Meat Quality and Chemical Composition of Broiler Chicken Produced on Ideal Protein Concept Using the Most Limiting Amino Acid

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Abstract

The ideal protein concept based on the most limiting amino acid is the standard to meeting the amino acid requirements for optimum growth and development of poultry bird. Lysine is the second most limiting amino acid in the diets of poultry birds. This study was conducted to evaluate the effects of dietary lysine on the muscle quality and chemical composition of 288 broiler chickens. Six experimental diets were formulated such that Diet 1 (control) contained 20% crude protein and supplemented with DL-methionine and L-lysine while Diets 2, 3, 4, 5 and 6 contained 20, 17, 14, 11 and 8% crude protein with amino acids supplementation respectively. Two hundred and eighty eight (288) day-old Arbor Acres broiler chicks were randomly assigned into 6 dietary treatments in four replicates using a completely randomized design (CRD) and each replicate contained 12 birds. The birds were subjected to the feeding trial for 56 days. Sample birds were weighed before slaughter and properly drained of blood. The carcass was scalded, eviscerated and dissected into major cuts. The results show that the pH of drum stick muscle differed significantly ($p<0.05$) among the treatment diets while the pH of breast and thigh muscles was not affected ($p>0.05$). The water holding capacity was not significantly influenced ($p>0.05$) as simulated amino acid diets increased for all muscles types. The study revealed that *feeding simulated amino acids with varying levels of crude protein significantly influenced the moisture, crude protein, fat and mineral (ash) contents in breast muscle of broiler chicken.*

Keywords: amino acids, simulated protein, meat quality, chemical composition, broiler chicken

Introduction

The amino acid requirements of poultry are influenced by dietary, environmental and genetic factors (Schutte and De Jong, 1999). The essential amino acids are supplied in the diets and sufficient quantities of non-essential amino acids must also be supplied to prevent the conversion of these essential amino acids into non-essential amino acids (Applegate, 2008). The insufficient supply of amino acids in relation to the needs of the animal could lead to excess of the least limiting amino acid consumed by animals being de-aminated and converted to energy rather than towards body protein synthesis and this breakdown will result in higher nitrogenous excretions (Applegate, 2008). The absorbed amino acids are very important for tissue protein synthesis in time and in a ratio that matches the amino acid requirements of individual tissues (Wecke and Liebert, 2013).

In practical poultry diets lysine is the second limiting amino acid (Schutte and De Jong, 1999).The quest to meeting the actual required amino acids needed for optimum performance in birds is to raise the birds on simulated amino acids diets that will not constitute problems to growth and development. The formulation of least-cost low-protein diets supplemented with synthetic amino acids to meet or exceed the minimum standards is one important goal of the nutritionist (NRC, 1994). Adequate nutrition plays an important role in muscle composition either by a greater or lesser extent (Bogosavljevic-Boskovic *et al*., 2006; Bogosavljevic-Boskovic *et al*., 2011). Therefore, this study is aimed at investigating the effects of feeding simulated protein concept using the most limiting amino acid (lysine) on the meat qualities and chemical composition of broiler chicken.

Material and Methods*Animal management and Sample collection*

The experiment was conducted in an open-sided deep litter poultry house at the Teaching and Research Farm, Ekiti State University, Ado-Ekiti, Nigeria. Two hundred and eighty eight (288) day-old Arbor Acres broiler chicks were used for the study. The chicks were weighed and randomly assigned into six experimental diets. Feed-grade amino acids sourced from Ajinomoto Animal Nutrition were included in the formulated diets used for the treatments. The control (diet 1) contained 20% crude protein and supplemented with DL-methionine and L-lysine while diets 2, 3, 4, 5 and 6 had crude protein inclusion level at 20, 17, 14, 11% and 8% crude protein respectively (Table 1). The experimental diets were formulated such that feed-grade amino acids were used to meet the crude protein deficiencies. The dietary treatments were replicated 4 times and each replicate contained 12 birds. Feeds and water were provided *ad-libitum* and the feeding trial lasted for 56 days. The feeds were withdrawn from the birds overnight prior slaughtering at end of the feeding period. The birds were weighed before slaughtering and the blood was properly drained. The carcass was scalded, eviscerated and dissected into major cuts. Muscle pH was measured 45 minutes post-mortem by inserting the probe of a digital pH meter (Knick Portamess ® 910, Germany) into the *Pectoralis major* (breast), drum stick and thigh. The dissected carcasses were weighed and chilled at 4°C for 24 hours. The water holding capacity (WHC) was based on the percentage of free water in meat (Grau and Hamm, 1953).

Laboratory analysis

The proximate composition of the thawed breast muscles was determined for moisture, fat, protein and ash, according to the standard procedures in AOAC (2005).

Statistical analysis

All data were subjected to one-way analysis of variance (ANOVA) and mean separation was based on the Duncan's Multiple Range Test using Minitab statistical package (Minitab, 2007).

Results and Discussion

The pH of drum stick muscle was significantly influenced ($p<0.05$) by the treatment diets. The pH of breast muscle of birds fed Diets 1, 2 and 3 was higher than the values obtained in birds fed Diets 4, 5 and 6, while pH of thigh muscles was higher in birds fed Diets 1, 2 and 4 than birds fed Diets 3, 5 and 6. Tang *et al.* (2007) and Dou *et al.* (2009) had observed that pH_{45} of the breast muscle was not affected by lysine inclusion in broiler diets. The high pH values observed in all muscles types at 45 minutes postmortem were within the normal range and showed that the process of glycolysis was on-going. This might be due to the fact that the birds were not stressed prior and during slaughtering. Besides, feeding the different levels of lysine did not constitute stress. Higher muscle pH results in shorter shelf-life of meat quality (Apple *et al.*, 2004) and would enhance higher water binding capacity of the muscle.

The breast muscles of birds fed Diet 3 had the highest water holding capacity (WHC) (68.33±2.06%) while the lowest was obtained in Diet 6 (58.59±3.16%). The WHC of drum stick muscles was higher in birds fed Diet 3 (65.63±11.96%) than those fed other treatment diets.Table 1: Feed composition of the experimental diets ($g.100g^{-1}$)

Ingredients	Control	Crude protein reduction/ Amino acid supplementation				
	Diet 1	Diet 2	Diet 3	Diet 4	Diet 5	Diet 6
	20%	20% CP	17% CP	14% CP	11% CP	8% CP
Maize	65.4	61.1	56.8	57.3	57.1	59.1
*SBM	28.0	32.0	25.3	19.8	13.0	6.0
Fish meal (72% CP)	2.0	-	-	-	-	-
Rice husk	-	-	8.0	10.0	15.0	20.0
Palm oil	-	-	3.0	6.0	8.0	8.0
Bone meal	2.5	2.5	2.5	2.5	2.5	2.5
Oyster shell	1.0	1.0	1.0	1.0	1.0	1.0
Salt	0.3	0.3	0.3	0.3	0.3	0.3

Premix	0.5	0.5	0.5	0.5	0.5	0.5
Amino acid supplementation						
Lysine	0.15	1.0	1.0	1.0	1.0	1.0
Methionine	0.15	0.7	0.7	0.7	0.7	0.7
Threonine	-	0.7	0.7	0.7	0.7	0.7
Tryptophan	-	0.2	0.2	0.2	0.2	0.2
Calculated composition						
CP(%)	19.9	19.9	17.0	14.1	11.0	7.7
ME ($kcal.kg^{-1}$)	2933.1	2890.7	2891.1	2926.3	2918.9	2899.2
Fat (%)	3.9	4.1	6.2	8.1	9.2	10.0
Moisture content (%)	3.8	3.6	3.5	3.3	3.1	2.9

*SBM- soyabean meal; CP- crude protein; ME – metabolisable energy

Table 2: pH and water holding capacity (WHC) of broiler chicken fed an ideal protein concept using most limiting amino acid

Parameter	Diet 1	Diet 2	Diet 3	Diet 4	Diet 5	Diet 6
pH						
Breast	6.15±0.23	6.17±0.19	6.24±0.41	6.05±0.25	5.99±0.09	5.77±0.15
Drum Stick	6.25±0.05[a]	6.17±0.18[a]	5.95±0.09[ab]	6.15±0.13[a]	6.04±0.08[a]	5.95±0.20[ab]
Thigh	6.24±0.15	6.23±0.10	6.02±0.17	6.21±0.28	6.03±0.08	6.02±0.14
WHC(%)						
Breast	62.93±11.82	61.05±7.81	68.33±2.06	64.27±6.16	67.07±9.74	58.59±3.16
Drum Stick	59. 16±3.4	56.84±11.80	65.63±11.96	59.01±6.98	62.60±1.93	61.22±6.00
Thigh	57.45±4.06	54.40±10.91	63.68±4.76	64.30±13.89	68.41±12.22	58.45±4.84

Mean± Standard deviation; a, b, means along the same row with different superscripts differ significantly (P<0.05).

The WHC of thigh muscles ranged from 54.40±10.91% to 68.41±2.22% in Diet 2 and Diet 3 respectively (Table 2). The values observed 56.90±6.22% obtained for broiler chicken (Apple *et al*., 2004). The treatment diets had no significant effects (p>0.05) on WHC of the muscle types of broiler chickens. The WHC was consistently higher in breast muscles than drum stick and thigh muscles. The high WHC observed in this study might be due to the presence of amino acids that leads to the development of myofibrillar protein which has high water binding capacity in the muscles. The WHC is one of the most important factors of meat quality for the consumer and processor (Gunter and Peter, 2007) as it plays important roles in improving eating quality such as tenderness, juiciness and chemical composition of the meat. However, it may contribute to rapid development of spoilage organisms thereby reducing meat shelf life. The factors such as pH, sarcomere length, ionic strength, osmotic pressure and development of rigor mortis influence the WHC by altering the cellular and extracellular components (Offer and Knight, 1988; Northcutt *et al*., 1994).

Table 3 shows the proximate composition of breast muscle portion of broiler chicken fed the treatment diets. The birds fed the treatment diets influenced significantly (p<0.05) chemical composition of the breast muscle. The birds fed Diet 6 had the highest moisture content (77.33±0.44%) while the least value was obtained from Diet 1 (72.34±0.70%). The protein content ranged from 20.63±0.44% in Diet 6 to 23.21±0.28% in Diet 1. The highest value of ether extract was obtained from birds fed Diet 1 (2.71±0.58%) with the least value was from birds fed Diet 6 (1.22±0.24%). The ash content of the breast muscles ranged from 0.83±0.21% in Diet 6 to 1.73±0.15% in Diet 1. The protein content of breast muscles of broiler chicken fed the dietary treatments observed in the present study was closer to the findings of Horniakova and Abas (2009) and fell within the range of 21.9 to 23.5% obtained by Zlender *et al*. (1995) for breast muscle of broiler chicken and the value of 22% protein reported by Bogosavljevic-Boskovic *et al*. (1999) in broiler chicken.

Table 3: Proximate composition of breast muscle of broiler chicken fed simulated protein (%)

Parameters	Diet 1	Diet 2	Diet 3	Diet 4	Diet 5	Diet 6
Moisture Content	72.34±0.70^{c}	74.11±0.9^{b}	76.16±0.74^{a}	74.40±0.86^{b}	75.35±0.46^{b}	77.33±0.44^{a}
Crude Protein	23.21±0.28^{a}	22.57±0.46^{a}	20.83±0.51^{c}	22.75±0.86^{a}	22.18±0.51^{ab}	20.63±0.44^{bc}
Ether Extract	2.71±0.58^{a}	2.21±0.61^{ab}	1.73±0.36^{ab}	1.67±0.35^{ab}	1.45±0.51^{ab}	1.22±0.24^{b}
Ash	1.73±0.15^{a}	1.11±0.37^{ab}	1.28±0.14^{ab}	1.17±0.10^{ab}	1.02±0.40^{b}	0.83±0.21^{c}

Mean± Standard deviation; a,b,c, means along the row with different superscripts differ significantly ($P<0.05$)

The protein values obtained in the study differ from the findings of Thim *et al*. (1997) who observed higher protein content in broiler chicken fed diets of high level of crude protein of plant source. The ether extract had lower values than 3.9 to 8.4% obtained by Zlender *et al*. (1995) and higher than values reported by Horniakova and Abas (2009) for breast muscle of broiler chicken. The ash content was low which agrees with the report of Horniakova and Abas (2009) for breast muscle of broiler chicken fed amino acid-based diets. The ash indicates muscle mineral content. These minerals are associated with the organic compounds involved in the muscle contraction process and the values increase as the animal grows. The chemical composition of muscle tissue of major primal cuts is important in determining nutritional quality of meat and suitability for human consumption (Ristic, 1999; Bogosavljevic- Boskovic *et al*., 2003).

Conclusion

The study showed that the feeding regime affected the proximate composition of breast muscles. The pH of breast and thigh muscles varied but was not significantly influenced by dietary treatments. The variation of pH observed in breast and thigh muscles followed the same trend with the increase in the level of crude protein in the diets. The WHC varied among dietary treatments in all muscles types evaluated. The pH, WHC and chemical properties of muscle types of broiler chicken fed simulated protein diets compared satisfactorily with birds placed on control diets. Also, the study indicated that meat derived from the broiler chicken fed simulated protein could meet the nutritional requirements of the consumer.

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Physical Characteristics of the Strains of West African Dwarf Goat in Ogun State, Nigeria

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Abstract

Six hundred and sixteen male and female West African Dwarf (WAD) goats comprising gold (135), black (111), buckskin (162), Chaimose (58), Swiss markings (25), white (20), Dalmatian (46) and chocolate (59) strains were used to determine the trend of inheritance for qualitative traits. The physical characteristics observed were: beard (Br^d), non-beard (Br+), wattle (Wa^W), non-wattled (Wa+), polled (Ho^P), horned (Ho+), blue *eye* (BL), gold *eye* (bl). Wattle, beard, pollness and blue *eye* are dominant physical characteristics. The possession of wattle was more in Swiss markings (72.0%), Chaimose (68.90%), chocolate (65.91%), white (65.0%) and gold (62.90%).while more of the strains possessed horns (>80%). The generated Hardy-Weinberg frequencies for wattle, beard, pollness and blue *eye* were low. The gene frequency of the recessive non-wattle allele was 0.79, 0.80, 0.77, 0.84, 0.85, 0.81, 0.78, 0.81 in the gold, black, buckskin, Chaimose, Swiss markings, white, Dalmatian and chocolate WAD goat respectively. The gene frequency of the recessive non- polled (horned) allele was 0.94, 0.95, 0.99 and 0.96 in Swiss markings, white, Dalmatian and chocolate respectively. The gene frequency of the recessive non-beard allele was 0.88, 0.96, 0.93 and 0.93 in gold, black, buckskin and Chaimose. The frequency of the dominant *eye* allele is 0.02, 0.02, 0.21, and 0.21 in the gold, black, buckskin and Chaimose. There is a need to conserve these adaptive features (horn, wattle) in the strains of WAD goat.

Keywords: WAD goat, Strains, allele, frequency, horn, wattle, bear

Introduction

There are about 300 breeds and types of goats widely distributed around the world with the majority found in the tropics and subtropics where they play very important role in agriculture and are used for various social obligations (Alaku, 2010). The diverse appearance is mostly superficial and established during the embryonic stages of development thereby limiting the size and complexity of the animal (Anon, 2015b). The diversity among breeds and the genetic variation within breeds contribute equally to the genetic variation found among animals within the species (ILRI, 2014). The variation within breeds is less vulnerable to loss but breeds are easily irretrievably lost when they are considered to be commercially non-competitive (ILRI, 2014).

The physical expression of a trait in an individual is the phenotype (Klug *et al.,*2006). These traits showing the simplest type of inheritance are a qualitative trait. The absence of horns is caused by the expression of a dominant allele (Ho^P) which is the polled allele while the horns presence is caused by (Ho^+) wild allele (Lauvergne *et al,* 1987). Animals utilize their horns in a variety of ways. They may be used in fighting, for defense from predators. Horns may be used in feeding such as to root in the soil or strip bark from trees. Some animals with horns use them for cooling, the blood vessels in the bony core allowing the horns to function as a radiator. Many animals use horns in displays during courtship (Anon, 2016). Wattles are part of chicken's heat regulation system. The wattles and combs are thick with capillaries and veins for the overheated blood to pass through. It is air cooled as it passes through these blood vessels. In turn, this cooler blood reduces the chicken's internal temperature (Chester, 2016). Wattles on Nigerian Dwarf goat are simple hair, covered appendages of flesh hanging from the throat area (Anon, 2014a). Wattle is dominant and the locus was named wattles (Wa) and has two alleles: wattled (Wa^w) and (Wa^+) wild or recessive allele (Lauvergne *et al.,* 1987). Wattles are due to a dominant autosomal locus with variable expression (Machado *et al.,* 2000). Sometimes, wattles are placed somewhere other than the usual "under the jaw on the neck" (Anon, 2014a).

Asdell and Smith (1928) have shown that beard trait is controlled by an autosomal gene and it depends on sex. The trait is dominant in males and recessive in females (Lauvergne *et al,* 1987). Adedeji *et al* (2006) reported that some female WAD goats have beards which may result from the secretion of excess of male hormone (androgen) (Odubote, 1994). The locus is named Br and has two alleles: bearded (Br^d) and (Br^+) wild (Lauvergne *et al.,* 1987). Unlike in the case of humans, blue eye (BL) in goats are dominant and the gold eye (bl) is recessive. Blue eye does not cause any health issues. In a very rare case, there have been reports of Nigerian goats having one blue eye and one brown eye (Anon, 2014b). The Nigerian dwarf goat has blue eyes but the gold colour/brown (recessive) is occasionally encountered (Anon, 2010).

The ability of the WAD goat to survive under adverse environmental conditions with low inputs and disease risk is attributed to the possession of adaptive traits, which have a positive effect on the genetic superiority or adaptability of the breed (Odubote, 1994). Characterization of WAD goat population for these adaptive features is important for its genetic improvement and the conservation of its genetic resources. Some studies have been carried out on the adaptive features of WAD goat population and that characterization for qualitative traits at various times in the humid zone of Nigeria both on-farm and free range (Odubote, 1994; Ozoje, 1998; Adedeji *et al,* 2006; Yakubu *et al,* 2010). However, there is a need to further characterize the breed of WAD goat in which several strains have emerged. The aim of this study is to characterize the strain of WAD goat populations based on their physical body characteristics.

Materials and Methods

The study area is the entire Ogun State, Nigeria which comprises of twenty local government areas located in Ijebu, Remo, Egba, and Yewa Divisions. Each local government area represented a stratum in which three towns were purposively selected. WAD goats within each town were used for the experiment. The sample size was 616 male and female WAD goats on which four physical characters were observed: presence (Br^d) or absence (Br^+) of beard, presence (Wa^W) or absence (Wa^+) of wattle, presence (Ho^+) or absence (Ho^P) of horns and blue (BL) or gold (bl) or blue-gold eye colour. The data were analyzed using simple descriptive statistics of percentages and frequency distribution; the frequencies of the recessive alleles were calculated using Hardy-Weinberg equilibrium (Falconer and Mackay, 1996).

Table 1:Frequency of a particular allele in gold, black, buckskin and chaimose WAD goat

Variables	Gold			Black			Buckskin			Chaimose		
	FC	FPA	%	FC	FPA	%	FC	FPA	%	FC	FPA	%
		135			111			162			58	
Wattled	50	0.21	37.04	44	0.20	39.64	67	0.23	41.36	18	0.16	31.03
Non-wattled	85	0.79	62.96	67	0.80	60.36	95	0.77	58.64	40	0.84	68.07
Horned	117	0.95	86.58	100	0.95	90.09	142	0.94	87.65	53	0.97	91.38
Polled	18	0.05	13.32	11	0.05	9.91	20	0.06	12.35	5	0.03	8.62
Beard	32	0.12	23.70	9	0.04	8.11	25	0.07	15.43	7	0.07	12.07
Non-beard	103	0.88	76.30	102	0.96	91.89	137	0.93	84.57	51	0.93	87.93
Eye colour												
Blue	6	0.02	4.44	6	0.02	5.41	16	0.05	9.88	4	0.04	6.90
Gold	129	0.98	95.56	105	0.98	94.59	146	0.95	90.12	54	0.96	93.10
Blue and gold	0	0	0	0	0	0	0	0	0	0	0	0

FC = Frequency, FPA= Frequency of a particular allele, % =Percent

The frequency of the dominant wattle allele in gold, black, buckskin and chaimose is 0.21, 0.20, 0.23, and 0.16 respectively. Swiss markings, white, Dalmatian and chocolate is 0.15, 0.19, 0.22, and 0.19 respectively. The frequency of a dominant polled allele in gold, black, buckskin and chaimose is 0.05, 0.05, 0.06, and 0.03. In the Swiss markings, white, Dalmatian and chocolate, the frequency of a dominant polled allele is 0.06, 0.05, 0.01 and 0.04. In the gold, black, buckskin and Chaimose, the frequency of dominant beard allele is 0.12, 0.04, 0.07, and 0.07. The frequency of the beard allele in Swiss markings, white, Dalmatian and chocolate is 0.02, 0.08, 0.14, 0.03. The frequency of the dominant eye allele (blue eye) in gold, black, buckskin and Chaimose is 0.02, 0.02, 0.21, and 0.21.

Table 2:Frequency of particular allele in Swiss markings, white, Dalmatian and chocolate WAD goats

Variables	Swiss markings			White			Dalmatian			Chocolate		
	FC	FPA	%	FC	FPA	%	FC	FPA	%	FC	FPA	%
		25			20			46			59	
Wattled	7	0.15	28.00	7	0.19	35.00	18	0.22	39.06	20	0.19	33.80
Non-wattled	18	0.85	72.00	13	0.81	65.00	28	0.78	60.76	39	0.81	65.91
Horned	22	0.94	88.00	18	0.95	90.00	45	0.99	97.65	54	0.96	91.26
Polled	3	0.06	12.00	2	0.05	10.00	1	0.01	2.17	5	0.04	8.45
Beard	1	0.02	4.00	3	0.08	15.00	12	0.14	26.04	4	0.03	6.76
Non-beard	24	0.98	96.00	17	0.92	85.00	34	0.86	73.78	55	0.97	92.95
Eye colour												
Blue	3	0.06	12.00	3	0.08	15.00	2	0.02	4.34	4	0.03	6.76
Gold	22	0.94	88.00	17	0.92	85.00	44	0.98	95.48	55	0.97	92.95
Blue and gold	0	0	0	0	0	0	0	0	0	0	0	0

The frequency of the dominant eye allele (blue eye) in the Swiss markings, white, Dalmatian, chocolate is 0.06, 0.08, 0.02, and 0.03. Wattle, beard, pollness, and blue eye are dominant physical/qualitative characteristics. The generated Hardy-Weinberg frequencies for these traits are low which agrees with the findings of Yakubu*etal.,* (2012) that the frequencies of both WAD and Red Sokoto goats for wattle, beard and pollness were quite lower than the expected Mendelian value of 0.75. The low values may be due to inbreeding that keeps occurring within the small population (households) and random mating that takes place in the larger populations (between towns within the local governments in Ogun State) without a consistent selection and culling of undesired characters. However, this large population isalsounder the influence of migration and selection which aid the introduction of new genes into larger population but these new genes are often in favour of the recessive genes coming from the various strains of WAD goats. One advantage of inbreeding when carried out for a period of time within the small population is that it tends to create lines or strains of animals that are uniform in type or in some other desirable characteristics and genes which can be transmitted with greater uniformity. However, the known shortcoming is that it increases the chances that recessive genes will appear during the early generation before the attainment of homozygosity.

Conclusion

Horn and wattle are the adaptive physical features in the strains of WAD goat. This study has determined the frequency of the dominant and recessive qualitative alleles in the strains of WAD goat. The presence of horn and wattle was more in >80% the strains of WAD goat. Further studies should be carried out on the effect of these adaptive features in the production and reproductive performance of these strains of WAD goat.

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