks 4 and 8 for YEC while PC3 had positive loading on keel length at week 8 for YEC. The diet significantly influenced the performance of the birds per genotype as the responses were different to the diet hence the divergence of the genotype from each other despite the utilization of the same feed ingredients. These components could be used as selection criteria for improving body size of Marshall broilers and YEC as well as in determining feed utilization and response of Marshall broilers and YEC.

Keywords: Genotype, Marshall broilers, Linear traits, Variation and Yoruba Ecotype Chickens

INTRODUCTION

For effective livestock characterization as it relates to different genotypes, the evaluation of body size and conformation are highly important as reported by Ibe (1989). Morphometric or qualitative analyses of form, structure, shape and size of an animal were reported useful in contrasting size and shape of animals (Ajayi *et al.*, 2008). Morphometric indices would also point to the potentials of some body parts and the impact of genotype on these parameters when fed graded level of *Moringa oleifera* seed meal (MOSM).

Linear traits such as shank length is a good indicator of leg development while body girth is an indicator of breast development. The effect of MOSM on body parameters was necessary as it is established that diets influenced the phenotypic expressions of different genotypes of chickens (Akintunde and Toye, 2014; Akintunde *et al.*, 2019). Akintunde *et al.* (2019) also confirmed genetic differences in the response of Marsahll broilers and Yoruba ecotype chickens as it relates to their haematological parameters in their utilization of graded levels of *Moringa oleifera* seed meal. However, body weight of chicken is a phenotypic expression of their genetic make-up under prevailing environmental condition and feeding regime. It is established that body weight play a pivotal role in the marketability of chickens. Variations in the body weight within a flock can be ascribed to variation in the genetic make-up and environmental condition (diet composition/quality inclusive) (Fayeye and Owoeye, 2016).

However, it is useful to examine genotypic variations by the use of dimension reduction tools in which the growth performance is pivotal in determining the genotypic response to MOSM inclusion. The study is aimed at determining the levels of similarities or differences between the two genotypic groups to dietary inclusion of MOSM using body weight and body linear traits of Yoruba ecotype chickens and Marshall broilers.

MATERIALS AND METHODS

The study was carried out at the Livestock Section of the Teaching and Research Farm of the Federal College of Animal Health and Production Technology, Moor Plantation, Ibadan. The city has coordinates of 70 24' 7.0632'' N and 30 55' 2.3268'' E. The vegetation is tropical rainforest: It has a tropical wet and dry climate with a lengthy wet season and relatively constant temperature throughout the year. The mean total rainfall for Ibadan is 1420.06 mm while the mean maximum temperature is 26.46 ^{0}C, minimum 21.42 ^{0}C and the relative humidity is 74.55%.

The study utilized 192 chickens made up of Yoruba Ecotype Chickens and Marshall Broilers fed various levels of Moringa oleifera diets. The experiment lasted for eight weeks Principal component analysis of fifty seven original variables was conducted. Moringa oleifera seed was added to the diet at levels of 0, 5, 10 and 15%. Birds were fed diet in the morning, water was supplied ad lib.

Data collected weekly on body weight, body girth, body length, thigh length, shank length, keel length and wing length were used to estimate the principal component analyses effect for body weight and morphometric indices in Yoruba Ecotype Chickens and Marshall Broilers as well as the overall effect on graded levels of MOSM for a period of eight weeks.

Linear body measurements - shank length (SL), thigh length (TL), keel length (KL), chest girth (CG), wing length (WL) and body length (BL) were determined.

Body Weight (BW): Body weight in gram (g) was recorded to two decimal places weekly using a sensitive weighing scale.

Body Length (BL): This was taken as the nostril to the pygostyle distance measured in centimeter (cm) units when a tape is stretched from the bird's nasal opening along its stretched neck and along its back to the tip of pygostyle.

Chest Girth (CG): This was measured in centimeter (cm) as the circumference when a tape is looped round the region of the breast, care was taken to ensure that the tape was run under (rather than over) the wing.

Shank Length (SL): This was taken as the distance in centimeter (cm) between the foot pad and the hock joint, measured by use of a set of Venier Calliper.

Thigh Length (TL): This was taken as distance between the tip of the tarsus and the ball joint, measured in centimeter (cm) by use of a tape measure.

Keel Length (KL): This was taken as the distance between the cranial and caudal termini of the keel bone, measured in centimeter (cm) by use of a tape measure.

Wing Length (WL): This was taken as the distance from the humerus-coracoid junction to the distal tip of the phalange digits and was measured in centimeter (cm) using a tape measure.

Statistical Analysis

Pearson's coefficients of correlation were first estimated for all the traits measured in the study. This was followed by principal component (PC) analysis. Cumulative proportion of variance criterion was employed in determining the number of PCs to extract. The factor matrix was rotated using the varimax criterion for easy interpretation of the PC analysis, which reliability was tested using the Kaiser–Meyer–Olkin (KMO) measure of sampling adequacy and Bartlett's Test of Sphericity.

Pearson correlation coefficients among the body measurements were calculated for each genotype of birds and each level of MOSM inclusion and the correlation matrix which was the primary data required for PCA generated. Bartletts test of sphericity was used to test if the correlation matrix was an identity matrix (each variable correlated with itself) or a correlation matrix full of zero. The suitability of the data set to PCA was further tested by KaiserMeyer-Olkin (KMO) measure of sampling adequacy. This tested whether the partial correlations among variables were small. A KMO measure of 0.60 and above is considered adequate (Eyduran *et al.*, 2010). Everitt *et al.* (2001) defined principal component analysis as a method of transforming variables in a multivariate data set, x_1, x_2, ……..x_p into new uncorrelated variables y_1, y_2,……….y_p which account for decreasing proportions of the total variance in the original variables defined as:

$y_1=a_{11}x_1+a_{12}x_2+ \ldots\ldots + a_{1p}x_p$.

$y_2=a_{21}x_1+a_{22}x_2+\ldots\ldots + a_{2p}x_p$.

$y_p=a_{p1}x_1+a_{p2}x_2+\ldots\ldots + a_{pp}x_p$.

The principal components y_1, y_2…….y_p account for decreasing proportions of the total variance in the original variables x_1, x_2,……x_p. Variance maximizing orthogonal rotation was used in the linear transformation of the factor pattern matrix in order to make the interpretation of the extracted principal components easier. The principal components analyses were performed using the factor program of SPSS 22 statistical package (SPSS, 2012)

RESULTS

Principal component analysis of fifty seven original variables in 192 chickens revealed that six principal components contributed significantly (Eigen value ≥1) to variation in the examined data (Table 1), collectively explaining 84.153% of the overall variation. PC1 accounted for over half (67.407%) of total variance while PC2, PC3, PC4, PC5 and PC6 accounted for the successively lower proportions of the explained variance.

As shown in Table 1, communalities in the whole of the experimental birds ranged between 0.690 and 0.930. PC1 had high loadings (correlations between the components and the variables) on body weights at week 4 while PC2 loaded heavily on wing lengths at week 4.

Table 1: Analysis showing the Principal Components extracted and their communalities irrespective of diet

Principal Component/Trait	1	2	3	4	5	6	Communalities
BW0	0.546	0.371	0.384	0.35	-0.172	0.017	0.736
BW4	0.887	0.346	0.109	0.052	0.157	-0.035	0.946
TL_4	0.293	0.842	0.052	-0.001	0.072	0.191	0.839
WL_4	0.309	0.84	0.029	0.099	0.248	-0.011	0.874
SL_4	0.388	0.778	0.256	0.217	0.065	-0.029	0.874
BL_4	0.64	0.619	0.199	-0.07	0.129	0.079	0.86
KL_4	0.592	0.456	0.07	0.445	0.188	0.113	0.809
BG_4	0.698	0.565	0.025	0.062	0.054	-0.032	0.815
TL_8	0.594	0.655	0.151	0.111	0.135	0.126	0.852
WL_8	0.535	0.669	0.045	0.316	0.111	0.013	0.847
SL_8	0.735	0.468	0.26	0.177	0.064	-0.009	0.863
BL_8	0.666	0.556	0.181	0.027	0.186	-0.013	0.821
KL_8	0.755	0.259	0.196	0.41	0.012	0.131	0.861
BG_8	0.827	0.421	0.1	0.161	0.084	0.039	0.906
Eigen Value	38.421	3.217	2.402	1.551	1.328	1.048	
% of Variance	67.406	5.644	4.214	2.721	2.33	1.839	
Cumulative %	67.406	73.05	77.264	79.984	82.314	84.153	

%= Percentage, PC= Principal component, TL = Thigh Length, WL = Wing Length, SL = Shank Length, BL = Body Length, KL = Keel Length, BG = Body Girth, BW = Body Weight

Figure 1 shows the results from the Principal component indices that the genotype did not influence the linear traits. . It was observed that the effect of diet (MOSM) on the linear traits were similar in both genotypes

Figure 2 shows the effects of diet on linear indices of broiler chickens. It was observed that the effect of diet (MOSM) on the linear traits were similar in both genotypes.

Figure 3 shows that the level of MOSM diet did not influence ($p>0.05$) the Linear traits in YEC. results shows that for most of the traits, the effect of 0% MOSM and 5% MOSM inclusion were similar while the chickens fed 10% and 15% MOSM were significantly different from 0% and 5% MOSM inclusion group.

Figure 4 above showed that the inclusion of MOSM at 15% had much effect on the body weight and Linear traits of Marshall Broilers when compared with other levels of inclusion.

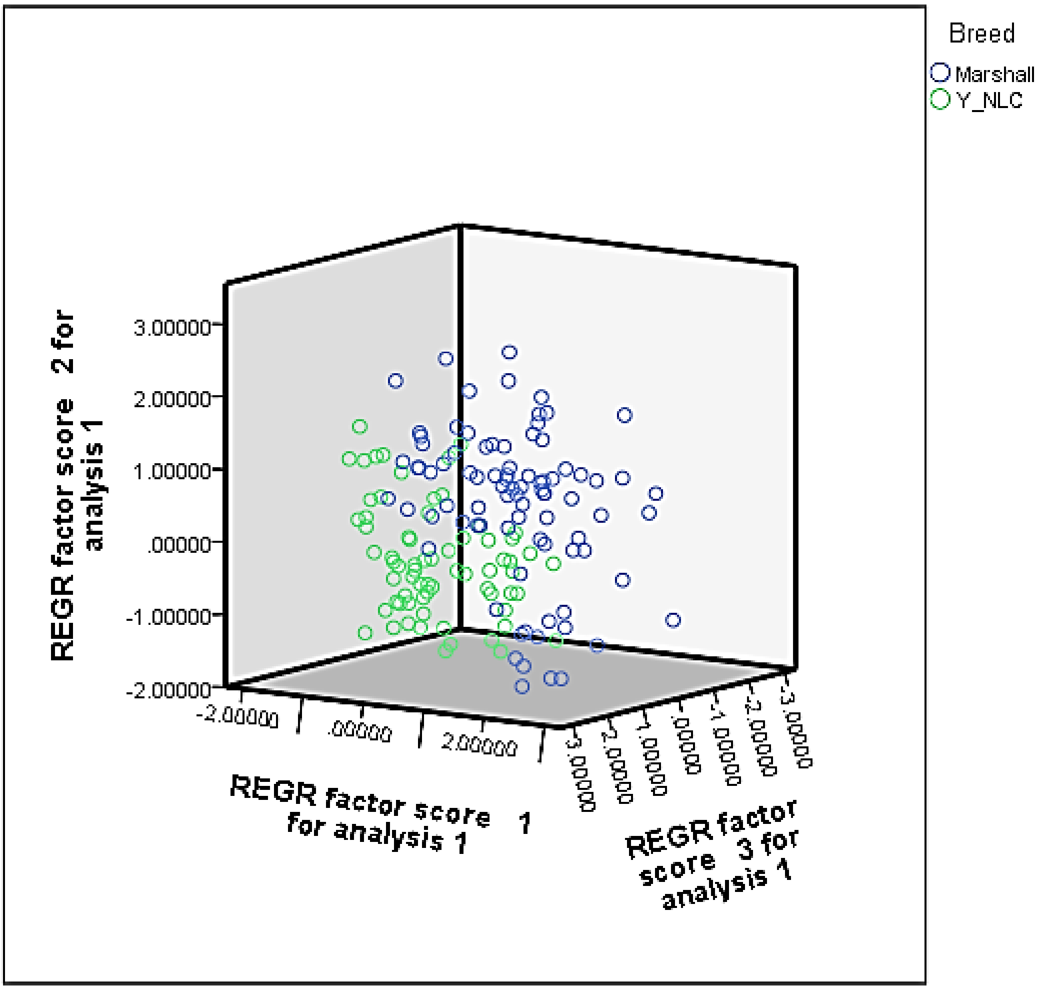

***Figure 1*:** *Effect of genotype on linear traits*

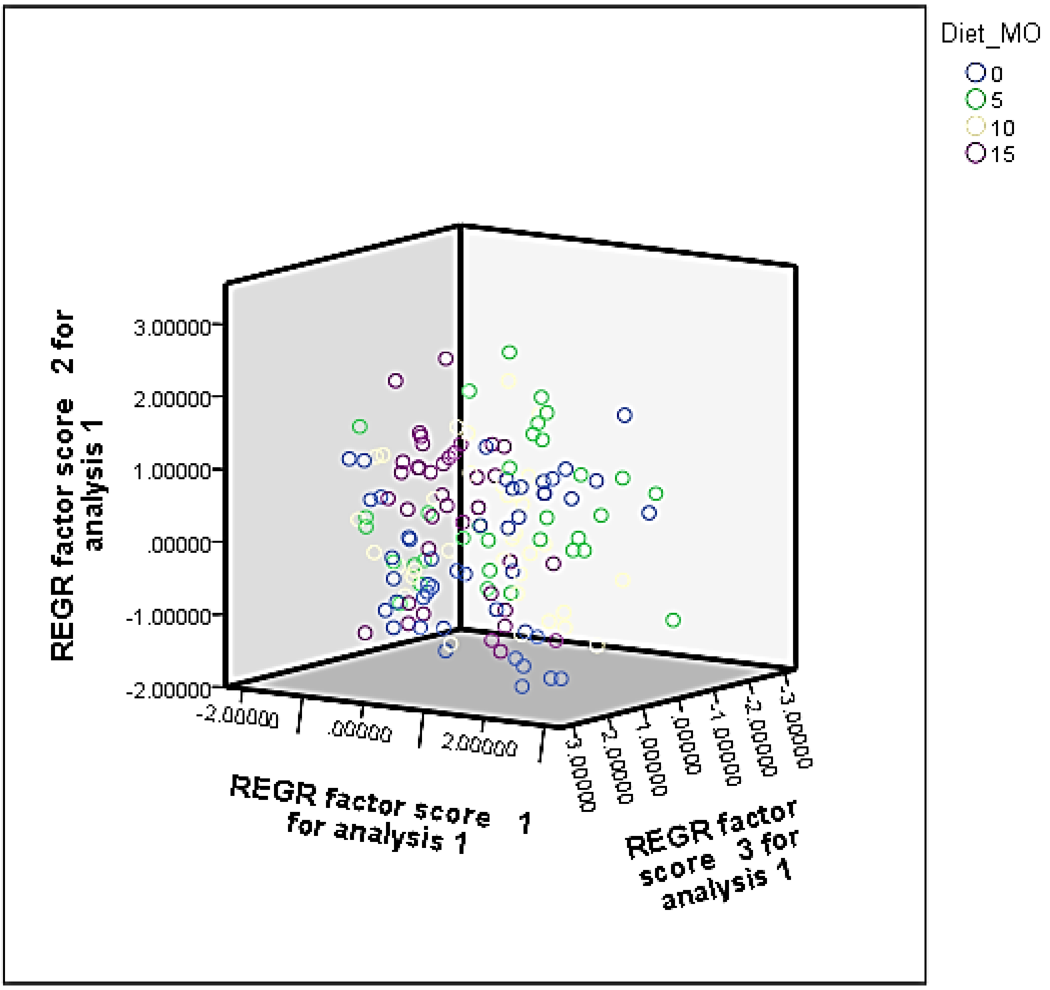

***Figure 2*:** *Effect of diet on linear traits*

Multivariate Dimension Reduction Principal Component Analysis for Body Weight and Linear Measurements over an 8 week period in the YEC

Principal component analysis of fifty seven original variables in 96 chickens revealed that twelve principal components contributed significantly (Eigen value ≥1) to variation in the examined data (Table 2), collectively explaining 85.029% of the overall variation. PC1 accounted for 37.11% of total variance while PC2, PC3, PC4, PC5, PC6, PC7, PC8, PC9, PC10, PC11 and PC12 accounted for the successively lower proportions of the explained variance.

As shown in Table 2, Communalities in the whole of the experimental birds ranged between 0.75 and 1.00. PC1 had high loadings (correlations between the components and the variables) on thigh length at weeks 4(0.770) while PC2 was orthogonal to PC1 and loaded heavily on body girth week 4 (0.807). PC3 loaded heavily on body weight week 4 (0.748).

Table2: Analysis showing the Principal Components extracted and their communalities of the length of body parts of the YEC

	Component												
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**Communalities**
BW0	-0.043	0.029	0.033	0.148	0.213	-0.056	0.137	0.912	0.073	-0.052	0.059	-0.071	0.941
BW4	0.185	-0.005	0.748	0.226	0.354	-0.033	0.234	0.102	0.036	0.151	-0.062	0.089	0.872
TL_4	0.77	0.299	0.233	0.257	-0.092	-0.001	0.119	0.118	0.006	0.213	0.021	-0.055	0.888
WL_4	0.617	0.422	0.015	0.405	-0.113	0.294	0.043	-0.064	-0.151	-0.06	-0.106	-0.161	0.891
SL_4	0.429	0.356	0.082	0.715	0.031	0.111	0	0.171	-0.064	-0.018	-0.066	-0.182	0.912
BL_4	0.314	0.748	0.051	0.2	-0.037	0	0.033	0.026	-0.005	0.189	0.251	-0.185	0.838
KL_4	0.156	0.197	0.31	0.21	0.727	0.318	0.093	0.106	0.066	0.056	-0.012	-0.186	0.894
BG_4	0.156	0.807	0.173	0.125	-0.066	0.059	0.147	0.008	-0.077	-0.19	-0.202	0.049	0.836
BW8	0.044	0.347	0.705	-0.099	0.011	0.234	-0.144	0.011	-0.12	-0.173	0.251	-0.026	0.813
TL_8	0.659	0.198	0.206	0.225	0.033	0.116	0.171	-0.046	0.063	0.188	0.45	0.167	0.881
WL_8	0.618	0.295	0.065	0.27	0.333	0.258	0.149	0.017	-0.185	-0.068	0.085	0.066	0.796
SL_8	0.337	0.343	0.111	0.666	0.119	-0.02	0.119	0.052	-0.123	0.09	0.251	0.115	0.818
BL_8	0.418	0.496	-0.174	0.187	-0.015	0.016	0.148	0.14	0.147	0.014	0.544	-0.021	0.847
KL_8	0.048	0.035	0.222	0.178	0.751	-0.139	0.101	0.152	0.184	0.202	-0.007	0.105	0.786
BG_8	0.147	0.247	0.295	-0.003	0.406	-0.134	0.22	0.109	0.134	0.284	0.105	0.551	0.825
Eigen Value	21.153	6.946	3.542	3.265	2.64	2.379	2.011	1.609	1.352	1.3	1.195	1.073	
	37.11	12.186	6.214	5.728	4.631	4.174	3.529	2.824	2.371	2.281	2.097	1.883	
	37.11	49.296	55.511	61.239	65.87	70.045	73.573	76.397	78.768	81.049	83.146	85.029	

%= Percentage, PC= Principal component, TL = Thigh Length, WL = Wing Length, SL = Shank Length, BL = Body Length, KL = Keel Length, BG = Body Girth, BW = Body Weight

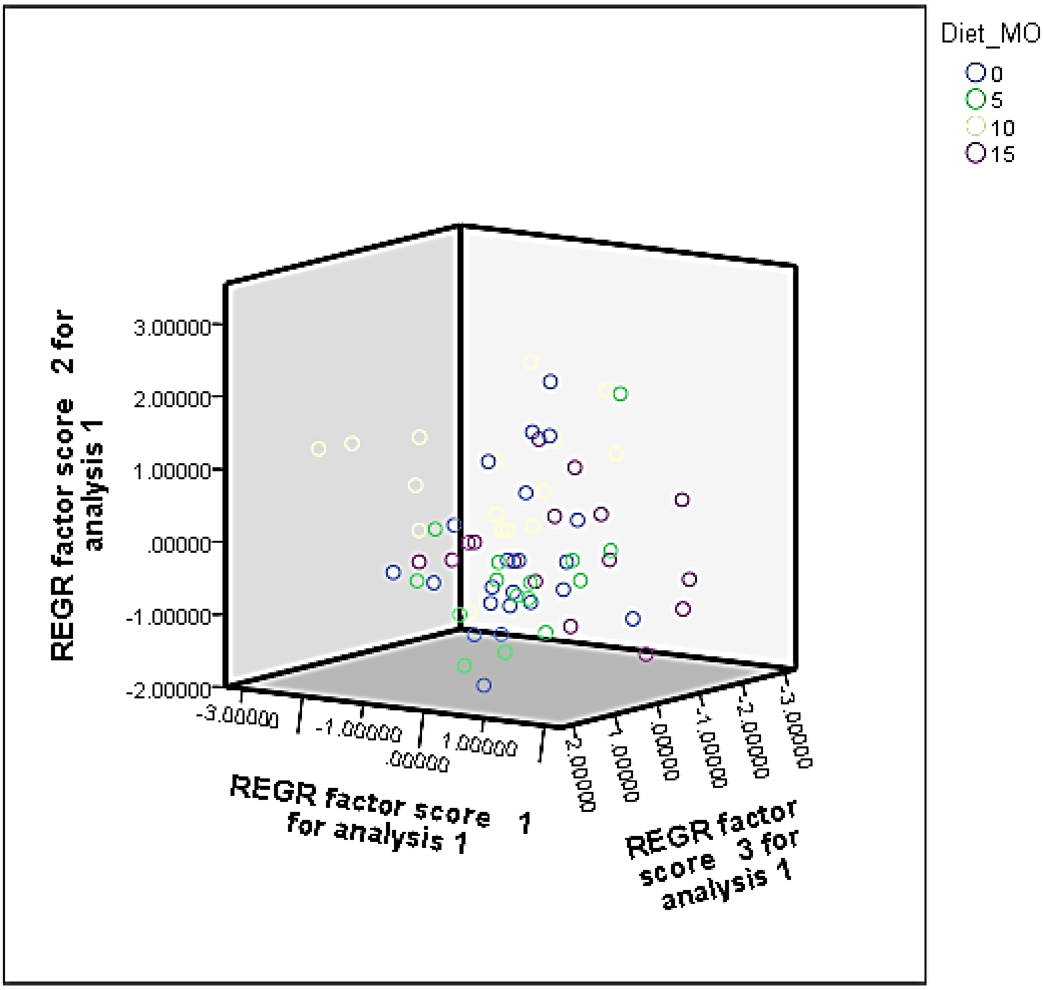

Figure 3: *Effect of MOSM on Linear traits of YEC*

Multivariate Dimension Reduction Principal Component Analysis for Body Weight and Linear Measurements over an 8- week period in the Marshall broilers (irrespective of diets)

Principal component analysis of fifty-seven original variables in 96 chickens revealed that twelve principal components contributed significantly (Eigen value ≥1) to variation in the examined data (Table 3), collectively explaining 82.523% of the overall variation. PC1 accounted for 38.513% of total variance while PC2, PC3, PC4, PC5, PC6, PC7, PC8, PC9, PC10, PC11 and PC12 accounted for the successively lower proportions of the explained variance.

As presented in Table 3, for the broiler chickens, PC1 had the highest positive loadings (correlations between the components and the variables) on body weights at week 8(0.897) while PC2 was orthogonal to PC1 and loaded heavily on thigh length week 4 (0.839). PC3 loaded heavily on keel length weeks 8 (0.723).

Table 3: Analysis showing the Principal Components extracted and their communalities of Marshall broilers

	Component												
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**Communalities**
BW0	-0.115	-0.067	0.015	-0.039	0.052	-0.057	0.017	0.049	-0.065	0.848	0.109	0.04	0.765
BW4	0.9	0.088	0.165	0.131	0.172	0.118	0.109	-0.044	-0.083	0.065	-0.038	-0.013	0.932
TL_4	0.185	0.839	-0.22	0.04	0.059	0.009	0.01	0.172	0.07	-0.099	-0.021	-0.072	0.841
WL_4	0.128	0.667	-0.147	0.278	0.269	-0.022	0.304	-0.023	-0.002	-0.014	0.359	0.046	0.856
SL_4	0.052	0.777	0.037	0.182	0.088	0.014	0.062	0.117	-0.16	0.033	-0.085	0.184	0.734
BL_4	0.493	0.427	-0.007	0.089	0.566	0.234	0.155	0.089	0.116	0.059	0.059	0.02	0.861
KL_4	0.328	0.297	0.084	0.73	0.105	0.126	0.012	0.293	0.008	-0.048	0.082	-0.106	0.868
BW8	0.897	0.179	0.082	0.077	0.033	-0.125	0.072	0.135	0.02	-0.033	0.023	-0.027	0.893
TL_8	0.361	0.639	0.344	-0.022	0.127	0.097	0.103	0.118	0.014	-0.153	0.103	0.08	0.749
WL_8	0.209	0.58	0.37	0.274	-0.141	-0.199	0.08	-0.077	-0.037	-0.229	0.237	0.116	0.787
SL_8	0.445	0.177	0.602	0.064	0.22	0.317	0.048	-0.072	-0.147	0.014	0.042	-0.13	0.792
BL_8	0.511	0.399	0.37	0.016	0.218	0.076	0.266	0.154	-0.148	-0.23	0.04	0.162	0.808
KL_8	0.178	-0.133	0.723	0.215	-0.047	0.296	0.04	0.128	0.054	-0.037	0.011	-0.048	0.734
BG_8	0.699	0.262	0.345	0.219	0.05	0.218	0.068	-0.045	-0.147	-0.186	0.124	0.083	0.859
Eigen Value	21.953	7.067	3.112	2.642	2.335	2.043	1.647	1.628	1.338	1.139	1.126	1.008	
% of Variance	38.513	12.399	5.459	4.635	4.097	3.584	2.89	2.856	2.347	1.999	1.975	1.769	
Cumulative %	38.513	50.912	56.371	61.006	65.102	68.687	71.577	74.433	76.78	78.779	80.754	82.523	

%= Percentage, PC= Principal component, TL = Thigh Length, WL = Wing Length, SL = Shank Length, BL = Body Length, KL = Keel Length, BG = Body Girth, BW = Body Weight

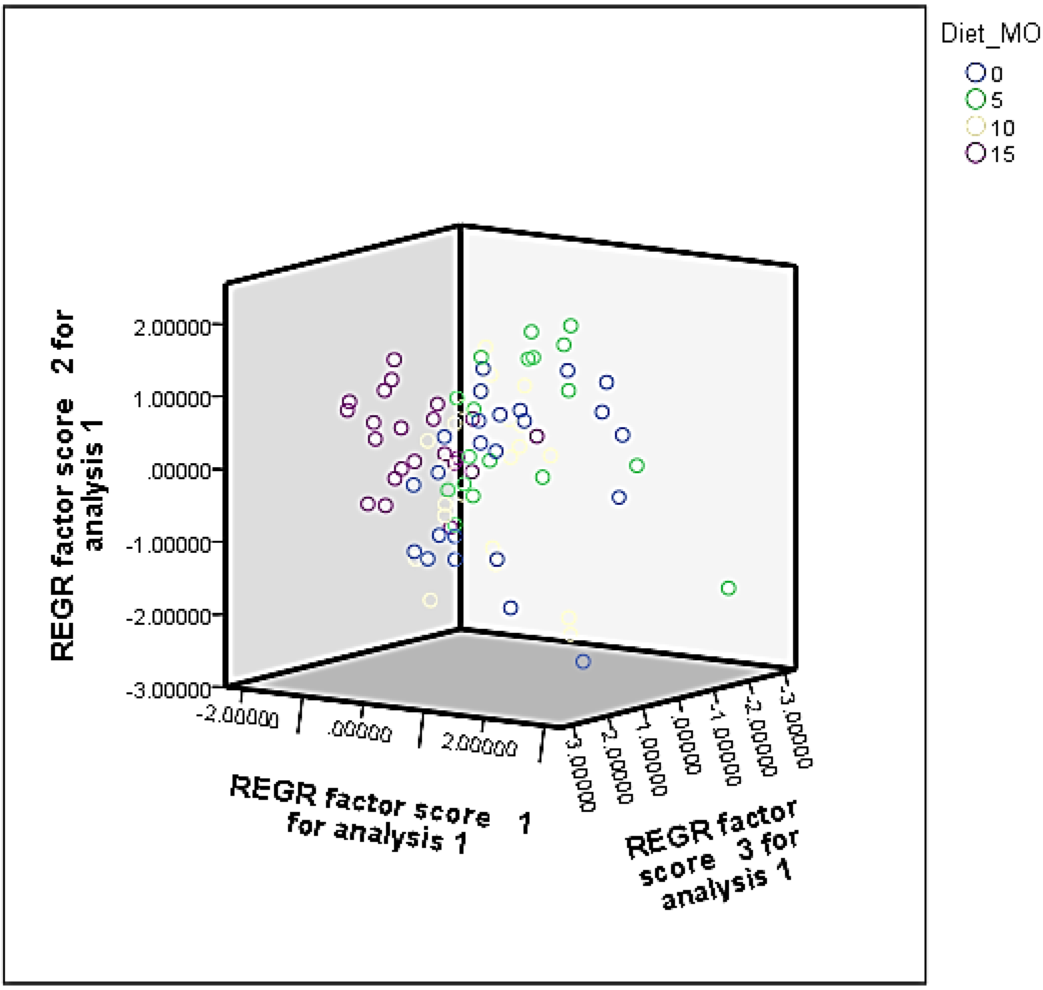

Figure 4: *Effect of MOSM on Principal Components of Marshall Broilers*

DISCUSSIONS

The knowledge and information on Linear traits are highly essential for understanding an animal and its growth biology in particular (Ojedapo *et al*. 2012). The result was also in agreement with the report of Ojedapo *et al*. (2012) who reported that growth traits showed increase in all body measurements as growth line. It also agreed with the report of Pingel et al. (1990) that age is a major determinant of growth and physiological development. They also reported that these morphometric relationships could be utilized for the genetic improvement of growth.

The growth pattern also agreed with the findings of Ojedapo *et al*. (2012) that weight of birds can easily be predicted from any given value of six body measurements (body length, drumstick length, shank thickness, keel length, body length and chest girth). The results also agreed with the findings of Adeniji and Ayorinde (1990) and Monsi (1992) that increasing chest girth or keel length through selection will result in corresponding increase in body weight.

For the PCA, Pundir *et al.* (2011) reported that positive and significant correlations among the body measurements in different strains of broilers indicate high predictability among the variables. The positive relationship between body weight and most of the body measurements showed that bodyweight can be predicted from body measurements. This was in agreement with the observation by Ajayi *et al.*

(2008). The values of communalities computed for the two genotypes of chickens confirm that PCA was appropriate for the data sets. The results was in agreement with the observations of Yakubu *et al*. (2009), they reported high range of communalities (0.755-0.987) for body measurements of Arbor Acre broilers. Mendes (2011) reported a communality range of 0.785-0.987 for body measurements of Ross broilers which was similar to what was obtained in this study but for YEC and Marshall broilers.

However, the study also agreed with the report of Salako (2006) who studied three strains of chicken, PC1 had the largest share of the total variance and correlated highly with breast width, thigh length and shank length. He however opined that PC1 could be described as the generalized form of broilers. Also, in a principal component analysis of body measurements of broilers, Yakubu *et al*. (2009) reported that PC1 had high positive loadings on body weight, breast circumference and thigh length of Arbor Acre and termed PC1 "form factor". Mendes (2011) reported that PC1 had the highest correlation with shank length, breast circumference and bodyweight of Ross 308 broilers. Yakubu *et al*. (2009) also reported that the first principal component accounted for the largest variance in the morphological traits of three Nigerian chicken genotypes.

The Principal component indices that the genotype did not influence the linear traits. This is an indication that the effect of diet was prominent on the phenotypic expression of the body weight and morphometric parameters. This further substantiated the results as birds fed 15% MOSM had the least values for body weight and all the morphometric parameters.

. It was observed that the effect of diet (MOSM) on the linear traits were similar in both genotypes. This similarity indicates that YEC and Marshal utilized the MOSM diets well and therefore performed as well as each other.

. The results of the performance of YEC on the diets showed that for most of the traits, Inclusion of 0% MOSM and 5% MOSM inclusion did not affect the performance of the birds howver, inclusion of MOSM in the diet at 10% and 15% MOSM gave significantly higher growth than at 0% and 5% MOSM inclusion. Higher performance of YEC on 10 and 15% MOSM indicates better utilization of the diets for growth than at lower inclusion levels. It is likely that at these levels, more nutrients were made available for growth of the birds.

The inclusion of MOSM at 15% had high effect on the body weight and linear traits of Marshall broiler birds when compared with other levels of inclusion. This indicates better utilization of 15% MOSM than 0-10% MOSM levels by Marshal birds. It appears from these results that YEC was better able to utilize lower levels of MOSM than Marshal birds.

Ogah *et al*., (2009) presented data that showed PC1 accounting for the largest variance in the body measurements of ducks with high positive loadings on body width, bill width, shank length, body length, head length and neck length. Pinto *et al*., (2006) used PCA to analyze performance and carcass traits measured in a population of *Gallus gallus*. The study showed that the first principal components explained the highest of the total variation. The first component is however called the generalized weight because the largest eigen vectors were associated with bodyweight. According to Mendes (2009), the first principal component provides an adequate summary of the data in most cases. This was so because the first component accounted for more than half of the total variations.

CONCLUSION

It can be concluded from this study that Marshall broilers showed higher body weight and morphometric traits than their YEC counterparts. The correlation between body weight and morphometric traits were high and positive while principal component was highly loaded for body weight at weeks 6 and 7 for Marshall broilers and thigh length at weeks 5 and 4 for YEC which described well body conformation in both genotypes of chickens. The result obtained from morphometric traits indicated that Marshall broilers were favoured for body weight compared to the YEC. More attention should be given to the thigh length which best describe meat quality in YEC for genetic improvement and development of YEC.

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