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Relationships between carcass traits and offal components in local poultry populations (*gallus gallus*) of Benin

Tougan P U [1], Dahouda M [2], Salifou C F A [1], Ahounou G S [1], Kpodekon M T [1], Mensah G A [3], Kossou D N F [1], Amenou C [1], Kogbeto C E [1], Lognay G [4], Thewis [5], Youssao I A K [1]

[1] Department of Animal Production and Health, Polytechnic School of Abomey-Calavi, 01 BP 2009,Cotonou, Republic of Benin.
[2] Department of Animal Production, Faculty of Agronomic Science, University of Abomey-Calavi, 01 BP 526, Republic of Benin.
[3] Agricultural Research Center of Agonkanmey, National Institute of Agricultural Research of Benin, 01 BP 884, Cotonou 01, Republic of Benin.
[4] Laboratory of Analytical Chemistry, Gembloux Agro-Bio Tech, University of Liège, 2, Passage des Déportés -5030 Gembloux, Belgique.
[5] Animal Sciences Unit, Gembloux Agro-Bio Tech, University of Liege, Passage des Déportés, 2, 5030 Gembloux, Belgium..

*** Correspondence**
Prof. Issaka YOUSSAO ABDOU KARIM / EPAC / Department of Animal Production and Health, Polytechnic School of Abomey-Calavi, 01 BP 2009,Cotonou, Republic of Benin. Phone : 00 229 95 28 59 88 ou 00 229 97 91 20 74, Fax : 00 229 21 36 01 99. E-mail : iyoussao@yahoo.fr, issaka.youssao@epac.uac.bj
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ABSTRACT

Objectives: The current work was carried out to determine the relationships between live weight, carcass traits and the offal components traits in Holli, Fulani, Sahoue, North and South indigenous chicken ecotypes of Benin. *Methodology and results:* 260 indigenous chickens of which 52 cockerels of each ecotype were slaughtered at 24 weeks old and used for carcass and offal composition study. Data collected were live weight, carcass weight, Carcass yields and the weights of breast, thigh-drumstick, wings, back, liver, gizzard, heart, tarsi, neck and head. It comes out from this study that in North chickens, except heart weight and carcass yields, slaughter weight was highly and positively correlated with hot carcass weight, breast weight, thigh-drumstick weight, wing weight, tarsi weight ($P<0.001$; $0.62 \leq r \leq 0.99$), weakly and positively associated to the heart weight ($P<0.05$; $r = 0.44$) but negatively correlated with the carcass drip loss ($P<0.01$, $r= -0.51$). The breast weight was moderately and positively correlated with gizzard weight ($P<0.01$, $r= 0.61$) while the thigh-drumstick and wing weights were highly and positively associated with gizzard weight ($P<0.001$, $0.67 \leq r \leq 0.78$). Similar relationships were also observed in Holli, Fulani and Sahoue ecotypes between live weight, carcass traits and offal components except carcass yields and the weights of heart, liver, head and tarsi. Contrary to North, Holli, Fulani and Sahoue chickens, heart weight and liver weight in South chicken weren't associated with the other carcass traits. However, the drip loss was negatively correlated with all other carcass traits evaluated in all chicken ecotypes. Holli and Fulani chickens were characterized by higher live weight, hot carcass weight, carcass yield, breast weight, wing weight, rest of carcass weight, neck weight, head weight, tarsi weight, thigh-

drumstick percentage, wing percentage, and heavier offal components (liver, gizzard, heart); whereas North and Sahoue chickens were characterized by higher head percentage, heart percentage, and rest of carcass percentage, while South chickens were only characterized by higher neck percentage and breast percentage. *Conclusion and application of finding:* The carcass and offal traits appeared to be some good indicators of live weight.
Key words: Body composition, correlation, indigenous chicken, principal components analysis.

INTRODUCTION

Poultry is one of the common domestic animals reared throughout the tropics and is descended from the red jungle fowl *Gallus gallus domesticus* (Vaisanen *et al.,* 2009). In Benin, the indigenous chickens represent 81.3 % of the national poultry flock (CountrySTAT, 2012). Despite the importance of this poultry flock, local poultry meat production remains below the consumer demand. This shortage created pressure on every form of food supply especially increase of meat imports (2.5 times from 2000 to 2010 accordingly to CountrySTAT, 2012). Despite the low domestic production of local chickens (2.020 tons in 2010), their meat is more appreciated by consumers in comparison with imported chicken meat (Houéssionnon, 2011) because of its leanness and relatively lower purchasing price. The lack of religious restriction against indigenous chicken consumption justifies the perennity of its production in Benin (Tougan, 2008). The local population of poultry of the species *Gallus gallus* of Benin is composed of various ecotypes among which are North, South, Holli, Fulani or Peuhl and Sahoue ecotypes (Bonou, 2006; Tougan *et al.,* 2013a). These indigenous poultry have a remarkable heterogeneity in phenotypical traits (Youssao *et al.,* 2007) and polymorphism trait (Youssao *et al.,* 2009). Several studies were carried out on carcass traits of these local genetic types (Youssao *et al.,* 2009; Youssao *et al.,* 2010; Youssao *et al.,* 2012; Tougan *et al.,* 2013a). The breeding mode and slaughter age effects on carcass composition of these five local chicken populations showed important differences in meat quality (Tougan *et al.,* 2013a). If the difference between the five ecotypes of local chicken is well known on phenotypical traits, polymorphism traits, and carcass composition, no knowledge exist on the relations between their carcass traits and offal components traits. The relationships between carcass characteristics and the offal components will be based on phenotypic correlations that determine the degrees of linking between two variables and the principal components analysis that presents groups of highly correlated variables and variable groups that oppose (Salifou *et al.,* 2012).

For accuracy and better judgment of the carcass characteristics and abilities for meat production of indigenous chicken population of Benin, it is imperative to know the degrees of linking between carcass traits and offal components traits. Therefore, this study was designed to establish the relationships between the offal components and the carcass characteristics of Holli, Fulani, Sahoue, North and South indigenous chicken ecotypes of Benin.

MATERIAL AND METHODS

Area of study: The study was conducted simultaneously at the experimental farm of "Ecole Polytechnique d'Abomey-Calavi (EPAC)" and at the free range poultry breeders located in Abomey-Calavi in Atlantic Department. Situated at latitude of 6° 27' north and at a longitude of 2° 21' east, the Commune of Abomey-Calavi covers an area of 650 km^2 with a population of 307745 inhabitants (INSAE 2010). This area exhibits climatic conditions of sub-equatorial type, characterized by two rainy seasons with an uneven spatial and temporal distribution of rainfall: major (from April to July) and minor (from September to November). These two seasons are separated by a dry season. Average rainfall is close to 1200 mm per year. The monthly average temperatures vary between 27 and 31°C and the relative air humidity fluctuates between 65%, from January to March, and 97%, from June to July.

Chicken and management : The chickens used in this experiment were from breeding animal of 10 hens and 3 cocks of each genetic type (North, South, Holli, Fulani and Sahoue), reared in confinement at the experimental farm of EPAC. Eggs from each genetic type were collected and incubated. After hatching, the chicks were weighed, identified by a sterile numbered ring fastened to the wing and reared under the same rearing system until 24 weeks old and then used in this study. The management of production system used was described by Tougan *et al.* (2013a,b). In each ecotype, 26 birds whose live weight was higher than the average live weight and 26 birds whose live weight was weaker than the average live weight were selected in each ecotype for slaughtering. Overall, 260 indigenous chickens of which 52 cockerels of each ecotype were slaughtered and used for the study of carcass and offal composition.

Slaughtering process, carcass cutting and data collecting: The 260 selected chickens were weighed and bled after 16 hours of deprived of water and feed (Tougan *et al.,* 2013a). The chickens were bled by section of the jugular vein and then scalded in hot water (70-80 °C) and plucked manually. Then, they were eviscerated and heart, kidney, crop and intestines were taken off. The legs were then sectioned at tibiotarsus-metatarsal articulation and head was separated from neck at cranium-atlas junction. The abdominal and thoracic cavity organs were then removed as well. The hot carcass weight was then recorded at 1hour *post mortem*. These hot carcasses were refrigerated at 4°C for 24 h and then weighed to obtain the cold carcass weight. A cut of each carcass was used to determine the weights of breast, thigh-drumstick, wings and the rest of carcass. The neck and the offal components (liver, gizzard, heart tarsi and head) were also weighted. The abdominal fat was not found and thus not measured. The percentage of each carcass and offal components was also determined in relation to the whole carcass. Similarly, carcass yields at 1 hour and 24 hours *post-mortem* were calculated by the equation:

$$\textbf{carcass yield}\ (\%) = \frac{\text{carcass weight (kg)}}{\text{Slaughter Live weight (kg)}} \times 100$$

Drip loss was determined from carcass weight loss after 24 hours cold storage at +4°C.

Statistical analysis: The data collected on the carcass composition of the five genetic types of chicken were analyzed with Statistical Analysis System software (SAS, 2006). The correlations between the different variables were determined by ecotype using *Proc corr* procedure of SAS (SAS, 2006). Principal Components Analysis (PCA) of carcass traits and offal components was carried out for each ecotype and for all ecotypes by the *Proc princompt* procedure of SAS (2006).

RESULTS

Correlations between live weight, carcass traits and offal components: The table 1 presents on top of diagonal the correlations between carcass traits and offal components for Holli ecotype, and under the diagonal those of North ecotype. Similarly, table 2 presents on top of diagonal the correlations between carcass traits and offal components for Fulani ecotype, and under the diagonal those of Sahoue ecotype. The correlations between carcass traits and offal components for South ecotype are showed in tables 3. In North chickens, except heart weight and carcass yields, slaughter weight was highly and positively correlated with hot carcass weight, breast weight, thigh-drumstick weight, wing weight, tarsi weight ($P<0.001$; $0.62 \leq r \leq 0.99$), weakly and positively associated to the heart weight ($P<0.05$; $r = 0.44$) but negatively correlated with the carcass drip loss ($P<0.01$, $r= -0.51$). Similar relationships were also observed between the hot and cold carcass weights and the others carcass traits and offal components. The breast weight was moderately and positively correlated with gizzard weight ($P<0.01$, $r= 0.61$) while the thigh-drumstick and wing weights were highly and positively associated with gizzard weight ($P<0.001$, $0.67 \leq r \leq 0.78$). Moreover, the thigh-drumstick was weakly correlated with the liver weight. However, no correlation was found between liver weight and respectively breast weight and wing weight. Furthermore, except neck weight, no significant association was found between the heart weight and the other carcass traits and offal components. Similarly, no significant correlations were found between the hot carcass yield and the other carcass traits except cold carcass yield and neck weight. Nevertheless, the drip loss was negatively correlated with other carcass traits evaluated in the current study. Except heart weight and cold carcass yield, the correlations between slaughter weight and offal components of Holli chickens were similar to those of North chickens. However, in Holli ecotype, Breast weight and thigh-drumstick weight were highly and positively correlated with the others carcass traits ($P<0.001$; $0.68 \leq r \leq 0.94$) except drip loss which was as in North ecotype negatively associated with the other carcass traits evaluated in the current study especially slaughter weight and cold carcass weight ($P<0.001$, $r= -0.48$). Moreover, the heart weight in Holli chicken was moderately and positively correlated with breast weight and thigh-drumstick weight ($P<0.01$, $0.51 \leq r \leq 0.53$), but moderately associated with the wing weight ($P<0.05$, $r= 0.4$). Concerning Fulani chickens, except liver weight, head weight, drip loss and carcass yields, slaughter weight was highly and positively correlated with the other carcass traits and offal components studied ($P<0.001$; $0.69 \leq r \leq 0.99$). Similar relationships were also observed between the hot and cold carcass weights and the others carcass traits and offal components. The breast weight and thigh-drumstick were moderately and positively correlated with heart weight ($P<0.01$; $0.5 \leq r \leq 0.55$) and gizzard weight ($P<0.01$, $0.52 \leq r \leq 0.58$) while the wing weights were weakly and positively associated with the heart weight ($P<0.01$, $r= 0.5$) and gizzard weight ($P<0.001$, $0.67 \leq r \leq 0.78$). However, no correlation was found between liver weight and respectively breast weight, thigh-drumstick weight and wing weight. Furthermore, except head weight, no significant association was found between the hot carcass yield and the other carcass traits and offal components. Nevertheless, as found in the 4 other genetic types, the drip loss was negatively correlated with other carcass traits evaluated in the current study. As found in North ecotype, except tarsi weight and carcass yields, slaughter weight in Sahoue chickens, was highly and positively correlated with carcass weights, breast weight, thigh-drumstick weight, wing weight, head weight, rest of carcass weight ($P<0.001$; $0.62 \leq r \leq 0.99$), moderately and positively associated to the heart weight, liver weight and gizzard weight ($P<0.001$; $0.56 \leq r \leq 0.6$) but negatively correlated with the carcass drip loss ($P<0.01$, $r= -0.51$). Similar associations were also observed between the hot and cold carcass weights and the others carcass traits and offal components. The breast weight was moderately and positively correlated with gizzard weight ($P<0.01$, $r= 0.61$) while the thigh-drumstick and wing weights were highly and positively associated with gizzard weight ($P<0.001$, $0.67 \leq r \leq 0.78$). Moreover, the thigh-drumstick was moderately associated with the liver weight and the gizzard weight, but weakly correlated with the heart weight. Contrary to the 4 other genetic types (North, Holli, Fulani and Sahoue), the heart weight and the liver weight in South chicken were not associated with the other carcass traits. However, the slaughter live weight in South chicken was highly and positively correlated with the hot carcass weight, breast weight, thigh-drumstick weight, rest of carcass weight, tarsi weight, neck weight and head weight ($P<0.001$; $0.62 \leq r \leq 0.99$), moderately associated to the cold carcass yield and wing weight, weakly and positively associated to the gizzard weight ($P<0.05$; $r = 0.44$) but negatively correlated with the carcass drip loss ($P<0.01$, $r= -0.51$). No correlation was found between the offal component and the breast weight and thigh-drumstick weight. Furthermore, except liver, neck and head weights which were weakly associated to the heart weight, no significant association was found between the heart weight and the other carcass traits studied on the one hand, and between the hot carcass yield and the other carcass traits except cold carcass yield, thigh-drumstick weight and gizzard weight in the other hand. Overall, the slaughter live weight was more associated with the other carcass trait in chicken of all ecotypes studied. Furthermore, carcass traits were better correlated with the offal components in Holli, Fulani and Sahoue chickens than North, while only gizzard weight was weakly associated with very few carcass traits in South ecotype.

Tableau 1: Correlations between live weight, carcass traits and offal components in Holli (above diagonal) and North chickens (below diagonal)

Variables	LW	HCW	CCW	C_Yield$_1$	C_Yield$_{24}$	Breast_W	Thigh_W	Wing_W	Back_W	Tarsi_W	Heart_W	Liver_W	Gizzard_W	Neck_W	Head_W	Drip loss
LW	1	0.99***	0.99***	0.33^{NS}	0.40*	0.94***	0.97***	0.88***	0.74***	0.67***	0.59***	0.90***	0.88***	0.89***	0.81***	-0.48***
HCW	0.99***	1	0.99***	0.45*	0.51**	0.95***	0.98***	0.88***	0.71***	0.65***	0.52***	0.89***	0.90***	0.90***	0.80***	-0.46*
CCW	0.99***	0.99***	1	0.45*	0.51**	0.95***	0.98***	0.89***	0.71***	0.65***	0.52**	0.89***	0.90***	0.91***	0.80***	-0.48***
C_Yield$_1$	0.16^{NS}	0.29^{NS}	0.3^{NS}	1	0.98***	0.46*	0.46*	0.34^{NS}	0.09^{NS}	0.11^{NS}	-0.27^{NS}	0.31^{NS}	0.53**	0.44*	0.27^{NS}	-0.09^{NS}
C_Yield$_{24}$	0.38^{NS}	0.49*	0.52**	0.87***	1	0.52**	0.52**	0.41*	0.16^{NS}	0.14^{NS}	-0.20^{NS}	0.37*	0.57**	0.50**	0.32^{NS}	-0.24^{NS}
Breast_W	0.85***	0.88***	0.89***	0.37^{NS}	0.58**	1	0.94***	0.78***	0.66***	0.68***	0.53**	0.86***	0.81***	0.80***	0.68***	-0.42*
Thigh_W	0.95***	0.95***	0.95***	0.22^{NS}	0.42*	0.84***	1	0.88***	0.69***	0.64***	0.51**	0.87***	0.86***	0.90***	0.78***	-0.50**
Wing_W	0.75***	0.76***	0.76***	0.26^{NS}	0.38^{NS}	0.69***	0.64***	1	0.61***	0.51**	0.40*	0.76***	0.76***	0.84***	0.84***	-0.52**
Back_W	0.82***	0.82***	0.83***	0.21^{NS}	0.44*	0.57**	0.73***	0.58**	1	0.48**	0.67***	0.78***	0.58**	0.65***	0.5**	-0.45*
Tarsi_W	0.69***	0.65***	0.65***	-0.07^{NS}	0.15^{NS}	0.54**	0.55**	0.47*	0.51**	1	0.70***	0.65***	0.42*	0.38^{NS}	0.57**	-0.22^{NS}
Heart_W	0.17^{NS}	0.21^{NS}	0.22^{NS}	0.33^{NS}	0.37^{NS}	0.13^{NS}	0.18^{NS}	-0.16^{NS}	0.26^{NS}	0.18^{NS}	1	0.88***	0.31^{NS}	0.39*	0.30^{NS}	-0.37^{NS}
Liver_W	0.44*	0.42*	0.42*	-0.03^{NS}	0.11^{NS}	0.38^{NS}	0.41*	0.34^{NS}	0.23^{NS}	0.34^{NS}	-0.09^{NS}	1	0.75***	0.77***	0.63***	-0.46*
Gizzard_W	0.72***	0.72***	0.72***	0.14^{NS}	0.3^{NS}	0.61**	0.67***	0.78***	0.47*	0.52**	-0.18^{NS}	0.45*	1	0.90***	0.70***	-0.35^{NS}
Neck_W	0.62***	0.66***	0.66***	0.47*	0.5**	0.5**	0.58**	0.35^{NS}	0.58**	0.35^{NS}	0.58**	0.03^{NS}	0.39*	1	0.70***	-0.49**
Head_W	0.75***	0.75***	0.74***	0.15^{NS}	0.29^{NS}	0.51**	0.75***	0.44*	0.7***	0.37^{NS}	0.14^{NS}	0.52**	0.43*	0.54**	1	-0.35^{NS}
Drip loss	-0.51**	-0.53**	-0.58**	-0.26^{NS}	-0.7***	-0.59**	-0.49*	-0.36^{NS}	-0.55**	-0.41*	-0.25^{NS}	-0.25^{NS}	-0.37^{NS}	-0.31^{NS}	-0.35^{NS}	1

LW: Live weight; **HCW:** Hot carcass weight; **CCW:** Cold carcass weight; **C_Yield1:** Carcass yield at 1hour *post-mortem*; **C_Yield24:** Carcass yield at 24hours *post-mortem;* **Breast_W:** Breast weight; **Thigh_W:** Thigh-drumstick weight; **Wing_W:** wing weight; **Back_W:** Back weight; **Tarsi_W:** Tarsi weight; **Heart_W:** Heart weight; **Liver_W:** Liver weight; **Gizzard_W:** Gizzard weight; **Neck_W:** Neck weight; **Head_W:** Head weight. **NS:** Non Significant**; *: P<0.05; **: P< 0.01; *** : P<0.001.**

Tableau 2: Correlations between live weight, carcass traits and offal components in Fulani (above diagonal) and Sahoue chickens (below diagonal)

Variables	LW	HCW	CCW	C_Yield$_{1}$	C_Yield$_{24}$	Breast_W	Thigh_W	Wing_W	Back_W	Tarsi_W	Heart_W	Liver_W	Gizzard_W	Neck_W	Head_W	Drip loss
LW	1	0.99***	0.99***	0.20^{NS}	0.39*	0.89***	0.91***	0;82***	0.68***	0.71***	0.69***	0.02NS	0.66***	0.75***	0.61**	_0.67***
HCW	0.99***	1	0.99***	0.29^{NS}	0.47*	0.88***	0.92***	0.81***	0.69***	0.7***	0.7***	0.47*	0.68***	0.76***	0.64***	_0.68***
CCW	0.99***	0.99**	1	0.29^{NS}	0.48*	0.88***	0.91***	0.82***	0.69***	0.69***	0.7***	0.47*	0.68***	0.76***	0.64***	_0.7***
C_Yield$_{1}$	_0.18^{NS}	_0.09^{NS}	_0.09^{NS}	1	0.95***	0.29^{NS}	0.2^{NS}	0.09^{NS}	0.34^{NS}	0.1^{NS}	0.3^{NS}	0.07^{NS}	0.34^{NS}	0.22^{NS}	0.45*	_0.32^{NS}
C_Yield$_{24}$	_0.08^{NS}	0.008^{NS}	0.02^{NS}	0.95***	1	0.44*	0.38^{NS}	0.29^{NS}	0.46*	0.18^{NS}	0.44*	0.21^{NS}	0.46*	0.41*	0.52**	_0.6**
Breast_W	0.94***	0.93***	0.93***	_0.13^{NS}	_0.05^{NS}	1	0.81***	0.61**	0.55**	0.49*	0.5**	0.35^{NS}	0.52**	0.55**	0.5**	_0.59**
Thigh_W	0.97***	0.96***	0.96***	_0.09^{NS}	0.03^{NS}	0.87***	1	0.75***	0.41*	0.68***	0.55**	0.35^{NS}	0.58**	0.53**	0.51**	_0.65***
Wing_W	0.7***	0.71***	0.71***	_0.04^{NS}	0.84*	0.63***	0.66***	1	0.46*	0.59NS	0.45*	0.34^{NS}	0.47*	0.72***	0.44*	_0.64***
Back_W	0.89***	0.88***	0.88***	_0.14^{NS}	_0.04^{NS}	0.75***	0.83***	0.44*	1	0.3NS	0.72***	0.32^{NS}	0.53***	0.79***	0.56**	_0.52**
Tarsi_W	0.38^{NS}	0.4^{NS}	0.38^{NS}	_0.04^{NS}	_0.05^{NS}	0.34^{NS}	0.2^{NS}	0.23^{NS}	0.31^{NS}	1	0.51**	0.32^{NS}	0.48*	0.35^{NS}	0.47*	_0.29^{NS}
Heart_W	0.56**	0.57**	0.56**	_0.15^{NS}	_0.08^{NS}	0.38^{NS}	0.46*	0.38^{NS}	0.6**	0.41*	1	0.45*	0.72***	0.67***	0.53**	_0.57**
Liver_W	0.56**	0.58**	0.57**	0.07^{NS}	0.09^{NS}	0.49*	0.54**	0.47*	0.34^{NS}	0.34^{NS}	0.45*	1	0.51**	0.61***	0.27^{NS}	_0.45*
Gizzard_W	0.6**	0.63***	0.62***	0.09^{NS}	0.1^{NS}	0.57**	0.5**	0.62***	0.47*	0.37^{NS}	0.52**	0.38^{NS}	1	0.6**	0.55**	_0.52**
Neck_W	0.7***	0.73***	0.72***	0.15^{NS}	0.26^{NS}	0.53**	0.74***	0.59**	0.62**	0.19^{NS}	0.48*	0.48*	0.31^{NS}	1	0.44*	_0.66***
Head_W	0.65***	0.65***	0.66***	_0.07^{NS}	0.06^{NS}	0.58**	0.65*	0.27^{NS}	0.6**	0.13^{NS}	0.33^{NS}	0.28^{NS}	0.34^{NS}	0.39*	1	_0.42*
Drip loss	_0.31^{NS}	_0.96***	_0.33^{NS}	0.01^{NS}	_0.29^{NS}	_0.25^{NS}	_0.39*	-0.17^{NS}	_0.31^{NS}	0.05^{NS}	_0.21^{NS}	-0.09^{NS}	_0.03^{NS}	_0.37^{NS}	_0.42*	1

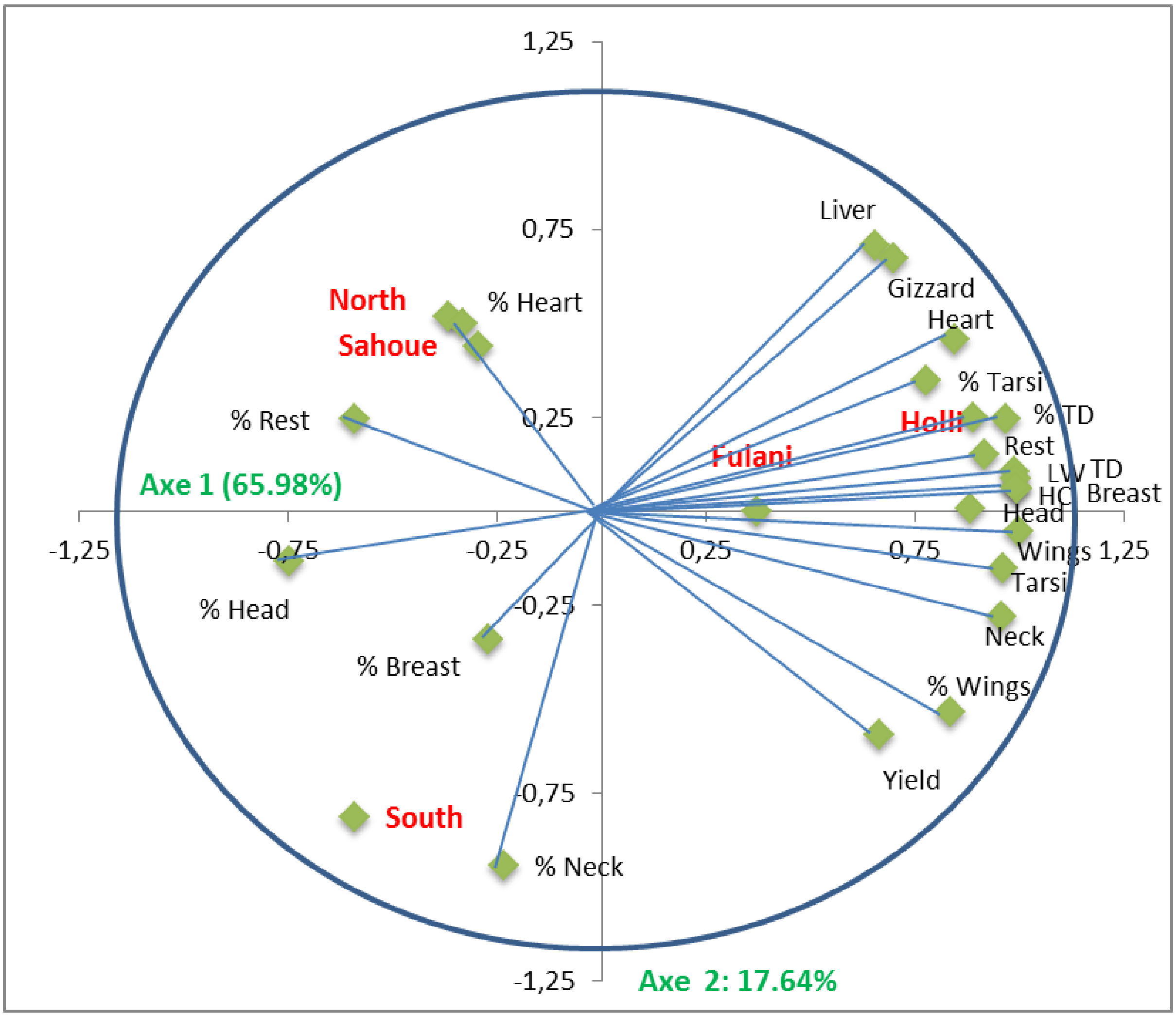
LW: Live weight; **HCW:** Hot carcass weight; **CCW:** Cold carcass weight; **C_Yield1:** Carcass yield at 1hour *post-mortem*; **C_Yield24:** Carcass yield at 24hours *post-mortem;* **Breast_W:** Breast weight; **Thigh_W:** Thigh-drumstick weight; **Wing_W:** wing weight; **Back_W:** Back weight; **Tarsi_W:** Tarsi weight; **Heart_W:** Heart weight; **Liver_W:** Liver weight; **Gizzard_W:** Gizzard weight; **Neck_W:** Neck weight; **Head_W:** Head weight. **NS:** Non Significant**; *: P<0.05; **: P<0.01 ; *** : P<0.001.**

Tableau 3: Correlations between live weight, carcass traits and offal components in South chicken

Variables	LW	HCW	CCW	C_Yield_1	C_Yield_{24}	Breast_W	Thigh_W	Wing_W	Back_W	Tarsi_W	Heart_W	Liver_W	Gizzard_W	Neck_W	Head_W	Drip loss
LW	1															
HCW	0.99^{***}	1														
CCW	0.99^{***}	0.99^{***}	1													
C_Yield_1	0.31^{NS}	0.40^{*}	0.40^{*}	1												
C_Yield_{24}	0.52^{**}	0.59^{**}	0.6^{**}	0.88^{***}	1											
Breast_W	0.82^{***}	0.83^{***}	0.83^{***}	0.31^{NS}	0.55^{**}	1										
Thigh_W	0.93^{***}	0.93^{***}	0.93^{***}	0.39^{*}	0.57^{**}	0.70^{***}	1									
Wing_W	0.53^{**}	0.53^{**}	0.52^{**}	0.18^{NS}	0.21^{NS}	0.29^{NS}	0.43^{*}	1								
Back_W	0.81^{***}	0.81^{***}	0.82^{***}	0.28^{NS}	0.52^{**}	0.73^{***}	0.73^{***}	0.18^{NS}	1							
Tarsi_W	0.62^{***}	0.64^{***}	0.62^{***}	0.33^{NS}	0.28^{NS}	0.30^{NS}	0.59^{**}	0.58^{**}	0.26^{NS}	1						
Heart_W	0.26^{NS}	0.26^{NS}	0.26^{NS}	0.16^{NS}	0.16^{NS}	-0.07^{NS}	0.27^{NS}	-0.14^{NS}	0.27^{NS}	0.38^{NS}	1					
Liver_W	0.22^{NS}	0.24^{NS}	0.24^{NS}	0.32^{NS}	0.26^{NS}	0.16^{NS}	0.10^{NS}	0.08^{NS}	0.30^{NS}	0.25^{NS}	0.46^{*}	1				
Gizzard_W	0.44^{*}	0.47^{*}	0.46^{*}	0.45^{*}	0.4^{*}	0.21^{NS}	0.39^{NS}	0.58^{**}	0.07^{NS}	0.65^{***}	0.27^{NS}	0.25^{NS}	1			
Neck_W	0.86^{***}	0.86^{***}	0.86^{***}	0.34^{NS}	0.50^{*}	0.66^{***}	0.74^{***}	0.42^{*}	0.61^{***}	0.63^{***}	0.47^{*}	0.24^{NS}	0.59^{**}	1		
Head_W	0.63^{***}	0.62^{***}	0.61^{***}	0.09^{NS}	0.16^{NS}	0.18^{NS}	0.69^{***}	0.38^{NS}	0.34^{NS}	0.65^{***}	0.48^{*}	-0.08^{NS}	0.45^{*}	0.66^{***}	1	
Drip loss	-0.55^{**}	-0.54^{**}	-0.58^{**}	-0.15^{NS}	-0.61^{***}	-0.61^{***}	-0.54^{**}	-0.14^{NS}	-0.6^{**}	-0.04^{NS}	-0.07^{NS}	-0.02^{NS}	-0.08^{NS}	-0.45^{*}	-0.18^{NS}	1

LW: Live weight; **HCW:** Hot carcass weight; **CCW:** Cold carcass weight; **C_Yield1:** Carcass yield at 1hour *post-mortem*; **C_Yield24:** Carcass yield at 24hours *post-mortem;* **Breast_W:** Breast weight; **Thigh_W:** Thigh-drumstick weight; **Wing_W:** wing weight; **Back_W:** Back weight; **Tarsi_W:** Tarsi weight; **Heart_W:** Heart weight; **Liver_W:** Liver weight; **Gizzard_W:** Gizzard weight; **Neck_W:** Neck weight; **Head_W:** Head weight. **NS:** Non significant**; *: P<0.05; **: P<0.01 ; *** : P<0.001.**

Principal components analysis of carcass traits and offal components: The figure 1 presents the principal components analysis of carcass traits and offal components of the five genetic types of chicken studied. Indeed, principal components analysis of carcass traits and offal components discriminated the five ecotypes according to according to their butcher aptitude. The first axis explains 65.98% of the variation and opposed carcass and offal component traits of Sahoue and North chickens to those of Holli chicken and to a lesser extent to Fulani chickens. The second axis explains 17.64% of the variation and opposed carcass and offal component traits of South chickens to those of the 4 others genotypes. Holli and to a lesser extent Fulani chickens were characterized by higher live weight, hot carcass weight, carcass yield, breast weight, wing weight, rest of carcass weight, neck weight, head weight, tarsi weight, thigh-drumstick percentage, wing percentage, and heavier offal components (liver, gizzard, heart); while North and Sahoue chickens were characterized by higher head percentage, heart percentage, and rest of carcass percentage. South chickens were characterized by higher neck percentage and breast percentage.



%: Percentage; **LW:** Live weight; **TD:** Thigh-drumstick, **HC:** Hot Carcass weight; **Yield:** Carcass yield; **Rest:** Rest of carcass.

Figure 1: Principal Components Analysis (PCA) of indigenous chicken carcass characteristics and the offal components of Holli, Fulani, Sahoue, North and South ecotypes of Benin

DISCUSSION

Correlations between live weight, carcass traits and offal components: Overall, the slaughter live weight and carcass weight were more associated with the other carcass trait in chicken of all ecotypes studied. In accordance with the finding of Olawumi (2013) on Arbor and Acre breed chicken in Nigeria, the obtained results showed that all the carcass traits measured were good indicators of live weight. Therefore, it is possible to predict the animal live weight carcass weight. Some variability in the relationships between live weight, carcass traits and offal components was found in the current study. Carcass traits were better correlated with the offal components in Holli, Fulani and Sahoue chickens than North, while only gizzard weight was weakly associated with very few carcass traits in South ecotype. The differences in carcass and offal traits between the five ecotypes could be due to the differences in their size and conformation (Bianchi *et al.,* 2006; Jaturasitha *et al.,* 2008; Abdullah & Matarneh, 2010). This result confirms the finding of Youssao *et al*. (2010) who showed that indigenous chicken populations of Benin are characterized by a great genetic diversity than that reported for commercial lines chicken (Hillel *et al.,* 2003; Granevitze *et al.,* 2007; Muchadeyi *et al.,* 2007; Berthouly *et al.,* 2008). In accordance with Havenstein *et al.* (2003a, 2003b), live weight, carcass yield and breast meat yield was mainly depending on genotype. Franco *et al.* (2012) found great difference in carcass characteristics between Mos and Sasso T-44 roosters. Similarly, Razuki *et al.* (2011) reported significant strain differences in body weight at different ages among breeds of broiler chickens.

The current results found on the phenotypic correlations between live weight, carcass traits and offal components are in accordance with the finding of Musa *et al.* (2006b) who reported difference in values of correlation coefficients between carcass traits, offal components and abdominal fat of Anka and Rugao breeds of chicken. In Anak broiler strain, Ojedapo *et al.* (2008) found significant positive phenotypic correlations between live weight and carcass weight (0.95), shank weight (0.93) and breast muscle weight (0.97) but observed significant negative phenotypic correlation (-0.78) between live weight and carcass weight in Wadi Ross strain. The work carried out in Nigeria by Olawumi (2013) on the phenotypic correlations between live body weight and carcass traits in Arbor and Acre breed of broiler chicken showed that live weight had statistically significant ($P<0.01$) positive phenotypic correlation with dressing weight, eviscerated weight, carcass weight, breast muscle weight, back weight, thigh weight and drumstick weight. In addition, he found as in the current study significant ($P<0.01$) positive phenotypic correlations among the various carcass traits. Furthermore, previous studies had reported positive genetic correlations of body weight with abdominal fat weight and abdominal fat percentage (Le Bihan-Duval *et al.,* 1998; Deeb & Lamont, 2002). In addition, Musa *et al.* (2006b) reported positive phenotypic correlation between live weight and carcass weight, breast muscle weight, leg muscle weight, abdominal fat weight, heart weight and liver weight in broiler chickens. However, the high correlation between the live weight and the hot carcass weight found in the present study values indicate that the indigenous chickens of Benin has small amount of viscera, feathers and blood since hot carcass weight was obtained after slaughter, de-feathering and evisceration. The high associations found between the live weight and the breast weight, and the thigh-drumstick weight implies that those traits may be some good indicators of live weight, and could be used to predict the live weight of indigenous chicken of Benin. In cane rat, Kolawole & Salako (2010) reported also a positive relationship between live weight and body length and heart girth. In local fowls, Ige *et al.* (2007) reported positive phenotypic correlation between body weight and linear measurements. The high correlation value reported in this study between live weight and carcass weight was comparable to the value ($r = 0.95$) reported by Musa *et al.* (2006a) who had found $r = 0.995$ in fat and lean chicken breeds, by Ojedapo *et al.* (2008) for Anak chicken breed and by Olawumi (2013) who reported the same coefficient correlation ($r=0.987$; $P<0.001$) in Arbor and Acre breed of broiler chicken. However in contrast, Deeb & Lamont (2002) reported significant ($P<0.05$) unfavourable positive correlation between the two traits in different strains of broiler chicken.

In addition, high positive correlations ($P<0.001$; $0.62 \leq r \leq 0.99$) was found between slaughter weight and breast weight, thigh-drumstick weight, wing weight, head weight and back weight in the five indigenous chicken breeds used in the current study. This was comparable to the values reported for Anak breed by Ojedapo *et al.* (2008) and by Olawumi (2013) in Arbor and Acre breed of broiler chicken. These traits appeared to be another good indicators of live weight, and these obtained results corroborates the findings of Musa *et al.* (2006a,b) in different breeds of broiler chickens and Isidahomen *et al.* (2012) who recorded strong association ($P<0.001$; $0.73 \leq r \leq 0.99$) between live weight and breast weight, thigh-drumstick weight, wing weight, head weight, neck weight and back weight in naked neck, Frizzle and Normal indigenous chicken breeds of Nigeria. The obtained result indicates that the latter traits could be used to predict the value of the former, and this implies that a heavier bird will surely give an appreciable breast, thigh-drumstick and wing meat portion compared to a small-sized one. Okoro & Ogundu (2006) obtained high and positive phenotypic correlations between body weight and other body parameters namely; thigh length, chest circumference, breast width, keel length and shank length. They suggested that these parameters may be good indicators of body weight. Similarly, Okpeku *et al.* (2003) reported that body weight was positively correlated with body length, chest circumference, femur and crust but obtained negative and low correlation between body weight and tarso-metatarsus (shank length) among local chickens in Edo state of Nigeria.

Moreover, Kabir *et al.* (2006) observed that there were positive and high genetic correlations between body weight and shank length at 20-40 weeks of age. Singh (2008) reported high and positive genetic and phenotypic correlations for body weight and conformation traits. The significant positive correlations found in the present study between live weight and offal components on the one hand, and between the carcass traits and offal components on the other hand corroborates the findings of Zerehdraran (2005); Musa *et al.* (2006b); Ojedapo *et al.* (2008) and Isidahomen *et al.* (2012) who reported positive and significant correlations between live weight, carcass weight, breast weight and organs traits in chicken. Overall, according to El-Labban (1999), the high and positive phenotypic correlation between body weight, carcass traits and offal component recorded in the current study could be as a result of pleiotrophic effects of genes and linkage effects which operate on these traits. Therefore, if the positive phenotypic correlations translate into positive genetic correlations thus, selection for one trait will improve the other as a correlated response. The drip loss was negatively correlated with other carcass traits evaluated in the current study. Thus, heavier carcass may have higher drip loss. This result confirms the finding of Abdullah & Matarneh (2010) and the reports of the investigation of Gigaud & Berri (2007) indicated that heavier chickens present a lower pHu, redder breast meat and higher drip loss.

Principal components analysis of carcass traits and offal components: Principal components analysis of carcass traits and offal components discriminated the five ecotypes according to their butcher aptitude. The first axis opposed carcass and offal component traits of Sahoue and North chickens to those of Holli chicken and to a lesser extent to Fulani chickens and the second axis opposed carcass and offal component traits of South chickens to those of the 4 others genotypes. This finding confirm that there is a gene linkage effect operating on these traits as found by several authors (Muhiuddin, 1993; Olawumi, 2013) Holli chickens were characterized by higher live weight, hot carcass weight, carcass yield, breast weight, wing weight, rest of carcass weight, neck weight, head weight, tarsi weight, thigh-drumstick percentage, wing percentage, and heavier offal components (liver, gizzard, heart); while North and Sahoue chickens were characterized by higher head percentage, heart percentage, and rest of carcass percentage; whereas South chickens were characterized by higher neck percentage and breast percentage. This variability in the carcass characteristics among birds may be related to the genetic variability of chickens used in the present study since they were reared under the same breeding system and environmental conditions. These findings corroborate the observations of Salifou *et al.* (2012) on the principal components analysis of carcass characteristics and offal component of Lagunaire, Borgou and Zebu Fulani bulls raised on natural pasture. These authors found that Principal Components Analysis of the carcass and offal component traits discriminated these three breeds according to their butcher aptitude. The body composition performances of Borgou bulls were in the middle of those of Lagunaire and Zebu bulls. Renand *et al.* (2002) also reported great differences in slaughter performances in Aubrac, Salers and Gasconne cattle breeds; the carcasses were heavier and leaner in Aubrac cattle.

CONCLUSION

The current work on phenotypic correlations between live weight, carcass traits and offal components in indigenous chicken populations of Benin showed that the slaughter live weight was more correlated with other carcass traits in chicken of all ecotypes studied. Furthermore, carcass traits were better correlated with the offal components in Holli, Fulani and Sahoue chickens than North, while only gizzard weight was weakly associated with very few carcass traits in South ecotype. The principal components analysis of carcass traits and offal components discriminated the five ecotypes according to their abilities for meat production and showed that Holli and to a lesser extent Fulani chickens were characterized by higher live weight, hot carcass weight, carcass yield, breast weight, wing weight, rest of carcass weight, neck weight, head weight, tarsi weight, thigh-drumstick percentage, wing percentage, and heavier offal components; while North and Sahoue chickens were characterized by higher head percentage, heart percentage, and rest of carcass percentage. South chickens were only characterized by higher neck and breast percentages. Therefore, selection based on one trait will improve the other traits as a correlated response since positive phenotypic correlations is reported to translate into positive genetic correlations.

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