Influence of supplemental L-arginine on physico-chemical and sensory properties of breast meat from turkeys

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Abstract

A total of one hundred and forty four grower (56-84d) turkeys were used to investigate the effect of dietary supplemental L-arginine on growth response, physico-chemical and sensory properties of the resultant breast meat. Dietary treatments consisted of basal diet supplemented with 0 (control), 0.05 and 0.10% L-arginine, respectively. A completely randomized design was used with turkeys randomly allotted to 18 pens; each pen housed eight birds. Six pens were assigned to each treatment. Growth performance of the birds, cook loss, refrigeration loss, freeze loss and water absorptive power of the breast meat were measured. Finisher turkeys fed diet supplemented with 0.05 % L-arginine and control group had reduced ($P < 0.05$) feed intake and improved ($P < 0.05$) feed conversion ratio. Meat samples from turkeys fed diet supplemented with L-arginine showed increased ($P < 0.05$) cook loss weight (in g) and percentage cook loss when compared with control group. Turkeys fed diet supplemented with 0.10% arginine had the highest ($P < 0.01$) percentage refrigeration loss, freeze loss weight (g) and percentage freeze loss. Increasing supplementation level of arginine showed a linear reduction ($P < 0.001$) in the thaw weight of breast meat. Sensory parameters of meat sample were not influenced ($P > 0.05$) by varying level of arginine supplemented. In conclusion, arginine supplementation seems to weaken the muscular cross-bridges in breast meat and hence resulted in higher cook loss, refrigerated loss and freeze loss.

Keywords: Turkey, Breast meat, Cook loss, Freeze loss, Refrigeration loss

Introduction

Poultry selection concentrated mainly on growth performance and muscle mass development without considering the outcome effect of these performance criteria on meat quality (Dransfield and Sosnicki, 1999). As growth increases in poultry bird, there are changes in protein dynamics leading to accretion of muscles and hence changes in muscle size (Dransfield and Sosnicki, 1999). Recent market demand on poultry meats focused on specific meat qualities such as tenderness, toughness, cohesiveness, colour, and water holding properties

(Sosnicki and Wilson, 1991).

The qualities of meat products obtained from poultry and the resultant organoleptic qualities have been reported to be dependent on the dietary components fed to such birds (Sauveur, 1997). In fast growing, meat-type birds like turkeys, selection for increased growth and high meat yield sometimes compromise sensory and functional qualities of the resultant meat product (Le Bihan-Duval *et al.*, 2003). The concentration of muscle fibres in meat influences the meat quality and sometimes sensory properties of such meat. Fast-growing chickens have been reported to

have larger cross-sectional area of muscle fibers than slow-growing lines (Remignon *et al.*, 1993).

Protein synthesis and consequently tissue accretion in chickens has been reported to depend largely on dietary arginine since birds are unable to synthesize arginine via the urea cycle (Lewis, 1996). Supplemental L-arginine has been reported to influence muscle pH (Baker, 2007), coordinate metallic ions (Remko *et al.*, 2008) and prevent fat and protein from oxidation (De Nigris *et al.*, 2003). Thus, L-arginine might have a potential for improvement of water binding capacity, texture and micro-structures of meat. Nitric oxide (NO), produced during the conversion of L-arginine to citrulline Wu and Morris (1998) have been reported to influence sensory properties of meat as it reacts with myoglobin to produce pink colour in meat products (Moller and Skibsted, 2002). There are also indications that intermediate products of L-arginine played significant role in retaining the freshness and preserving meat quality during the early post-mortem stage (Brannan and Decker, 2002). Few research studies existed on the role of L-arginine on pork meat quality and products (Tan *et al.*, 2009; Zhou *et al.*, 2014). However, scientific information on the effect of L-arginine on poultry meat is rare in literatures. This study therefore seeks to investigate the influence of dietary supplemental L-arginine on physio-chemical and sensory properties of breast meat from meat-type turkeys.

Materials and methods

Experimental animal and management

The experiment was carried out at the Turkey Unit of the Directorate of University Farms, Federal University of Agriculture Abeokuta, Nigeria (FUNAAB). The L-arginine used in this study was obtained

from Shanghai TECH, Chemical Industry Testing Co Ltd, China. A total of 144 day old, male British United Turkeys was procured from a commercial hatchery. The poulters were brooded together for 28 days. The brooding, temperature was controlled at 34.5°C for the first 0 to 2 days and then gradually reduced by 2°C per week to a final ambient temperature of 27°C at the last week of brooding. The poulters were reared on deep litter housing system littered with dried wood shavings. Normal vaccination program and medication schedule was strictly followed. Feed and clean water was supplied *ad libitum*. Poulters were fed with corn-soybean pre-starter diets and starter diets which met their normal requirement during brooding and starter phase.

Dietary treatment

The experiment commenced at the end of the starter phase. At day 57, turkey poulters were randomly assigned on weight equalization basis to three dietary treatments. A completely randomized design was used with turkeys randomly allotted to 18 pens; each pen housed 8 birds. Six pens were assigned to each treatment. A basal diet was formulated to meet the minimum nutrient requirement for growing **(57-84 days) and finishing (85-112 days) turkeys.**

Dietary treatments consisted of basal diet supplemented with 0% (control diet; T1), 0.05% (T2) and 0.10% (T3) L-arginine, respectively as shown in Table 1.

Growth response and breast meat yield

Live weight of the birds per pen ($n = 6$ per treatment) was measured weekly while the weight gain was computed. Feed intake was also measured as the difference between the feed offered and leftovers while feed conversion ratio was computed as the ratio of feed consumed to weight gain. At 112 days of the study, a turkey per replicate ($n = 6$ per treatment) was randomly selected

based on final live weight. Bird selected for carcass analysis were fasted overnight, slaughtered and eviscerated manually following standard commercial procedures (Jensen, 1984). Individual carcasses were weighed and dissected into cut parts to

separate the breast meat yield following the standard description for dissection of poultry (Hahn and Spindler, 2002). The weight of the breast meat yield (g) was recorded and expressed as relative weights in g/kg live-weight.

Table 1: Gross composition of experimental grower (8-12 weeks) and finisher (12-16 weeks) diets

Supplemental levels of L-Arginine (%)	Grower diet			Finisher diet		
	0	0.05	0.10	0	0.05	0.10
Ingredient composition						
Maize	57.00	57.00	57.00	62.20	62.20	62.20
Fish meal (72% CP)	8.60	8.60	8.60	4.60	4.60	4.60
Soyabean meal	26.50	26.50	26.50	24.00	24.00	24.00
Wheat offal	5.30	5.30	5.30	6.00	6.00	6.00
Bone meal	0.50	0.50	0.50	0.80	0.80	0.80
Limestone	0.80	0.80	0.80	0.60	0.60	0.60
*Vitamin/mineral premix	0.50	0.50	0.50	0.50	0.50	0.50
Salt (NaCl)	0.30	0.30	0.30	0.30	0.30	0.30
Palm oil	0.50	0.50	0.50	1.00	1.00	1.00
Total	100.00	100.00	100.00	100.00	100.00	100.00
Calculated analysis						
Metabolisable energy (Kcal/kg)	3516.00	3516.00	3516.00	3574.60	3574.60	3574.60
Crude protein (%)	22.63	22.63	22.63	19.55	19.55	19.55
Crude fibre (%)	4.22	4.22	4.22	4.38	4.38	4.38
Ether extract (%)	3.11	3.11	3.11	3.07	3.07	3.07
Calcium (%)	0.88	0.88	0.88	0.75	0.75	0.75
Phosphorus (%)	0.44	0.44	0.44	0.38	0.38	0.38
Lysine (%)	1.30	1.30	1.30	1.05	1.05	1.05
Methionine (%)	0.43	0.43	0.43	0.35	0.35	0.35
Basal arginine (%)	1.48	1.48	1.48	1.31	1.31	1.31
Supplemental arginine (%)	0.00	0.05	0.10	0.00	0.05	0.10
Total arginine (%)	1.48	1.53	1.58	1.31	1.36	1.41
Arginine/lysine ratio	1.14	1.18	1.22	1.25	1.30	1.34

*Vitamin/Mineral Premix composition per Kg diet: vit A: 40, 000IU, vit D₃: 4000IU, vit E: 40.0 mg, vit K₃: 8mg, vit B₁: 1.0mg, vit B₂: 8mg, vit B₆: 5mg, vit B₁₂: 0.025mg, Niacin: 60mg, Panthothenic acid: 20mg, Folic acid: 2000mg, Biotin: 150mg, Iron: g, Manganese: 64mg, Zinc: 40mg, Copper: 8mg, Cobalt: 80mg, Iodine: 0.15mg, Selenium: 0.2mg, Choline: 300mg.

Breast meat quality analysis

Cook loss determination

About 50g sample of the *Pectoralis* breast muscle was dissected from each selected turkey, wrapped in separate airtight polythene bag and placed in a water bath at 70°C for 30 minutes. After cooking, residual moisture was removed from each of the meat samples and allowed to cool to room temperature. The meat samples were re-weighed and differences in weight were recorded as weight loss.

Refrigerated loss determination

Approximately 10g of breast muscle from

each treatment was weighed and labelled before refrigeration (-4°C) and weighed again after 24 hours of refrigeration at -4°C to determine the refrigerated loss.

Freeze loss determination

Approximately 10g of breast muscle from each treatment was weighed and labelled before freezing and weighed again after 24 hours of refrigeration at -26°C to determine the freeze loss.

Water absorptive power determination

Exactly 3g each of raw meat samples from the breast muscle was weighed and placed in sterilized test tubes; 10mL of distilled

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water was poured in and then left for an hour. At the expiration of 1 hr, meat sample was removed and reweighed. The increase in the weight of the samples indicated the volume of water absorbed.

Sensory evaluation of meat samples

Samples from the breast meat muscle were washed in clean water, packed in a transparent double layer polythene bag and tagged for identification. Thereafter, the samples were boiled (70°C) for 30 minutes, thereafter allowed to cool under room temperature and served to the panelists. Panel members were not given any information about the meat or the experimental treatments and procedures. Seven experienced panelists were used for the sensory evaluation. Bite size portions of boiled meat samples from the breast muscle weighing about 10g was served at room temperature to the trained panelists. Each panelist was required to masticate one sample per treatment with ranked preferences in the following categories: color, juiciness, meaty flavor, tenderness, saltiness, overall flavor and overall acceptability and scores was awarded using a 9 point Hedonic scale as described by Sanwo *et al.* (2011). Between each sample, panelists were instructed to cleanse their palates with distilled water.

Statistical analysis

Data obtained were subjected to one-way analysis of variance in a completely randomized design. Data were analysed using SAS package (SAS, 1999). Where treatment effect was significant ($P < 0.05$), the differences between means were detected using Tukeys' Test. Linear (L) and Quadratic (Q) polynomial contrast were also applied to evaluate the effect of varying supplemental levels of L-arginine.

Results

In Table 2, the growth response and breast

meat yield of turkeys fed diet supplemented with L-arginine are presented. It showed that L-arginine supplementation had no effect on growth response of grower (56-84 d) turkeys. Finisher (85-112 d) turkeys fed diet supplemented with 0.05 % L-arginine and control group had reduced ($P < 0.05$) feed intake and improved ($P < 0.05$) feed conversion ratio. However, finisher (85-112 d) turkeys fed diet supplemented with 0.10 % L-arginine recorded the highest (Q. $P < 0.001$) feed intake and the worst ($P < 0.028$) feed conversion ratio. Finisher turkeys fed diet supplemented with L-arginine irrespective of inclusion level showed reduced dressing percentage while 0.05% L-arginine supplementation significantly ($P < 0.05$) increased relative breast meat yield but relative breast meat yield was reduced with 0.01% arginine supplemental level.

The effect of arginine supplementation on cook, refrigerated and freeze loss and water absorption power of turkey meat is presented in Table 3. Breast meat samples from turkeys fed diet supplemented with L-arginine (irrespective of levels of inclusion) showed increased ($P < 0.05$) cook loss weight (g) and percentage cook loss when compared with control group. Meat from turkeys fed diet supplemented with 0.10% arginine recorded the highest ($P < 0.01$) percentage refrigerated loss, freeze loss weight (g) and percentage freeze loss.

Breast meat from control group and turkeys fed diet supplemented with 0.05% arginine showed reduced refrigerated loss, freeze loss (g) and percentage freeze loss when compared with values obtained for turkeys fed diet supplemented with 0.10% arginine. Increasing supplementation levels of arginine showed a linear reduction ($P < 0.001$) in the thaw weight of breast meat.

Table 2: Growth response and breast meat yield of turkeys fed diet supplemented with L-arginine

Parameters	<i>L-Arginine supplemental levels (%)</i>			SEM	P-value	
	0	0.05	0.10		Linear	Quadratic
<i>56 – 84 d</i>						
Weight gain (g/bird)	3266.30	3158.00	3281.70	10.07	0.654	0.688
Feed intake (g/bird)	8186.70	8188.30	8366.70	17.16	0.661	0.803
FCR	2.51	2.59	2.55	0.02	0.628	0.744
<i>85 – 112 d</i>						
Weight gain (g/bird)	3136.70	3041.70	3475.00	30.13	0.304	0.385
Feed intake (g/bird)	12792.00 ^b	11525.00 ^b	17262.00 ^a	542.90	0.009	0.001
FCR	4.08 ^b	3.79 ^b	4.97 ^a	0.23	0.062	0.028
Breast meat yield						
Dressing percentage (%)	78.92a	73.67b	73.17b	4.38	0.044	0.070
Breast meat yield (g/turkey)	2399.5	2297.10	2290.50	0.42	0.220	0.074
Relative breast meat yield (g/kgLWT)	258.01a	261.72a	241.11b	15.39	0.011	0.035

^{a, b, c} Means in the same row with different superscripts differ significantly ($P < 0.05$).

SEM = Standard error of the mean

Table 3: Effect of Arginine supplementation on physiochemical properties of breast meat obtained from finisher turkeys fed experimental diets

Physiochemical parameters	L-Arginine supplementation (%)			SEM	P-value	
	0	0.05	0.1		Linear	Quadratic
Weight before cook (g)	70.35	71.00	71.25	0.23	0.130	0.668
Weight after cook (g)	58.55 ^a	56.90 ^b	57.20 ^{ab}	0.34	0.083	0.134
Cook loss weight (g)	11.80 ^b	14.10 ^a	14.05 ^a	0.46	0.023	0.119
Percentage cook loss	16.77 ^b	19.72 ^a	19.86 ^a	0.61	0.024	0.106
Weight before refrigeration (g)	30.90	25.75	25.25	1.22	0.050	0.288
Weight after refrigeration (g)	29.20 ^a	24.05 ^{ab}	23.15 ^b	1.21	0.030	0.294
Refrigerated loss (g)	1.70	1.70	2.10	0.11	0.147	0.374
Percentage refrigerated loss	5.51 ^b	6.56 ^b	8.33 ^a	0.47	0.004	0.533
Weight before freezing (g)	31.30 ^a	31.60 ^a	30.05 ^b	0.23	0.003	0.007
Weight after freezing (g)	31.15 ^a	31.40 ^a	29.75 ^b	0.27	0.001	0.005
Freeze loss (g)	0.15 ^b	0.20 ^b	0.30 ^a	0.02	0.001	0.267
Percentage freeze loss	0.48 ^b	0.64 ^b	0.99 ^a	0.08	0.000	0.172
Thaw weight (g)	30.90 ^a	29.60 ^b	28.15 ^c	0.41	0.000	0.754
Water absorptive power (g)	0.25 ^b	0.35 ^{ab}	0.50 ^a	0.05	0.030	0.755

^{abc} Means on the same row having different superscripts are significantly different ($P < 0.05$).

SEM= Pooled standard error of means.

Table 4: Effect of Arginine supplementation on sensory properties of breast meat obtained from finisher turkeys fed experimental diets

Sensory parameters	L-Arginine supplementation (%)			SEM	P-value	
	0	0.05	0.1		Linear	Quadratic
Colour	6.79	7.00	7.00	0.20	0.675	0.809
Juiciness	5.35	5.37	5.93	0.37	0.538	0.722
Flavour	5.93	6.93	6.07	0.25	0.819	0.091
Tenderness	6.50	5.71	6.50	0.26	1.000	0.168
Saltiness	5.36	4.86	4.86	0.19	0.311	0.556
Overall flavour	6.14	6.93	6.50	0.18	0.410	0.110
Overall acceptability	6.57	7.07	6.79	0.17	0.615	0.289

SEM= Pooled standard error of means.

Influence of supplemental L-arginine on meat quality

The result of the sensory properties of breast meat obtained from turkeys fed experimental diets (Table 4) shows that all the sensory parameters measured were not affected ($P>0.05$) by varying dietary levels of arginine supplemented. Numerically, breast meat from turkeys fed diet supplemented with 0.05% arginine recorded the highest flavor and overall acceptability.

Discussion

Improved feed conversion ratio obtained for finisher turkeys fed diet supplemented with 0.05 % L-arginine suggested a better utilization of dietary protein at 0.05 % L-arginine supplemental level than 0.10 % level. Mendes *et al.* (1997) and Brake *et al.* (1998) also reported improved feed conversion with the addition of arginine to broilers' diet. 0.05% L-arginine supplementation significantly ($P<0.05$) increased relative breast meat yield. Arginine exhibits a secretagogue activity which induces the release of pituitary and pancreatic hormones thus increase feed intake, improve feed conversion ratio and body protein synthesis (Davila *et al.*, 1987).

The composition and amount of intramuscular connective tissue in breast meat samples have been reported to depend on the nutrition of the animals and muscle type (Oshima *et al.*, 2009; Christensen *et al.*, 2011). During cooking of meat, chemically bound water is released as a result of melting nature of the embedded fat and denaturation of the proteins (Vieira *et al.*, 2009). Increased cook loss recorded for meats from turkeys fed diet supplemented with L-arginine implied that the release of bound water was higher in meat of birds fed diet supplemented with L-arginine. Earlier studies reported that broilers fed arginine deficient diet showed the lowest meat cook

loss (Jiao *et al.*, 2010). Miller *et al.* (1980) noted that the water loss in meat samples increase during freezing as a result of damage to the muscle tissue. As the water freezes, the concentration of the remaining solubles (proteins, carbohydrates, lipids, vitamins and minerals) increases, thereby disrupting the homeostasis of the complex meat system (Lawrie, 1998). Freezing and thawing have been reported to contribute significantly to the reduction in the water-holding capacity of meat (Vieira *et al.*, 2009). Loss in water holding capacity is connected to the disruption of the muscle fibre structure, as well as the modification and/or denaturation of the proteins. Dietary inclusion of 0.10% arginine thus produces the highest quantity of drip loss during refrigeration and freezing. Composition of the drip that is lost during freezing has been found to consist mostly of sarcoplasmic proteins (Savage *et al.*, 1990).

McCormick (1999) also attributed labile and great tenderness of meat to the presence of greater fraction of less cross-linked and heat-soluble collagen. There are cross-bridges between the collagen molecule units and this cross bridges determine the physical strength and heat stability of intramuscular connective tissue. The result of the current study shows that arginine supplementation seems to weaken these cross-bridges and hence resulted in higher cook loss, refrigerated loss and freeze loss.

Although arginine supplementation did not significantly influence sensory properties of breast meat obtained from turkeys but numerically breast meat from turkeys having 0.05% arginine supplemental level had the highest flavour and overall acceptability. This could be due to increased flavour influenced by dietary arginine supplementation. Arginine supplementation has been reported by Zhou *et al.* (2014) to result in the improved culinary properties of

meat.

Conclusion

The study showed that L-arginine supplementation in diets for finisher turkeys resulted in increased cook loss, refrigerated loss, freeze loss and water absorptive power of resultant breast muscle. These water losses are more prominent at 1% L-arginine supplementation. Arginine supplementation seems to weaken the muscular cross-bridges within the breast meat and hence resulted in higher cook loss, refrigerated loss and freeze loss.

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