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Influence of sex and slaughter age on body composition of Muscovy ducks reared in South Benin

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Abstract

Muscovy ducks reared in Benin have a good growth performance and are very rustic animals. However, these birds' carcass traits are little-known. This study aimed to evaluate the body composition of Muscovy ducks reared in South Benin. Thus, data on carcass traits and fifth quarter components were collected from February 07 to April 04, 2018 on 40 Muscovy ducks, including 5 males and 5 females by age class with a total of four age classes. The age 1 was for ducks of 4 to 6 months old, the age 2 for ducks of 6 to 8 months old, the age 3 for birds of 8 to 10 months old and the age 4 for animals older than 10 months. The collected data was analyzed with SAS (Statistical Analysis System, 2013). Means, standard deviations and coefficients of variation were calculated by the procedure Proc meansand the frequenciesby the procedure Procfreq.The live weight at slaughter, the hot carcass weight, the cold carcass weight, the body components weight of males were higher ($p<0.001$) than those of females. The hot carcass yield, the cold carcass yield and the percentages of carcass components and of the fifth quarter had this same trend. On the contrary, the abdominal fat weight of males was lower than that of females ($p<0.01$). This study also revealed that the live weight at the slaughter, the hot carcass weight, the cold carcass weight and the carcass components weight increased gradually with age ($p<0.001$). However, age has no effect on the thighs, liver and head percentages ($p>0.05$). The principal components analysis revealed three groups of traits: the group 1 concerns quantitative traits, the group 2, organ percentages considering carcass weights, and the group 3, carcass yields at slaughter. The animal age at slaughter, the animal live weight at slaughter, the hot carcass weight, the cold carcass weight, the carcass cuts weight and the fifth quarter components weight were positively correlated with each other and negatively correlated with the percentages of the carcass cuts and of viscera. In sum, the body composition of Muscovy ducks varies according to the sex and animal age at slaughter.

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Introduction

Poultry meat is the households' most produced and consumed meat product in South Benin (ContryStat, 2015). This meat growing consumer demand has accelerated all poultry species production of which estimated total population was 18,619,000 heads in 2015 (DE, 2016). Among all these poultry species, chicken is the most reared followed by guinea fowl, duck, turkey and pigeons (Youssao *et al.*, 2010; FAOSTAT, 2015). Due to these species importance in the livestock sector empowerment program and in the sufficient availability of meat and meat products of quality, several studies were carried out on their meat, especially on exotic chickens, local chickens and accessorily on guinea fowl. Thus, works were carried out on body composition, carcass traits, technological, organoleptic and nutritional qualities of meat from local chickens reared in North and South Benin (Youssao *et al.*, 2012; Tougan *et al.* ., 2013) and recently on pre-slaughter stress effect on carcass and meat quality from local chickens reared in South Benin (Bonou *et al.*, 2017). Concerning guinea fowl, Daouda *et al.* (2008) studied the effect of diet with cassava chips and leaves during finishing period on carcass traits and meat quality. As for the other local poultry species, their carcass traits and meat quality are not yet studied in Benin. Among these species, duck is the most important in terms of numbers and its meat is highly appreciated by consumers. More than 50% of breeders from Depression, Fishery and Land Bar agro-ecological zones report that Muscovy ducks meat and carcass qualities are good (Houessionon *et al.*, 2018). This study aims to evaluate the body composition of Muscovy duck according to sex and slaughter age. Sex and age were chosen as variation factors because they explain a large part of variability of food animals' meat production abilities (Tougan *et al.*, 2013a).

Material and methods

Study area

The Muscovy ducks used in the present study were reared at Duck Experimental Farm of the Laboratory of Animal Biotechnology and Meat Technology of the University of Abomey-Calavi. This farm is in South Benin, precisely in the Township of Abomey-Calavi, district of Togba, area of Agori, at 6° 42' 6" North longitude and 2° 32' 4" East latitude. The Township of Abomey-Calavi is bounded to the North by the Township of Zè, to the South by the Atlantic Ocean, to the East by the Townships of So-Ava and Cotonou and to the West by the Townships of Tori Bossito and Ouidah. It has an area of 539 km² and a population of more than 656,358 inhabitants in 2013 (INSAE, 2016). The climate is of subequatorial type with 2 rainy seasons and 2 dry seasons. The major rainy season is from April to July and the minor from September to November. These seasons are separated by two dry seasons.

Animal management

This study was carried out over 40 Muscovy ducks produced from two males and four females. At the hatching, they were first reared in chicken coops up to 8 weeks old, then in henhouses up to 4 months and finally on a course of 300 m². These chickens coops and henhouses were all made of local materials and well ventilated for animals. Three feeds were distributed during the animal breeding: a starter feed, a growing feed and a laying feed. For all the ducks, the starter feed was used for eight weeks and was followed by the growing feed, from the 8th week up to the laying onset at 6 months. The laying feed was served to the birds from 6 month old going. Feeds given to animals were bought in the commerce and their nutritional values are presented in the table I.

Health monitoring

Animals were regularly given health and medical cares. In order to limit mortalities and maintain their vitality in farm, sanitary prophylaxis was instituted by installing footbaths at farm entrance and breeding facilities were also cleaned and disinfected.

Concerning the medical prophylaxis, birds were vaccinated against Newcastle disease with CEVA® regularly treated against gastrointestinal parasites with Alfamisole® (Levamisole 200mg) and monthly treated against coccidiosis using Amprolium® (hydrochloride of amprolium).

Birds choice and slaughter

Animals were chosen according to their age and weight. All males and females with weights close to the average weight were selected as ten (10) birds including five (5) males and five (5) females for each age class. In total, 4 age classes were formed: 1st class (4 months; 6 months), 2nd class (6months; 8 months), 3rd class (8 months; 10 months) and 4th class (> 10 months).

They were fed until the slaughter day eve before a feed withdrawal of 12 hours. They were bled by section of the jugular vein and then scalded in boiling water and manually plucked. Birds had a number through which they were identified.

Body composition of Muscovy duck

After slaughter and plucking, the ducks' legs were sectioned at the tibio-metatarsal joint and the head separated from the neck at the skull-atlas junction. Abdominal and thoracic cavities organs were removed, as well as abdominal fat. Slaughtered animals' carcasses were kept in coolers and sent to the Laboratory of Animal Biotechnology and Meat Technology. Data were collected using a data sheet containing: animal's number or identifier, age, sex and slaughter date. The animal live weight at slaughter, the hot carcass weight and that of the cold carcass were taken with a 5000 gram KERN scale of precision 50 gram. Each carcass were cut to determine the weights of the breast, of the thigh-drumstick, of the wings and of the carcass rest. Liver, gizzard, heart, head and legs were also weighed. The hot and the cold carcasses yields were calculated based on the live weight at slaughter. Carcass cuts and fifth quarter components percentages were calculated in relation to the cold carcass weight.

Statistical analysis

The collected data were analysed with the Statistical Analysis System (SAS, 2013) software. Averages, standard deviations and variation coefficients were calculated using the Proc means procedure and frequencies using the Proc freq procedure. A linear model with fixed effects has been adjusted to data and includes sex and slaughter age fixed effects. The generalized linear model procedure was used for analysis of variance. The F test was used to determine the significance of each model effect. Averages were compared paired by the t test. The correlations between variables were determined using the Proc corr procedure. The Principal Components Analysis (PCA) of carcass traits was performed by the Proc princompt procedure.

Results

Muscovy ducks carcass traits according to the sex

The body composition of the Muscovy duck varied according to the sex (Table 2). The live weight at slaughter, the hot carcass weight and the cold carcass weight of males were significantly higher ($p<0.001$) than those of females.

Table 1. Nutritional values of feeds.

Items	First period	Growing period	Laying period
Crude protein (%)	21	19	18.5
Lysine (%)	1.1	1	0.9
Methionine (%)	0.5	0.44	0.44
Calcium (%)	1	1.01	5
Total phosphorus (%)	0.55	0.5	0.5
Crude ash (%)	7.37	7.12	13
Crude cellulose (%)	2.5	3.32	-
Sodium (%)	0.2	-	-
Crude fat (%)	5.54	5	4.5
Flavomycin (%)	0.007	0.007	0.005
Chloride (%)	0.23	-	-
Metabolizable energy (kcal/kg)	2900	2800	2500

The same trend was recorded for the hot and cold carcasses yields ($p<0.01$). On the other hand, the chilling loss in females was higher ($p<0.05$) than that in males. However, the carcass cuts weight: breast, wings and thigh-drumstick and the fifth quarter components weight: heart, neck, liver, gizzard, head and legs, were lower ($p<0.001$) in females compared to males. In addition, the abdominal fat weight observed in females was higher ($p<0.01$) than that in males. However, there was no difference between the proportions of thigh-drumstick, heart and liver ($p> 0.05$) of females and males.

Table 2. Body composition of Muscovy ducks by sex and slaughter age.

Variables	Sex effet		Slaughter age effet				RSD	ANOVA	ANOVA
	Female	Male	Age 1	Age 2	Age 3	Age 4		Sex	Age
Live weight (g)	1857.5a	3158.75b	2075c	2515b	2635b	2807.5a	152.20	***	***
Hot carcass weight (g)	1222.5a	2217.50b	1430c	1765b	1775b	1910a	147.37	***	***
Cold carcass weight (g)	1184.95a	2170.80b	1377.5c	1714b	1742.5ba	1877.5a	149.20	***	***
Hot carcass yield (%)	66.08a	70.17b	69.03a	69.38a	67.05a	67.04a	4.45	**	NS
Cold carcass yield (%)	64.03a	68.56b	66.55a	67.17a	65.75a	65.72a	4.45	**	NS
Chilling loss (%)	3.10a	2.30b	3.58a	3.23a	2.04b	1.96b	1.11	*	**
Breast (g)	356.91a	628.78b	378.27c	486.9b	541.07a	565.15a	59.44	***	***
Wings (g)	239.71a	458.99b	275.96c	328.99b	401.39a	391.06a	32.01	***	***
Thigh (g)	250.44a	460.16b	310.39c	368.14ba	353.83a	388.83b	29.17	***	***
Fifth quarter (g)	408.50a	567.50b	370.45c	450.28b	483.74ba	541.10a	84.33	***	***
Abdominal fat (g)	27.00a	15.86b	17.05c	20.72b	22.26ba	24.90a	17.95	**	***
Heart (g)	13.36a	23.20b	16.22c	18.50b	17.61ab	20.79a	2.12	***	***
Neck (g)	116.65a	228.97b	136.22c	181.68b	173.21b	200.12c	15.75	***	***
Liver (g)	30.75a	45.76b	32.35b	36.42b	49.22a	35.03b	10.39	***	**
Gizzard (g)	42.14a	53.94b	45.85b	53.12a	41.42b	51.77a	6.84	***	**
Head (g)	70.99a	115.09b	80.7c	93.92b	92.96ba	104.56a	18.18	***	NS
Legs (g)	43.09a	90.17b	59.30c	65.63b	68.01ba	73.58a	6.63	***	***
Breast (%)	30.08a	28.87a	27.49c	29.14bc	30.49a	30.49a	2.51	NS	*
Wings (%)	20.22a	21.11b	19.97bc	19.39c	22.76a	20.53b	1.18	*	***
Thigh (%)	21.19a	21.45a	22.27a	22.01ab	20.33b	20.67ab	2.04	NS	NS
Fifth quarter (%)	33.42a	25.59b	25.92a	25.51a	27.25a	28.33a	6.99	***	NS
Abdominal fat (%)	2.21a	0.72b	1.19a	1.17a	1.25a	1.30a	1.60	**	NS
Heart (%)	01.13a	1.08a	1.18a	1.10ab	1.01b	1.12a	0.12	NS	*
Neck (%)	9.81a	10.54b	9.79b	10.49a	9.77b	10.64a	0.75	**	*
Liver (%)	2.60a	2.17a	2.3ab	2.28ab	2.94a	2.02b	07.33	NS	NS
Gizzard (%)	3.56a	2.55b	3.38b	3.31b	2.51a	3.01b	0.44	***	***
Head (%)	6.00a	5.35b	5.88a	5.62a	5.54a	5.67a	0.83	*	NS
Legs (%)	3.64a	4.21b	4.19a	3.81b	3.85b	5.67a	0.33	***	*

*: $p<0.05$; **: $p<0.01$; ***: $p<0.001$; NS: $p> 0.05$; RSD: residual standard deviation; Averages of the same row followed by different letters differ significantly at the threshold of 5%; Age 1: 4 months - 6 months; Age 2: 6 months - 8 months; Age 3: 8 months - 10 months; Age 4: from 10 months.

Muscovy ducks carcass traits according to the slaughter age

The carcass composition was also influenced by the duck slaughter age (Table 2). The slaughter live weight, the hot and the cold carcasses weights, the wings weight and that of the thigh-drumstick as well as the fifth quarter components weight increased with birds' age.

These weights increased gradually from age class 1 to age class 4. The lowest weights were recorded in ducks from age class 1 followed respectively by those from age class 2, 3 and 4. On the contrary, the head weight, the hot and the cold carcasses yields as the abdominal fat weight didn't vary with age ($p>0.05$). On the other hand, the chilling loss decreased gradually with the ducks age ($p<0.01$). As for organs percentages, only the thighs, the liver and the head showed no significant differences between the age classes ($p> 0.05$).

Table 3. Body composition of Muscovy ducks according to slaughter age by sex.

Variables	Female				Male				RSD	ANOVA
	Age 1	Age 2	Age 3	Age 4	Age 1	Age 2	Age 3	Age 4		
Live weight (g)	1680f	1800e	1910d	2040d	2470c	3230b	3360a	3575a	152.20	***
Hot carcass weight (g)	1150e	1200d	1250d	1290d	1710c	2330b	2300b	2530a	147.37	***
Cold carcass (g)	1120d	1149.8d	1220d	1250d	1635c	2278.2b	2265b	2505a	149.20	***
Hot carcass yield (%)	68.47a	66.83a	65.67a	63.33a	69.59a	71.93a	68.43a	70.75a	4.45	NS
Cold carcass yield (%)	66.62a	64.03a	64.1a	61.38a	66.48a	70.31a	67.4a	70.06a	4.45	NS
Chilling loss (%)	2.68c	4.19a	2.41cb	3.11b	4.48a	2.26c	1.5dc	0.97d	1.11	**
Breast (g)	310.56d	355.8c	365.64c	395.66c	445.98bc	618a	716.5a	734.64a	59.44	**
Wings (g)	219.14d	229.06b	266.34d	244.3dc	332.78dc	428.92b	536.44a	537.82a	32.01	***
Thighs (g)	233.46d	262.4c	248.4c	257.4c	387.33b	473.8a	459.26a	473.8a	29.17	**
Fifth quarter (g)	310.7d	369.02c	369.02b	505.68a	430.2b	531.54a	598.46a	575.51a	84.33	NS
Abdominal fat (g)	14.3d	16.98c	16.98c	24.32a	19.8b	24.46a	27.54a	26.48a	17.95	NS
Heart (g)	13.23d	13.39d	12.26d	14.56d	19.2c	23.62b	22.96b	27.02a	2.12	**
Neck (g)	106.37d	115.52d	112.34d	132.36c	166.08b	247.84a	234.08a	267.88a	15.75	***
Liver (g)	22.9c	30.2b	39.82b	30.08bc	41.8bc	42.64b	58.62a	39.98b	10.39	NS
Gizzard (g)	40.5d	44.78c	36d	47.28c	51.2b	61.46a	46.84b	56.26b	6.84	NS
Head (g)	65.8e	68.06e	75.72d	74.36b	95.6ac	119.78b	110.2b	134.76a	18.18	NS
Legs (g)	40e	41.86e	45.28d	45.22e	78.6c	89.4c	90.74b	101.94a	6.63	*
Breast (%)	27.81a	30.89a	29.97a	31.65a	27.18a	27.38a	31.61a	29.33a	2.51	NS
Wings (%)	19.55bc	19.92bc	21.82a	19.57bc	20.4b	18.86c	23.69a	21.48a	1.18	*
Thighs (%)	20.8ab	23a	20.37ab	20.59b	23.74a	21.01a	20.29ab	20.76ab	2.04	NS
Fifth quarter (%)	27.02b	30.75b	29.52b	39.20a	25.16b	22.81c	26.02b	22.75c	6.99	*
Abdominal fat (%)	1.24b	1.42a	1.36a	1.32a	1.56a	1.05b	1.20b	1.05b	1.60	*
Heart (%)	1.19a	1.16a	1.01a	1.17a	1.17a	1.04a	1.01b	1.08b	0.12	NS
Neck (%)	9.44a	9.1ab	9.2b	10.58a	10.14b	10.97b	10.33b	10.7a	0.75	NS
Liver (%)	2.04a	2.65a	3.28a	2.44a	2.57a	1.91a	2.6a	1.6b	07.33	NS
Gizzard (%)	3.63a	3.88a	2.96c	3.8b	2.96ab	2.74c	2.07c	2.25c	0.44	NS
Head (%)	5.9a	5.93a	6.22a	5.96a	5.86a	5.31a	4.87a	5.38a	0.83	NS
Legs (%)	3.57c	3.65b	3.71c	3.62c	4.81a	3.98b	3.99b	4.07a	0.33	**

*: p<0.05; **: p<0.01; ***: p<0.001; NS: p>0.05; RSD: residual standard deviation: Averages of the same row followed by different letters differ significantly at the threshold of 5%; Age 1: 4 months - 6 months; Age 2: 6 months - 8 months; Age 3: 8 months - 10 months; Age 4: from 10 months;

Slaughter age and sex interaction on ducks carcass traits

Ducks carcass traits comparison by slaughter age for each sex is presented in the Table 3. The age effect on these characteristics was more observed in males than in females. Thus, the live weight at slaughter, the hot and the cold carcasses weights of males increased (p<0.001) with slaughter age. On the other hand, in females, apart from birds from age class 1, no significant difference was observed between these variables. The same trend was observed with the breast, the thigh-drumstick and the wings weights (p<0.01). Age didn't affect the hot and the cold carcasses yields in both males and females. However, the chilling loss of females was different from one age class to another (p<0.01). The weights of the heart, of the neck and of the legs of males varied more with age (p<0.05) than those of females. No significant difference was found between the percentages of breast, thigh and of fifth quarter components (p>0.05) for all the age classes in both males and females.

Correlations between Muscovy duck body components

The Table 4 presents the correlation coefficients between age and slaughter weight, carcass traits and fifth quarter components of the Muscovy duck.

Table 4. Correlations between age, slaughter weight, carcass traits and fifth quarter components of Muscovy duck.

Variables	LW	HCar	CCar	Breast	Wings	Thigh	FQuar	Fat	Heart	Neck	Liver	Gizzard	Head	Legs	HCarY	CCarY	CL
Age	0.60**	0.52*	0.51*	0.57**	0.71***	0.17NS	0.30NS	-0.26NS	-0.11NS	0.23NS	0.55*	-0.15NS	0.82***	0.56*	-0.33NS	-0.28NS	-0.17NS
LW		0.72***	0.70***	0.63**	0.54*	0.45*	0.77***	-0.34NS	0.32NS	0.59**	0.50*	0.41NS	0.69***	0.76***	-0.69NS	-0.63***	-0.17NS
HCar			0.99***	0.85***	0.76***	0.37NS	0.28NS	-0.35NS	0.26NS	0.84***	0.06NS	0.41NS	0.76***	0.78***	0.004NS	0.07NS	-0.31NS
CCar				0.80***	0.77***	0.36NS	0.24NS	-0.38NS	0.20NS	0.84***	0.07NS	0.37NS	0.76***	0.80***	0.02NS	0.1NS	-0.46**
Breast					0.71***	0.25NS	0.32NS	-0.37NS	0.34NS	0.74***	0.07NS	0.43NS	0.68**	0.66**	-0.03NS	-0.02NS	-0.03NS
Wings						0.23NS	0.09NS	-0.34NS	0.12NS	0.46*	0.34NS	-0.01NS	0.73***	0.69***	0.003NS	0.07NS	-0.34NS
Thigh							0.08NS	0.21NS	-0.01NS	0.27NS	0.22NS	0.26NS	0.38NS	0.47*	-0.30NS	-0.27NS	-0.08NS
FQuar								-0.34NS	0.32NS	0.28NS	0.49*	0.40NS	0.29NS	0.37NS	-0.79***	-0.79**	0.14NS
Fat									-0.34NS	-0.30NS	0.31NS	-0.16NS	-0.33NS	-0.33NS	-0.84**	-0.86**	0.37NS
Heart										0.32NS	-0.02NS	0.61**	-0.15NS	0.23NS	-0.18NS	-0.22NS	0.23NS
Neck											-0.20NS	0.58**	0.54*	0.66**	0.02NS	0.10NS	-0.34NS
Liver												-0.08NS	0.35NS	0.24NS	-0.65**	-0.62**	-0.06NS
Gizzard													0.03NS	0.47*	-0.18NS	-0.18NS	0.04NS
Head														0.64**	-0.22NS	-0.14NS	-0.32NS
Legs															-0.30NS	-0.19NS	-0.44NS
HCarY																0.98***	-0.08NS
CCarY																	-0.28NS

*: p<0.05; **: p<0.01; ***: p<0.001; NS: p>0.05; LW: live weight; HCar: hot carcass; CCar; cold carcass; FQuar: Fifth quarter; Fat: abdominal fat; HCarY: hot carcass yield; CCarY: cold carcass yield; CL: chilling loss.

The animal age at slaughter was positively correlated with the live weight at slaughter, the hot carcass weight, the cold carcass weight, the breast weight, the wings weight, the head weight and the one of the legs (p<0.05). Similarly, the live weight at slaughter was highly associated to the weights of the hot carcass, of the cold carcass, of the cuts and to those of some fifth quarter organs such as: neck, liver, head and legs (p<0.05). By contrast, there was a negative correlation between the live weight at slaughter and the cold carcass yield (p<0.001).

The hot carcass and the cold carcass weights were significantly correlated with the weights of the breast, of the thigh-drumstick, of the neck, of the head and with that of the legs (p<0.001).

The cold carcass weight was inversely correlated (p<0.01) with the chilling loss and had no effect on the thigh-drumstick weight and on the fifth quarter weights (p>0.05). The weights of the breast, of the thigh-drumstick and of the wings were not related to the heart, liver and gizzard weights (p>0.05). However, negative but not significant correlations were observed respectively between the chilling loss, the age, the live weight and those of the hot carcass, breast, wings, thigh-drumstick, neck, liver, gizzard, head and legs (p>0.05).

Correlation between carcass traits and percentages of cuts and of fifth quarter

The Table 5 presents the correlation coefficients between age, slaughter weight, weight and percentages of carcass, cuts and of fifth quarter components of the Muscovy ducks.

The animal age at slaughter was positively correlated with wings and liver percentages (p<0.05) and was not related to percentages of breast, thigh-drumstick, abdominal fat, heart, neck, gizzard, head and of legs (p>0.05).

The animal live weight at slaughter, the hot carcass weight and that of the cold carcass were not correlated with percentages of breast, wings, thigh-drumstick, abdominal fat and of some fifth quarter organs as: heart, liver, gizzard, head and legs (p>0.05).

Table 5. Correlations between age, slaughter weight, weight and percentages of carcass, cuts and of fifth quarter components of Muscovy ducks.

Variables	PBreast	PWings	PThighs	PFQuar	PFat	PHeart	PNeck	PLiver	PGizzard	PHead	PLegs
Age	0.39^{NS}	0.55*	-0.17^{NS}	0.17^{NS}	-0.49^{NS}	-0.38^{NS}	-0.01^{NS}	0.45*	-0.39^{NS}	0.36^{NS}	0.21^{NS}
LW	0.30^{NS}	0.09^{NS}	-0.01^{NS}	0.61**	-0.56^{NS}	-0.09^{NS}	0.40^{NS}	0.37^{NS}	0.14^{NS}	-0.11^{NS}	0.32^{NS}
HCar	0.35^{NS}	0.12^{NS}	-0.29^{NS}	0.05^{NS}	-0.57^{NS}	-0.28^{NS}	0.56*	-0.12^{NS}	0.01^{NS}	-0.44^{NS}	-0.05^{NS}
CCar	0.25^{NS}	0.12^{NS}	-0.31^{NS}	-0.01^{NS}	-0.60^{NS}	-0.35^{NS}	0.55*	-0.12^{NS}	-0.04^{NS}	-0.45*	-0.03^{NS}
Breast	0.78***	0.24^{NS}	-0.29^{NS}	0.13^{NS}	-0.59^{NS}	-0.11^{NS}	0.54*	-0.07^{NS}	0.10^{NS}	-0.27^{NS}	0.01^{NS}
Wings	0.35^{NS}	0.73***	-0.28^{NS}	-0.10^{NS}	-0.56^{NS}	-0.30^{NS}	0.17^{NS}	0.19^{NS}	-0.34^{NS}	-0.16^{NS}	0.10^{NS}
Thighs	0.02^{NS}	-0.0^{NS}	0.77***	0.01^{NS}	-0.01^{NS}	-0.22^{NS}	0.14^{NS}	0.20^{NS}	0.13^{NS}	-0.01^{NS}	0.32^{NS}
FQuar	0.28^{NS}	-0.12^{NS}	-0.07^{NS}	0.97***	-0.53^{NS}	0.17^{NS}	0.25^{NS}	0.44^{NS}	0.34^{NS}	0.04^{NS}	0.28^{NS}
Fat	-0.26^{NS}	-0.60^{NS}	0.34^{NS}	0.75*	-0.53^{NS}	0.20^{NS}	0.11^{NS}	0.89**	0.63^{NS}	0.44^{NS}	0.31^{NS}
Heart	0.34^{NS}	-0.01^{NS}	-0.15^{NS}	0.27^{NS}	0.12^{NS}	0.85***	0.35^{NS}	-0.06^{NS}	0.57**	-0.49*	0.11^{NS}
Neck	0.32^{NS}	-0.17^{NS}	-0.3^{NS}	0.08^{NS}	-0.37^{NS}	-0.15^{NS}	0.91***	-0.36^{NS}	0.25^{NS}	-0.52*	-0.05^{NS}
Liver	0.06^{NS}	0.47*	0.19^{NS}	0.48*	-0.55^{NS}	-0.08^{NS}	-0.33^{NS}	0.98***	-0.12^{NS}	0.36^{NS}	0.31^{NS}
Gizzard	0.29^{NS}	-0.40^{NS}	0.01^{NS}	0.32^{NS}	-0.55^{NS}	0.38^{NS}	0.59**	-0.15^{NS}	0.91***	-0.50*	0.28^{NS}
Head	0.30^{NS}	0.32^{NS}	-0.13^{NS}	0.11^{NS}	-0.95***	-0.55*	0.26^{NS}	0.21^{NS}	-0.31^{NS}	0.23^{NS}	0.03^{NS}
Legs	0.22^{NS}	0.21^{NS}	-0.06^{NS}	0.18^{NS}	-0.95***	-0.21^{NS}	0.42^{NS}	0.10^{NS}	0.16^{NS}	-0.32^{NS}	0.57**
HCarY	-0.07^{NS}	-0.02^{NS}	-0.33^{NS}	-0.81^{NS}	0.33^{NS}	-0.16^{NS}	0.01^{NS}	-0.66**	-0.20^{NS}	-0.33^{NS}	-0.53*
CCarY	-0.16^{NS}	-0.02^{NS}	-0.36^{NS}	-0.84***	-0.49^{NS}	-0.25^{NS}	0.06^{NS}	-0.64**	-0.25^{NS}	-0.37^{NS}	-0.49**
CL	0.44^{NS}	-0.03^{NS}	0.23^{NS}	0.26^{NS}	-0.56^{NS}	0.47*	-0.20^{NS}	0.03^{NS}	0.26^{NS}	0.26^{NS}	-0.10^{NS}

*: p<0.05; **: p<0.01; ***: p<0.001, NS: P>0.05. LW: live weight; HCar: hot carcass; CCar: cold carcass; FQuar: Fifth quarter; Fat: abdominal fat; HCarY: hot carcass yield; CCarY: cold carcass yield; PBreast: breast percentage; PWing: wings percentage; PThigh: thighs percentage; PFQuar: Fifth quarter percentage; PFat: abdominal fat percentage; PHeart: heart percentage; PNeck: neck percentage; PLiver: liver percentage; PGizzard: gizzard percentage; PHead: head percentage; PLeg: legs percentage; CL: chilling los.

The correlations between the breast weight, the wings weight and the thigh-drumstick weight and respectively the percentages of some fifth quarter organs such as heart, liver, gizzard, head, legs and the abdominal fat percentage were not significant.

Correlations between percentages of carcass cuts and of fifth quarter components of Muscovy duck

The table 6 presents the correlation coefficients between percentages of the carcass cuts and of the fifth quarter components.

The correlation was positive and not significant between percentages of breast and those of wings and of fifth quarter components (p>0.05). Besides, it was negative and not significant with thigh-drumstick and abdominal fat percentages (p>0.05). The wings percentages was negatively and significantly correlated with abdominal fat and gizzard percentages (p<0.05). Similarly, the abdominal fat percentage was highly related to the liver and head percentages (p<0.001).

Principal Component Analysis of carcass traits and of fifth quarter

The Fig. 1 shows the principal components analysis of carcass traits and those of fifth quarter. Two axes were obtained for the results interpretation. Axis 1 explains 60.03% of variations and axis 2 represents 16.63% of variations.

Three groups were obtained: the group 1 concerns the carcass weight and those of cuts and of fifth quarter components; the group 2 is about to the proportions

of cuts and of fifth quarter components; and the group 3 concerns carcass yields at slaughter. Considering the axis 1, the carcass cuts weight and those of the viscera and of the offal were opposed to the percentages of the carcass cuts and of the thoracic and abdominal viscera. Considering the axis 2, the slaughter yields were opposed to the percentages of carcass cuts and of viscera and in little extent, to carcass, offal and viscera weights.

Table 6. Correlations between percentages of carcass cuts and those of fifth quarter components in Muscovy duck.

Variables	PWings	PThigh	PFQuar	PFat	PHeart	PNeck	PLiver	PGizzard	PHead	PLeg
PBreast	0.28^{NS}	-0.15^{NS}	0.23^{NS}	-0.09^{NS}	0.19^{NS}	0.30^{NS}	0.02^{NS}	0.19^{NS}	0.03^{NS}	0.03^{NS}
PWing		-0.09^{NS}	-0.16^{NS}	-0.77*	-0.08^{NS}	-0.31^{NS}	0.44^{NS}	-0.48*	0.23^{NS}	0.19^{NS}
PThigh			0.01^{NS}	0.45^{NS}	0.01^{NS}	-0.24^{NS}	0.30^{NS}	0.15^{NS}	0.30^{NS}	0.36^{NS}
PFQuar				0.88**	0.26^{NS}	0.11^{NS}	0.47^{NS}	0.36^{NS}	0.15^{NS}	0.30^{NS}
PFat					0.29^{NS}	-0.15^{NS}	0.96***	0.80*	0.96***	0.61^{NS}
PHeart						0.02^{NS}	-0.02^{NS}	0.56^{NS}	-0.23^{NS}	0.17^{NS}
PNeck							-0.44^{NS}	0.38^{NS}	-0.48*	-0.05^{NS}
PLiver								-0.11^{NS}	0.45*	0.33^{NS}
PGizzard									-0.33^{NS}	0.32^{NS}
PHead										0.10^{NS}

*: p <0.05; **: p<0.01; ***: p<0.001; NS: p> 0.05; PBreast: breast percentage; PWing: wings percentage; PThigh: thighs percentage; PFQuar: Fifth quarter percentage; PFat; abdominal fat percentage; PHeart: heart percentage; PNeck: neck percentage; PLiver: liver percentage. PGizzard: gizzard percentage; PHead: head percentage; PLeg: legs percentage.

Discussion

Body composition of Muscovy ducks reared in South Benin according to the sex

The ducks carcass traits varied significantly according to the sex. Thus, the live weight at slaughter, the hot carcass weight, the cold carcass weight, the breast weight, the wings weight, the thighs weight and the weight of the fifth quarter components of females were lower than those recorded in males. The same trends were obtained by Tomasz *et al.* (2007), Omojola (2007), Baeza *et al.* (2013) and Makram *et al.* (2017) in Muscovy ducks. This difference in body components weight of females and males is due to the high sexual dimorphism in this species of which, females weigh half lower than males (Dikken *et al.*, 2004, Cicar, 2014, Houessionon *et al.*, 2018). Similarly, in previous studies on carcass composition of other poultry species such as chickens, guinea fowl, geese, similar results are observed. Indeed, Youssao *et al.* (2010), Tougan *et al.* (2013) and Bonou *et al.* (2017) reported in different studies carried out on local *Gallu-Gallus* poultry populations, sex effect on different carcass components weights. Dahaouda *et al.* (2008) and Uhlířová *et al.* (2018) also had similar results respectively in guinea fowl and geese.

The carcass yields of males (70.17%) and females (66.08%) in this study are almost similar to those reported by Makram *et al.* (2017) in males (71.6%) and females (68.5%) in the same species in Egypt. On the contrary, in Poland, Adamski *et al.* (2011), in a study on the effect of diet with boiled cereal grains on carcass traits of Pekin ducks (*Anas platyrhynckos*), report lower yields of 66.6% and 62.9% respectively in male and female. The chilling loss and the abdominal fat weight of females in the current study are superior to those obtained in males. The same trend is observed by Tomasz *et al.* (2004) and Makram *et al.* (2017) who reported abdominal fat proportions of 2.5% and 1.37%, respectively, in Pekin and Muscovy ducks. The high abdominal fat weight observed in females in this study is not accompanied

by that of the liver weight; males had heavier livers. By contrast, in Egypt, Makram *et al.* (2017) recorded the highest abdominal fat and liver weights or percentages in females in a study of Muscovy duck carcass traits. This difference between males and females is probably related to a better food conversion in male that promotes muscle formation while in female, the nutrients metabolism promotes fat, at the same age. In addition, breast, wings and thighs percentages in our study are higher than those obtained by Omojala (2007) in Nigeria and Makram *et al.* (2017) in Egypt on males and females of Muscovy ducks.

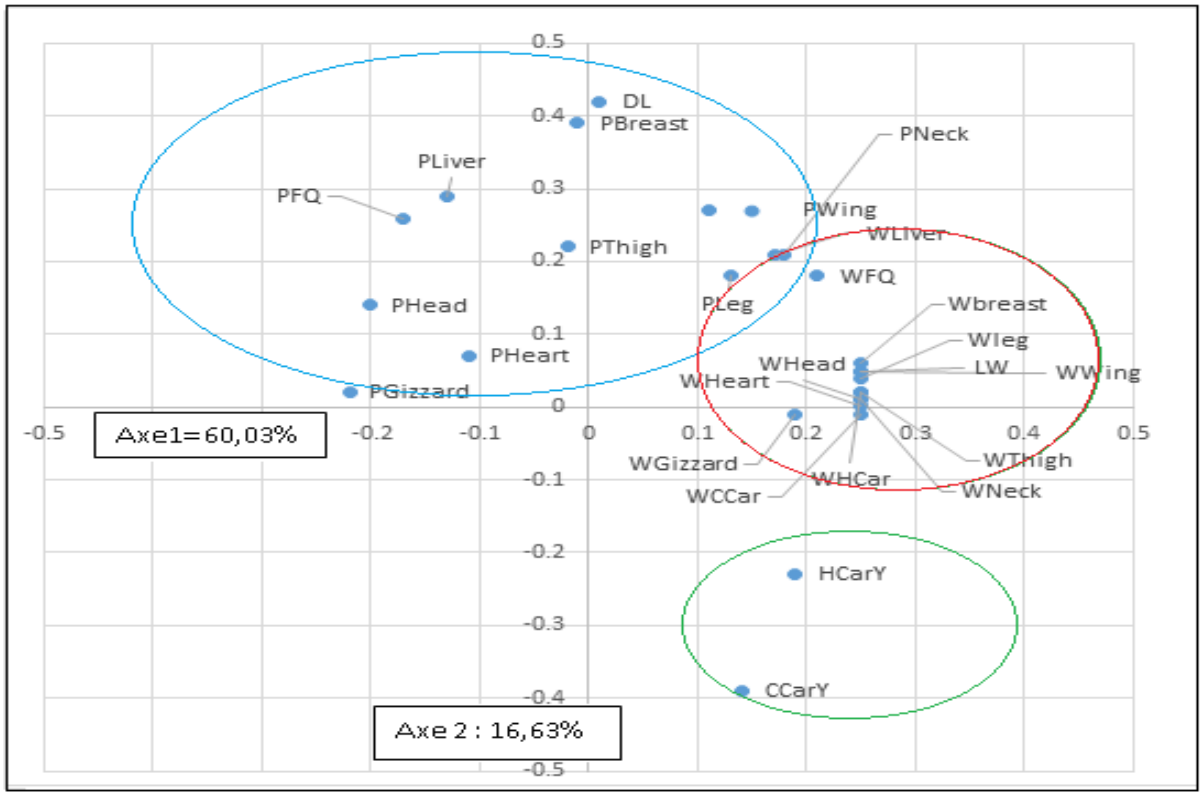

Fig. 1. Principal Component Analysis of carcass and fifth quarter characteristics of Barbary Duck. LW: live weight; WHCar: Hot carcass weight; WCCar; Cold carcass weight; WGizzard: gizzard weight; WThigh: thighs weight; WNeck: neck weight; WWing: wings weight; WLiver: liver weight; WFQ: fifth quarter weight; WHead: head weight; WHeart: heart weight; Wleg: legs weight; Wbreast: breast weight; HCarY: hot carcass yield; CCarY: cold carcass yield, Pbreast: breast percentage, PWing: wing percentage, PThigh: thighs percentage, PFQ: fifth quarter percentage; PHeart: heart percentage; PNeck: neck percentage; PLiver: liver percentage; PGizzard: gizzard percentage; PHead: head percentage; PLeg: legs percentage; DL: chilling loss.

Body composition of Muscovy ducks reared in South Benin according to the age at slaughter

The Muscovy ducks carcass traits depend on the age at slaughter. Thus, the live weight at slaughter, the hot carcass weight and those of the cold carcass and of the cuts such as breast, wings, thigh-drumstick and of the fifth quarter components have increased following birds age. Similar results are reported by Larzul *et al.* (2006) and Erisir *et al.* (2009) respectively on *Cairina moschata* and *Anas platyrhyncos*. The average weight of Muscovy ducks of more than 10 months in our study is 2807.5 g but according to Baeza *et al.* (2013) studies on carcass quality, the average live weight of 14-weeks-old Muscovy ducks non-crammed is 5418 g against 6393 g for crammed birds. Also, in the current study, it is found that the same age's Muscovy ducks of different sexes have different weights and percentages of cuts and of fifth quarter organs because females weigh half lower than males (Houessionon *et al.*, 2018).

Chartin *et al.* (2006), comparing the body composition of Muscovy ducks of more than 12 weeks, recorded liver weights of 77 g and 467 g respectively in lean and crammed birds. Furthermore, in our study, the highest liver weight was 49.22 g in 8 to 10-months-old ducks and this weight is lower than those above. This difference in weight could be explained by the higher live weight of crammed ducks compared to the non-crammed one. When live weight is higher, liver gets heavier and peripheric subcutaneous and abdominal fats double (Baeza *et al.*, 2013). The same trend is reported by Larzu *et al.* (2006) in lean and crammed ducks of 12 weeks of age.

Relationship between the Muscovy duck body components

In the current study, the animal age at slaughter is related to the live weight at slaughter, the hot carcass weight, the cold carcass weight and to the carcass cuts weight. Similar results are reported by Larzul *et al.* (2006) and Erisir *et al.* (2009). Besides, there is also a high relationship between the animal live weight, the hot carcass weight, the cold carcass weight and the fifth quarter weight. Similar results were got by Tougan *et al.* (2013) in local poultry populations of *Galus galus* species and by Uhlířová *et al.* (2018) in geese. The carcass cuts weight and those of viscera and of offal are highly related to the ducks live weight and opposed to the percentages of carcass cuts and of thoracic and abdominal viscera. So, in Muscovy duck, it is possible to act on a carcass component to have a given live weight. Baeza *et al.* (2013) even report similar correlations between duck carcass components weight, especially for magret muscle, abdominal fat, liver and live weight. This relationship between duck body components could be used to estimate live bird weight.

Conclusion

The study on Muscovy duck body composition revealed that the live weight at slaughter, the hot carcass weight, and the weight of males' body components are higher than those recorded in females as well as the hot carcass and the cold carcass yields and the percentages of carcass components and of fifth quarter. Also, it should be noted that this duck carcass composition depends on the birds' age at slaughter and this effect is more remarkable in male than in female. Age did not affect hot carcass and cold carcass yields in both males and females. The weights of the carcass cuts and of the fifth quarter components are highly related to each other and opposed to the percentages of carcass cuts and of fifth quarter components. Better knowledge for this species, additional studies are needed on its technological and organoleptic meat quality.

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