RUFORUM Working Document Series (ISSN 1607-9345)2019, No. 18 (1):377 - 385.
Available from httpp://repository.ruforum.org

Research Application Summary

Performance of Kuroiler and local Ugandan chickens reared under extensive and intensive management systems: Carcass and meat traits

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Abstract

The effect of management system on carcass traits of Kuroiler and local chickens was the focus of this study. Day old chicks were brooded artificially and at three weeks, 240 chicks were distributed to farmers either practicing intensive or extensive system of management. The completely randomized design was used with three replications. At twenty weeks of age cocks from both breeds were selected from each replication and sacrificed for carcass analysis. Cocks of the Kuroiler ecotype had better carcass yield ($P<0.05$) than local cocks. However, local cocks had higher wing and neck weights. The muscles and breast, drumsticks and thighs of Kuroiler cocks were also significantly heavier ($P<0.05$) than those of local chickens. Differences in chemical and physical properties of carcasses from Kuroiler and local cocks were only observed with regard to body pH. Kuroiler chickens are better in producing the prized chicken cuts but does not differ much in quality. We conclude that meat from Kuroiler does not differ from that of local chickens and therefore could be promoted as such.

Key words: Breed, carcass parameter, local chickens, Kuroiler, meat quality

Résumé

L'effet du système de gestion sur les caractéristiques de la carcasse des poulets Kuroiler et locaux était au cœur de cette étude. Les poussins d'un jour ont été élevés artificiellement, et à trois semaines, 240 poussins ont été répartis chez les éleveurs pratiquant soit un système de gestion intensif, soit un système de gestion extensif. Le plan d'expérience complètement randomisé a été utilisé avec trois répétitions. À l'âge de vingt semaines, les coqs des deux races ont été sélectionnés dans chaque répétition et sacrifiés pour l'analyse des carcasses. Les coqs de l'écotype Kuroiler avaient une meilleure rendement de la carcasse ($P<0,05$) que les coqs locaux. Cependant, les coqs locaux avaient des poids d'aile et de cou plus élevés. Les muscles de la poitrine, les cuisses et les pilons des coqs Kuroiler étaient également significativement plus lourds ($P<0,05$) que ceux des poulets locaux. Des différences dans les propriétés chimiques et physiques des carcasses des coqs Kuroiler et locaux n'ont été observées qu'en ce qui concerne le pH corporel. Les poulets Kuroiler sont meilleurs pour produire les morceaux de poulet prisés, mais leur qualité ne diffère pas beaucoup. Nous concluons que la viande des Kuroiler ne diffère pas de celle des poulets locaux et pourrait donc être promue en tant que telle.

Mots-clés : Race, paramètre de la carcasse, poulets locaux, Kuroiler, qualité de la viande

Introduction

The global meat production reached 302 million tons in late 2012, having risen by 15% over the preceding decade and with the average consumption per person in developing countries standing at 32.3 kg and rising faster than for the industrialised countries (Mehta-Bhatt and Ficarelli, 2014). Chicken meat production across the world recently scored second to pork, with 106 million tons (Chemnitz, 2014) and poultry is expected to become the most-produced meat in the near future (Nierenberg and Reynolds, 2012). Whereas the issue of quantity of chicken produced and made available to the human population is steadily being addressed globally; concerns on quality have not been targeted by the commodity workers. Quality of meat is judged by its tenderness, flavour, colour and its taste (Kugonza *et al*., 2015). This quality is influenced by the breed, production system, age at slaughter and the nutritional regime (Sogunle *et al*., 2010; Sanka and Mbaga, 2014). For quite some time, chicken meat type has been improved through selection of better chicken breeding stock mainly to increase growth performance and their body composition, but the characteristics that consumers consider include colour of the meat and that of the skin, texture, taste and flavour. The appearance of chicken meat and skin is a result of interaction between genotype and production system, with the skin of local chickens becoming more yellow when birds had outdoor access; however, this did not occur when fast growing birds had outdoor access (Fanatico *et al*., 2007; Magala *et al*., 2012).

Skin colour results from the birds' genetic ability to produce melanin pigments in the dermal or epidermal melanophores and the birds' genetic ability to absorb and then deposit carotenoid pigments in its epidermis (Fletcher, 1999). In addition, colour is also influenced by the presence of myoglobin and haemoglobin pigments in muscles, while the discoloration of meat can be associated with the amount, chemical state and the way light is reflected off meat on these pigments (Northcutt, 2009). Local/native chickens have yellow skin while the skin of exotic/temperate breed skin tends to be darker (Jaturasitha *et al*., 2008). A correlation between muscle pH and meat colour exists with high muscle pH being associated with darker meat while low pH values are associated with lighter meat (Fletcher, 1999). In the extremes, high pH meat is often characterized as being dark, firm and dry and while the lighter meat is pale, and soft. Lower pH of chicken may be due to the better welfare conditions that reduce the stress pre-slaughter and thus amount of glycogen (Castellini *et al*., 2002; Musa *et al*., 2006).

Meat of local chickens has more advantages than that of exotic/commercial breeds especially at market level, and this is due to genetic potential and production system which make muscle of slow growing chickens to have poor water holding capacity which makes their meat to be more tender (Fanatico *et al*., 2007). This meat also tends to have low fat, chewy texture, better colour and flavour characteristics making local chicken meat to be the most preferred by consumers (Wattanachant *et al*., 2004; Saowakon *et al*., 2008; Magala *et al*., 2012).

Kuroiler chickens are new breed in Uganda having been recently introduced from India where they were bred for better growth performance (Harth, 2011) and are believed to produce meat similar characteristics to that of local chickens since their plumage and other body phenotypic features are similar. The objective of this study therefore was to determine the meat characteristics of Kuroiler and local chickens reared under intensive and extensive/free range management system.

Materials and Methods

Study sites and experimental design. The experiment was conducted at selected farms in Gulu district (2^{O} 51' 21 N, 32^{O} 25' 23 E) in Northern Uganda and Kiryandongo district (1^{O} 22' and 2^{O} 20 N, 31^{O} 22' and 32^{O} 23 E) in Mid-western Uganda. The experiment was 2x2x2 factorial with two chicken genotypes (Kuroiler and Local), two management systems (Intensive and Extensive) and two locations (Gulu and Kiryandongo districts). A completely randomized design was used with three replications. An experimental unit was ten chickens, giving a total of 240 birds.

Experimental birds and their management. Kuroiler chicks of one-day age were procured from the National Animal Genetic Resource Centre in Entebbe, Uganda which holds a franchise of Keggfarms in India, from whom they directly import the chicken genetics. The local chicks used in the study were procured from a private hatchery located in Gulu town. The two sets of chicks were partitioned into two batches, one for each location (Gulu and Kiryandongo) where they were then artificially brooded for three weeks, using a charcoal stove as the source of heat. During the brooding stage, all the chicks were housed in ventilated buildings in which the floors were covered with wood shavings. Chicks were fed a standard commercial chick mash obtained from a feed mixing firm in Gulu town and containing 20% CP, 3000 kcal/kg ME and 1% calcium. Drinking water was provided ad libitum. Vaccinations against Marek's disease, New Castle Disease NCD), Gumboro, infectious bronchitis, fowl pox and fowl typhoid were carried out following veterinary vaccination schedules to prevent breakouts of those infections.

After artificial brooding, the chicks were then randomly partitioned into groups for the respective experimental treatments. In each district, six farm household sites were selected; each of three farms reared five Kuroiler and five Local chicks under intensive management, while another three also reared five Kuroiler and five Local chicks under free range system. In the free range system, the birds were housed at night in specialised poultry units and were released in the morning to an unlimited/ restricted range area. Water was provided ad libitum, but no supplementary feed was given. The hens and cockerels under this system were dewormed monthly after initial release from the house. In the intensive system, chickens were placed in pens of open-sided poultry houses at a spacing of three birds per square metre. Litter was provided in the form of wood shavings and was kept dry by regular raking to avoid caking. The chickens had ad libitum access to food and cool fresh water.

At the age of 20 weeks, three cocks from each replicate were randomly selected and fasted for 18 hours and thereafter were slaughtered following conventional procedure, cognizant of all required animal handling and welfare considerations.

Data collection

Dressing percentage and carcass yield: After slaughtering and evisceration, the weight of the hot carcass, organs (intestines, liver, gizzard, heart, proventriculus and the testes) and the head was recorded. The hot carcass, organs and head yield was expressed as percentage of live body weight. Dressing percentage was computed as the ratio between hot carcass weight (without organs, intestines and head) and live body weight. The eviscerated carcasses were chilled at 4oC for twenty-four hours. The cold carcass weight was recorded. Carcass yield was computed as the ratio between the cold carcass then (without head) and live body weight. The cold carcass was partitioned into breast, wings, back, neck, thighs and drumsticks. The weight of breast, wings, back, neck, thighs and drumsticks were expressed as percentages of the cold carcass weight.

Carcass pH: the pH of the carcass was recorded on whole intact raw breast muscle (pectoralis major) one hour after slaughter (initial pH) as well as after chilling the carcasses for twenty-four hours at 1-4 ^{o}C (ultimate pH) as described by Qi *et al*. (2010). A portable pH meter was used.

Drip loss: samples of muscles from the breast, thigh and drumstick were weighed and suspended in a plastic bag using a string and place in a refrigerator at 1-4 ^{o}C (Omojola and Adesahinwa, 2007). After forty-eight hours, the muscles were weighed again. Drip loss was expressed as the percentage weight loss during refrigeration.

Cooking loss: samples used for determining the cooking loss were taken from the breast, thigh and drumstick muscles sealed individually in plastic bags (30 microns thickness) and cooked in a

thermostatically controlled water bath at 75 ^{o}C for 45 minutes (Rizz *et al*., 2007). After cooking, the samples were put under running cold water to cool for fifteen minutes. The samples were then dried and weighed. The weight loss during cooking was expressed as the cooking loss percentage (Kugonza *et al*., 2015).

Data analysis: Data analysis was performed using Statistical Analysis Systems, Portable Version 9.1.3 (SAS, 2004). Slaughter parameters were assessed using General Linear Models, with breed and management system of chickens as fixed effects.

The model used was:
$Y_{ijk} = \mu + b_i + m_j + bm_{ij} + e_{ijk} \sim N (0, \sigma\sigma^2)$

Where, y is observation of the trait in breed i reared under management system j of chicken: μ = overall mean, bi = effect of breed (i = 2), mj = management system effect (j = 2), bm is the interaction between breed and management system, eijk is the random effect on the trait, independently and identically distributed with mean = 0 and variance = σ^2.

Results

Slaughter characteristics of Kuroiler and Local cocks raised under two management systems. Dressing percentage and relative organ weight of Kuroiler and local cocks raised under extensive and intensive management system are presented in Table 1. The dressing percentage and relative organs weight of both breed reared under the two management system were similar (P>0.05), but Kuroiler chicken tended to have a higher dressing percentage than that for local chicken.

Carcass yield and carcass composition. Carcass yield and relative carcass portion weight of Kuroiler and local cocks reared under intensive and extensive management system are presented in Table 2. Although the breast, thigh, drumsticks, back, feet and carcass yield did not differ within the two management systems, Kuroiler cocks showed the highest carcass yield (P<0.05), while local cocks had the highest relative wing and neck yield (P<0.05). Muscles and bones in Kuroilers were significantly heavier (P<0.05) than those of local cocks (Table 3). Management system had an impact on the weight of breast lean and on the ratio of lean and bone. Cocks under intensive management had significantly heavier (P<0.05) breast muscles and lean: bone ratio.

Chemical and physical characteristics. The initial pH, the cooking loss and drip loss of carcass muscles did not differ between breed and management system (P>0.05) as shown in Table 4. Chicken reared under extensive management system showed the lowest pH after 24 hours of chilling compared to those under intensive (P<0.05).

Discussion

Slaughtering characteristics of chicken meat can differ between breed and management system. Dressing percentage, heart weight, liver weight and abdominal fat weight have been found to be significantly different (P<0.01) in Anka and Rugao breed in China (Musa *et al*., 2006). Nevertheless, our finding of no differences between breeds and between management systems have also been reported elsewhere (Jaturasitha *et al*., 2008). Olawumi *et al*. (2012) showed that the dressing percentage of different strains of broiler birds was not significantly different (P>0.05). Management system of birds is one of factors which play a role on the growth performance of chickens and as such, would be expected to also influence their meat characteristics. Interestingly, Magala *et al*. (2012) who also worked with local cocks reared under extensive and intensive system in Central Uganda found non-significant differences (P>0.05) in dressing percentage, as did Połtowicz and Doktor (2011) elsewhere.

Table 1. Dressing (%) of chickens between two breed reared under two management systems

Variable	Level	Dressing %	Organ weight (expressed as percentage of live weight)									
Breed			Head	Heart	Liver	Intestines	Gizzard	Proventriculus	Crop	Lungs	Kidney	Testes
	Kuroiler	66.75	4.41	0.55	1.41	5.55	2.02	0.30	0.43	0.64	0.09	0.85
	Local	63.02	4.77	0.56	1.69	5.97	1.81	0.38	0.62	0.67	0.13	0.60
Management System												
	Intensive	65.34	4.73	0.63	1.42	5.45	2.15	0.28	0.47	0.60	0.11	0.81
	Extensive	64.42	4.45	0.48	1.68	6.05	1.68	0.40	0.59	0.71	0.11	0.64
LSD		9.464	1.072	0.165	0.254	1.438	0.837	0.129	0.129	0.218	0.040	0.216

Means within variable having similar superscripts did not differ significantly (P>0.05)

Table 2. Effect of breed and management system on relative carcass portions of carcasses

Variable	Level	Cold carcass (g)	Carcass portions (expressed as percentage of cold carcass)						
Breed			Breast	Thigh	Drumstick	Wing	Back	Neck	Feet
	Kuroiler	2072.00[a]	22.96	19.95	18.40	11.10b	21.63	6.80b	5.98
	Local	1158.74[b]	23.78	19.72	18.22	14.06a	22.93	8.96a	7.22
Management System									
	Intensive	1718.40	24.81	20.38	18.49	12.34	22.81	8.17	6.65
	Extensive	1512.33	21.99	19.29	17.77	12.82	21.74	7.59	6.55
LSD		373.5	3.11	2.13	2.39	1.76	3.81	1.76	1.745

[a], [b] Means within variable and age group having different superscripts differ significantly (P<0.05)

Table 3. Effect of breed and management system on relative lean and born portion of carcasses

Variable	Level	Muscles with bone (g)			Muscles only (g)			Total Lean and bone		
Breed		Breast	Drumstick	Thigh	Breast	Drumstick	Thigh	Lean (g)	Bone (g)	Lean: bone
	Kuroiler	479.66[a]	372.33[a]	414.00[a]	302.66[a]	217.66[a]	304.00[a]	824.33[a]	491.66[a]	1.87
	Local	268.11[b]	209.37[b]	225.40[b]	138.37[b]	124.33[b]	169.22[b]	422.92[b]	279.96[b]	1.53
Management System										
	Intensive	418.44	310.37	347.07	256.03a	194.66	266.22	716.92	358.96	1.91a
	Extensive	329.33	271.33	292.33	185.00b	147.33	198.00	530.33	362.66	1.45b
LSD		84.693	60.048	68.237	50.24	46.227	84.195	156.43	66.66	0.29

[a,b] Means within variable and age group having different superscripts differ significantly (P<0.05)

Table 4. Chemical and physical properties of chicken muscles between two breeds reared under two management systems

Variable	Level	Chemical properties		Physical properties					
		Initial pH	Ultimate pH	Drip Loss (%)			Cooking Loss (%)		
				Breast	Thigh	Drumstick	Breast	Thigh	Drumstick
Breed									
	Kuroiler	6.10	5.54	3.74	5.26	4.94	26.42	29.79	28.11
	Local	6.05	5.49	4.48	5.21	5.34	21.36	26.23	27.18
Management System									
	Intensive	6.04	5.82a	4.37	5.27	5.28	26.54	29.12	28.82
	Extensive	6.10	5.22b	3.85	5.21	5.01	21.54	26.89	26.82
LSD		0.174	0.191	0.934	1.117	1.292	4.159	4.974	4.242

[a,b] Means within variable and age group having different superscripts differ significantly (P<0.05)

Whereas there were significant differences in carcass weight between the two chicken breeds, the management system did not affect carcass yield of the cocks. Varying strains of broilers have also been found to significantly differ (P<0.05) in carcass weight (Karima and Fathy, 2005). Commercial broiler breeds reared under intensive management have been found to differ significantly (Ojedapo *et al*., 2008), so did the chicken breeds in Thailand (Nakarin *et al*., 2014) and indigenous chickens in Spain (Franco *et al*., 2012). The genetic potential for growth performance of chicken breeds depends on the potential for deposition of muscles and results into different live and carcass weights. Broilers tend to have higher carcass, breast, and thigh yields than indigenous chickens (Zhao *et al*., 2009).

However, Jaturasitha *et al*. (2008) reported no difference (P>0.05) in carcass yield of four indigenous Thai chickens and Dou *et al*. (2009) found no difference in eviscerated carcass, breast and thigh percentages among three raising systems (P>0.05). Other studies elsewhere have reported that outdoor access had no effect on carcass yield of broiler chickens (Chen *et al*., 2013). Similarly, intensive and semi-intensive systems of managing chickens have been found to have no influence on weight of breast, thigh and drumstick meat of local chicken in Tanzania (Sanka and Mbaga, 2014). Lean and bone weight of the breast, drumstick and thigh portion of carcasses of Kuroiler and local chickens in our study were nevertheless significantly different. The study of Thai chickens (Jaturasitha *et al*., 2008) had also found significant differences in weight of breast muscles of four breeds.

Genetic potential such as the genetic type, breed, the line or the strain affect several characteristics of chicken meat quality (Toucan *et al*., 2013). Meat of Kuroiler and local cocks did not show any differences physical and chemical properties. After slaughter the glycogen in the muscle is converted into lactic acid causing a fall in pH from an initial value, and this explain the low pH of breast muscle after 24hours of chilling. Chicken under extensive system have muscles with higher glycogen reserves and that makes them have a lower ultimate pH (Smith and Northcutt, 2009). Low ultimate pH causes a long shelf life because it increases the lag phase time of psychrotrophic bacteria that are known to spoil meat, and the rate of pH can also be reduced by glycolytic enzymes just after death (Allen *et al*., 1997; Fanatico *et al*., 2007; Magala *et al*., 2012). Our results are supported by those of Jaturasitha *et al*. (2008), who found no difference in pH of meat from Thai chicken breeds. However, Musa *et al*. (2006) reported differences (P<0.05) in meat pH between Chinese chicken breeds, though in that study, the water holding capacity by meat from the studied breeds were not significant (P>0.05). Similarly, Diaz *et al*. (2010) also reported a significant (P<0.05) difference in ultimate pH of capon cocks from different Spanish breeds.

Our study found a significant (P<0.05) effect of management system on pH of chicken, consistent with a contemporary study (Magala *et al*., 2012), that reported pH of cocks reared under intensive and

extensive management differing significantly ($P<0.05$), though cooking loss and drip loss did no differ. Elsewhere, Sanka and Mbaga (2014) found that rearing system did not affect the pH of meat from Tanzanian local chickens. Similarly, for meat from Chinese chickens, Wang *et al*. (2009) found that pH of the muscles were largely unaffected ($P>0.05$) by the system used to raise the chickens. On the other hand, an evaluation of the cooking and drip loss of broiler chicken reared under extensive management system in China also reported no difference (Chen *et al*. (2013). It is therefore discernible that several traits of chicken meat are highly dependent on the management system and breed influences to some extent.

Conclusion

Kuroiler cocks vary from local chickens in Uganda is several meat attributes. Being that this breed is recently introduced into Africa, consumers need a reason to switch from their conventional choice of meat. The higher carcass yields could be that required motivator. We observe that if the Kuroiler chickens attain their superior carcasses in a shorter time frame, as has been reported elsewhere, meaning that a tenderer and a more acceptable meat product is what consumers get. On the basis of the slaughter characteristics reported in this study, Kuroiler chicken does not differ much from local chicken in the physical and chemical properties, meaning that Kuroiler chicken will easily gain acceptance by consumers "as local chicken". However, a study on sensory characteristics of the chicken from the two breeds would add more information to this endeavour.

Acknowledgments

This study was financed through a research grant (RU-CGS-GRG-30-9-11) to the project "Enhancing local chicken productivity through strategic breeding and nutrition management in Northern Uganda" from the Regional Universities Forum for Capacity Building in Agriculture (RUFORUM). We are also grateful to all the farmers that participated in this study. This paper is a contribution to the 2019 fifteenth RUFORUM Annual General Meeting.

Ethical Standards

This research followed ethical standards and complied with regulations of the Uganda National Council for Science and Technology (UNCST).

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