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Effect of dietary vitamin D_3 supplementation on meat quality of naked neck chickens

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Consumers' interest of indigenous chicken meat is increasing. An experiment was conducted to determine the effect of vitamin D_3 supplementation on meat quality of indigenous male naked neck chickens. Different supplementation levels of 0, 2000, 4000, 6000 and 8000 IU of vitamin D_3 per kg DM of feed were used. 13 weeks old male naked neck chickens with a mean live weight of 1200 ± 3 g were supplemented with vitamin D_3 for a period of seven days before slaughter. A 2 (cooking or not) x 2 (postmortem agings of 0 or 24 hs) x 5 (vitamin D_3 levels) factorial arrangement in a complete randomized design was used for shear force analysis of raw or cooked naked neck chicken meat. A 2 (postmortem agings of 0 or 24 hs) x 5 (vitamin D_3 levels) factorial arrangement in a complete randomized design was used for sensory evaluation of the meat. A quadratic equation was used to determine vitamin D_3 supplementation levels for optimum shear force value and sensory attributes. Vitamin D_3 supplementation did not improve (P>0.05) shear force values of unaged or aged raw and cooked naked neck chicken meat. Shear force values of unaged raw or cooked meat were optimized at different levels of 3735 (r^2=0.832) and 2512 (r^2=0.669) IU of vitamin D_3 per kg DM feed, respectively. Shear force values of aged raw or cooked meat were optimized at different levels of 6728 (r^2=0.274) and 4249 (r^2=0.873) IU of vitamin D_3 per kg DM feed, respectively. Vitamin D_3 supplementation had no effect (P>0.05) on unaged meat tenderness, juiciness and flavour. However, vitamin D_3 supplementation improved (P<0.05) aged meat tenderness and flavour. Tenderness, juiciness and flavour of aged naked neck chicken meat were optimized at supplementation level of 6830 (r^2=0.839), 6894 (r^2=0.683) and 9795 (r^2=0.657) IU of vitamin D_3 per kg DM. It was concluded that vitamin D_3 supplementation improved tenderness and flavour of aged naked neck chicken meat. However, shear force values of unaged or aged raw or cooked naked neck chicken meat were not improved by vitamin D_3 supplementation.

Key words: Shear force, postmortem aging, calpains, connective tissue, tenderness, juiciness, flavor.

INTRODUCTION

Indigenous chicken breeds are abundant in Southern Africa and the world as a whole. They are widely distributed in the rural areas where they are kept by a majority of the rural households. These chickens are economically, nutritionally and culturally important to the rural households (Food and Agriculture Organization, 2010). The meat from these chickens is very much liked by many people because of its good taste (Fanatico et al., 2005b; Moula et al., 2009c; Kingori et al., 2010). Consequently, a real demand of meat from indigenous chicken breeds is currently requested in spite of their relatively high prices (Kingori et al., 2010). However, the meat is hard to cook and chew (Wattanachant et al., 2004). Most of these chickens mature and reach the

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Table 1. Nutrient composition of diets for male naked neck chickens.

Diet	V_0	V_{2000}	V_{4000}	V_{6000}	V_{8000}
Dry matter(g/kg feed)	880	880	880	880	880
Energy(MJ ME/kg feed)	16.8	16.8	16.8	16.8	16.8
Crude protein(g/kg DM)	220	220	220	220	220
Lysine(g/kg DM)	11.5	11.5	11.5	11.5	11.5
Calcium(g/kg DM)	12	12	12	12	12
Phosphorus(g/kg DM)	7	7	7	7	7
Vitamin D_3 (IU/kg DM feed)	2000	4000	6000	8000	10000

V_0, Male naked neck chickens not supplemented with vitamin D3; $V_{2000,}$ male naked neck chickens supplemented with 2000 IU of vitamin D3 per kg DM of feed; $V_{4000,}$ male naked neck chickens supplemented with 2000 IU of vitamin D3 per kg DM of feed; $V_{6000,}$ male naked neck chickens supplemented with 2000 IU of vitamin D3 per kg DM of feed; $V_{8000,}$ male naked neck chickens supplemented with 2000 IU of vitamin D3 per kg DM of feed.

market weight at around 13 weeks of age; at this age the meat is already tough and hard to chew. Tenderness has been identified as the single most important factor affecting consumers' satisfaction and perception of taste (Morgan et al., 1991; Savell et al., 1991). The increase in connective tissues and the decrease in protein breaking system as the birds get older are the main reasons the meat becomes tough (Wattanachant et al., 2004). Vitamin D_3 is responsible for increasing the muscle calcium, which in return increases the activity of calpains, the intracellular proteases responsible for postmortem meat tenderness in cattle, sheep and pigs (Montgomery et al., 2002; Boleman et al., 2004; Enright et al., 1998). Vitamin D_3 supplementation has been found to improve beef tenderness ratings (Karges et al., 2001; Montgomery et al., 2002; Swanek et al., 1999). However, there is limited and inconclusive information on the effect of vitamin D_3 supplementation on the carcass quality of chickens. Navid et al. (2011) reported that vitamin D_3 supplementation had no effect on aged meat tenderness of old laying hens. Vitamin D_3 had no effect on the muscle tenderness, but had synergistic effect with calcium (Ma et al., 2009). The objective of this study was, therefore, to determine the effect of dietary vitamin D_3 supplementation level on shear force values, meat tenderness, juiciness and flavour of indigenous naked neck chicken meat under postmortem aging.

MATERIALS AND METHODS

Study location

This research was conducted at the University of Limpopo experimental farm, South Africa. The farm is situated 10 km north-west of the Turfloop campus of the University of Limpopo. The ambient temperatures around the area are above 30°C in summer and below 25°C in winter. It lies at latitude 27.55 S and longitude 24.77 E. The area receives a mean rainfall of less than 400 mm.

Experimental designs, procedures and dietary treatments

The experiment commenced with 20 male naked neck chickens aged 13 weeks, with a mean live weight of 1200 g ± 3 g that were raised under close confinement. The chickens were randomly assigned to five treatments with four replicates, thus, 20 floor pens (1.5 m^2) were used. The experimental feeds were isocaloric but with different dietary vitamin D_3 levels (Table 1). After a seven-day period of supplementation, the chickens were slaughtered and 20 meat samples were exposed to 0 (unaged) and 24 h (aged) postmortem agings. A 2 (cooking or not) x 2 (postmortem agings of 0 or 24 hs) x 5 (vitamin D_3 levels) factorial arrangement in a complete randomized design was used for shear force analysis of raw and cooked naked neck chicken meat. A 2 (postmortem agings of 0 or 24 hs) x 5 (vitamin D_3 levels) factorial arrangement in a complete randomized design was used for sensory evaluation.

Shear force analysis

Shear force assessment was done according to Warner-Bratzler Shear Force determination procedures (Dawson et al., 1991). Frozen samples of chicken breast meat were thawed for 24 h at 2°C. The samples were removed, tagged and used for raw and cooked Warner Bratzler Shear Force (WBSF) measurements. For the cooked meat, thawed meat was prepared according to an oven-broiling method using direct radiant heat (AMSA, 1995). An electric oven was set on "broil" for 10 min prior to preparation (260°C). Breast cuts were placed on an oven pan on a rack to allow meat juices to drain during cooking and placed in the pre-heated oven 9 cm below the heat source. The cuts were cooked to an internal temperature of 35°C, then turned and finished at 70°C. Cooked cuts were cooled down at room temperature (18°C) for at least 2 h before WBSF measurements. Three cylindrical samples (12.5 mm core diameter) of each cut were cored parallel to the grain of the meat, and sheared perpendicular to the fibre direction using a Warner-Bratzler shear device mounted on an Universal Instron Apparatus (cross head speed = 200 mm / min, one shear in the centre of each core). The reported value in kg represents the average of three peak force measurements of each sample. The raw samples were performed on similar cuts held at room temperature (18°C).

Sensory evaluation

An oven rack set at 160°C and allowed to pre-heat for 20 min was used to cook the meat for sensory evaluation. The meat samples of 1.5 cm thickness were broiled for approximately 50 min and turned over every 25 min (AMSA, 1995). Tongs were used for turning to avoid piercing that could lead to moisture escape. A taste panel of 10 assessors evaluated the meat for tenderness, juiciness and

Table 2. Evaluation scores used by the sensory panel.

Score	Meat		
	Tenderness	**Juiciness**	**Flavour**
1	Too tough	Much too dry	Very bad flavour
2	Tough	Dry	Poor flavour
3	Neither tough nor tender	Neither dry nor juicy	Neither bad nor good flavour
4	Tender	Juicy	Good flavour
5	Too tender	Too juicy	Very good flavour

Table 3. Effect of vitamin D_3 supplementation on shear force values (kg) of raw and cooked unaged male naked neck chicken meat.

Treatment	Raw	Cooked
A_0V_0	0.96^b	1.65^b
A_0V_{2000}	1.91^a	1.86^{ab}
A_0V_{4000}	1.91^a	1.86^{ab}
A_0V_{6000}	1.27^{ab}	1.53^b
A_0V_{8000}	0.92^b	3.09^a
SE	0.143	0.223

$^{a,\ b}$, Means in the same column not sharing a common superscript are significantly different (P< 0.05); SE, standard error; A_0V_0, unaged male naked neck chicken meat not supplemented with vitamin D_3; A_0V_{2000}, unaged male naked neck chicken meat supplemented with 2000 iu of vitamin D_3 per kg of dm of feed; A_0V_{4000}, unaged male naked neck chicken meat supplemented with 2000 iu of vitamin D_3 per kg dm of feed; A_0V_{6000}, unaged male naked neck chicken meat supplemented with 2000 iu of vitamin D_3 per kg dm of feed; A_0V_{8000}, unaged male naked neck chicken meat supplemented with 2000 iu of vitamin D_3 per kg dm of feed.

flavour using a 5-point scale in the University of Limpopo Food Science Lab (Table 2).

Chemical analysis

Dry matter contents of the feed and meat samples were determined by drying the samples at 105°C for 24 h. Gross energy values of the feeds were determined using an adiabatic bomb calorimeter and semi-micro Kjeldahl method used to analyse nitrogen content (University of Limpopo Laboratory, South Africa). Diets were analysed for fatty acids, phosphorus, calcium and lysine according to the method described by AOAC (2002). High performance liquid chromatography (HPLC) was used to quantify vitamin D_3 in the experimental chicken feeds (LATS, University of Limpopo, Polokwane) according to the methods described by Swan-Choo and Siong (1996).

Statistical analysis

Effects of dietary vitamin D3 supplementation on meat quality were analysed using the general linear model procedure of the statistical analysis system (SAS, 2008). The statistical model used was:

$$Y_{ijk}=\mu+ T_1+ \sum_{ijk}$$

Where, Y_{ijk} is the overall observation (shear force values, meat tenderness, juiciness and flavour), T_1 is the effect of different vitamin D_3 supplementation levels and $\sum_{ijk}$ is the residual effect. Duncan test for multiple comparisons was used to test the significance of differences between the treatment means (SAS, 2008). The responses in optimum shear force value, meat tenderness, juiciness and flavour changes to vitamin D_3 supplementation were modeled using the following quadratic equation:

$$Y=a+b_1x +b_2x^2$$

Where, 'Y' is meat tenderness, juiciness flavour, or shear force value; 'a' is intercept; 'b_1' and 'b_2' are coefficients of the quadratic equation; 'x' is the vitamin D_3 level and '$-b_1/2b_2$' is the 'x' value for optimum response. The quadratic model was fitted to the experimental data by means of the NLIN procedure of SAS (2008) and used because it gave the best fit.

RESULTS

Results of the effect of vitamin D_3 supplementation on shear force values of raw or cooked unaged male naked neck chicken meat are presented in Table 3. Raw meat from chickens not supplemented with vitamin D_3 and from those supplemented with 8000 IU vitamin D_3 per kg DM of feed had lower (P<0.05) shear force values than those produced from chickens supplemented with 2000 and 4000. However, raw meat from male naked neck

Table 4. Vitamin D_3 supplementation levels (IU/kg DM feed) for optimal shear force values (kg) of raw and cooked unaged and aged male naked neck chicken meat.

Trait	Formula	r^2	Vitamin D_3 level	Optimal Y- level
Unaged				
Raw	$Y=1.076+0.00042589X -0.000000057X^2$	0.832	3735	1.871
Cooked	$Y=1.827-0.00021107X + 0.000000042X^2$	0.669	2512	1.561
Aged				
Raw	$Y=1.603 -0.000121107 X+ 0.000000009X^2$	0.274	6728	3.084
Cooked	$Y=2.485 -0.000314428 X+ 0.000000037X^2$	0.873	4249	1.817

r^2, Regression coefficient; vitamin D_3 level, level of dietary vitamin D_3 supplementation for optimal Y- level.

Table 5. Effect of vitamin D_3 supplementation levels (IU/kg DM of feed) on shear force values (kg) of raw and cooked aged male naked neck chicken meat.

Treatment	Raw	Cooked
A_1V_0	1.76	2.54
A_1V_{2000}	1.09	1.86
A_1V_{4000}	1.26	1.98
A_1V_{6000}	1.56	1.91
A_1V_{8000}	1.01	2.38
SE	0.143	0.223

SE, Standard error; A_1V_0, aged male Naked neck chicken meat not supplemented with vitamin D_3; A_1V_{2000}, aged male Naked neck chicken meat supplemented with 2000 IU of vitamin D_3 per kg of DM of feed; A_1V_{4000}, aged male Naked neck chicken meat supplemented with 2000 IU of vitamin D_3 per kg DM of feed; A_1V_{6000}, aged male Naked neck chicken meat supplemented with 2000 IU of vitamin D_3 per kg DM of feed; A_1V_{8000}, aged male Naked neck chicken meat supplemented with 2000 IU of vitamin D_3 per kg DM of feed.

chickens supplemented with 2000, 4000 and 6000 IU vitamin D_3 levels had similar ($P>0.05$) shear force values. Similarly, raw meat from unsupplemented chickens and those supplemented with 6000 and 8000 levels had similar ($P>0.05$) shear force values. Male naked neck chickens supplemented with 8000 level produced cooked meat with a higher ($P<0.05$) shear force value than those from meat produced by chickens not supplemented or supplemented with 6000. However, cooked meat from unsupplemented chickens and those supplemented with 2000, 4000 and 6000 IU vitamin D_3 per kg DM of feed had similar ($P>0.05$) shear force values. Shear force values for both raw and cooked meat of male naked neck chickens were optimized at supplementation levels of 3735 (r^2=0.832) and 2512 (r^2=0.669) IU vitamin D_3 per kg DM of feed, respectively (Table 4). Results of the effect of vitamin D_3 supplementation on shear force values of raw or cooked aged male naked neck chicken meat are presented in Table 5. Vitamin D_3 supplementation had no ($P>0.05$) effect on the shear force values of raw or cooked aged male naked neck chicken meat. Shear force values for raw and cooked aged meat of male naked neck chickens were optimized at vitamin D_3 supplementation levels of 6728 (r^2=0.274) and 4249 (r^2=0.873) IU per kg DM of feed, respectively (Table 4).

Vitamin D_3 supplementation had no ($P>0.05$) effect on tenderness, juiciness and flavour of unaged male naked neck chicken meat (Table 6). Results of the effect of vitamin D_3 supplementation on tenderness, juiciness and flavour of aged male naked neck chicken meat are presented in Table 7. Male naked neck chickens supplemented with 4000 and 8000 IU of vitamin D_3 per kg DM of feed produced meat with improved ($P<0.05$) tenderness compared to that produced by unsupplemented chickens. However, male naked neck chickens supplemented with 2000, 4000, 6000 , and 8000 IU of vitamin D_3 per kg DM of feed produced meat of similar ($P>0.05$) tenderness. Similarly male naked neck chickens not supplemented with vitamin D_3 produced meat with similar ($P>0.05$) tenderness to those produced by chickens supplemented with 2000 and 6000 IU of vitamin D_3 per kg DM of feed. Male naked neck chickens supplemented with 2000, 6000 and 8000 IU of vitamin D_3 per kg DM of feed produced meat with improved ($P<0.05$) flavour compared to that produced by meat from chickens not supplemented with dietary vitamin D_3. Meat produced

Table 6. Effect of vitamin D_3 supplementation on tenderness, juiciness and flavour of male naked neck chicken meat without postmortem aging*.

Treatment	Tenderness	Juiciness	Flavour
A_0V_0	3.1	2.7	3.1
A_0V_{2000}	3.3	2.9	3.2
A_0V_{4000}	3.2	3.0	3.5
A_0V_{6000}	3.2	3.3	3.7
A_0V_{8000}	3.1	3.6	3.7
SE	0.040	0.032	0.081

SE, Standard error; A_0V_0, Unaged male naked neck chicken meat not supplemented with vitamin D_3; A0V2000, unaged male naked neck chicken meat supplemented with 2000 IU of vitamin D_3 per kg of DM of feed; A_0V_{4000}, unaged male naked neck chicken meat supplemented with 2000 IU of vitamin D_3 per kg DM of feed; A_0V_{6000}, unaged male naked neck chicken meat supplemented with 2000 IU of vitamin D_3 per kg DM of feed; A_0V_{8000}, unaged male naked neck chicken meat supplemented with 2000 IU of vitamin D_3 per kg DM of feed; *, Meat are graded on a 5-point scale.

Table 7. Effect of vitamin D_3 supplementation level on tenderness, juiciness and flavour of aged (24 hr. postmortem aging) male naked neck meat*.

Treatment	Tenderness	Flavour	Juiciness
A_1V_0	2.8^{b}	2.8^{c}	2.4
A_1V_{2000}	3.2^{ab}	3.4^{ab}	3.4
A_1V_{4000}	3.6^{a}	3.1^{bc}	3.1
A_1V_{6000}	3.4^{ab}	3.4^{ab}	3.3
A_1V_{8000}	3.6^{a}	3.6^{a}	3.5
SE	0.170	0.371	0.356

$^{a, b, c}$, Means in the same column not sharing a common superscript are significantly different (P< 0.05); SE, standard error; *, meat graded on a 5-point scale (Table 2); A_1V_0, aged male naked neck chicken meat not supplemented with vitamin D_3; A_1V_{2000}, aged male naked neck chicken meat supplemented with 2000 IU of vitamin D_3 per kg of DM of feed; A_1V_{4000}, aged male naked neck chicken meat supplemented with 2000 IU of vitamin D_3 per kg DM of feed; A_1V_{6000}, aged male naked neck chicken meat supplemented with 2000 IU of vitamin D_3 per kg DM of feed; A_1V_{8000}, aged male naked neck chicken meat supplemented with 2000 IU of vitamin D_3 per kg DM of feed.

by chickens supplemented with 2000, 4000, and 6000 IU of vitamin D_3 per kg DM of feed had similar (P>0.05) flavour. Vitamin D_3 supplementation had no (P>0.05) effect on juiciness of aged male naked neck chickens meat. Tenderness, juiciness and flavour of aged male naked neck chickens meat were optimized at vitamin D_3 supplementation levels of 6830 (r^2 = 0.839), 6894 (r^2 = 0.683), and 9795 (r^2 = 0.657) IU per kg DM of feed, respectively (Table 8).

DISCUSSION

The current results indicate that vitamin D_3 supplementation had no effect on shear force values of raw or cooked unaged male naked neck chicken meat. These results are similar to those of Rider et al. (2004) where vitamin D_3 supplementation had no effect on shear force values of unaged raw or cooked beef steaks. Wiegand et al. (2002) also found no differences in shear force values between vitamin D_3 treated and untreated pork chops. However, Boleman et al. (2004) reported higher shear force values for vitamin D_3 treated lamb chops compared to those of the control. In the present study, unaged cooked male naked neck chicken meat had higher shear force values than those from raw meat. This was probably due to the total collagen soluble contents. In older indigenous chickens, after heat denaturation, more highly cross-linked collagen will shrink and remain insoluble, effectively squeezing the heat denatured myofibrillar gel leading to loss of moisture and a tougher texture (Wattanachant et al., 2004). The present study indicates that shear force values of unaged raw male naked neck chicken meat were optimized at a vitamin D_3 supplementation level of 3735(r^2=0.832) IU per kg DM of feed. Shear force values of unaged cooked male naked neck chicken meat were optimized at a vitamin D_3 supplementation level of 2512 (r^2=0.669) IU per kg DM of feed. Vitamin D_3 supplementation improved tenderness and flavour of aged naked neck meat. This

Table 8. Vitamin D_3 supplementation levels (IU/kg DM of feed) for optimal tenderness, juiciness and flavour of aged male Naked neck chicken meat (24 hr. postmortem aging).

Trait	Formula	r^2	Vitamin D_3 level	Optimal Y-level
Tenderness	$Y=2.811+0.00021857X-0.000000016 X^2$	0.839	6830	3.557
Juiciness	$Y=2.563+ 0.000262 X+ 0.000000019 X^2$	0.683	6894	3.466
Flavour	$Y=2.863+ 0.000137 X- 0.000000007 X^2$	0.657	9795	3.534

r^2: Regression coefficient; vitamin D_3 level, level of dietary vitamin D_3 supplementation for optimal Y- level.

offers a solution to the problem of hardiness of indigenous chickens. However, Vitamin D_3 did not improve tenderness and flavour of unaged, shear force of aged naked neck chicken meat.

Vitamin D_3 supplementation had no effect on shear force values of raw or cooked aged male naked neck chicken meat. These results are similar to those of Scanga et al. (2001) who reported that vitamin D_3 did not improve tenderness of aged cooked beef steaks. However, Karges et al*.* (1999; 2001) observed that feeding vitamin D_3 for six days prior to slaughter significantly reduced shear force values of gluteus medium steaks. Vitamin D_3 supplementation levels of 6728 (r^2=0.274) and 4249 (r^2=0.873) IU per kg DM of feed were calculated to produce optimum shear force values for aged raw and cooked male naked neck chicken meat, respectively, in the current study. Optimal shear force values in the current study were attained at lower dietary vitamin D_3 supplementation levels as compared to supplementation levels observed in beef steers (Karges et al*.,* 2001). Lee et al. (2008) explained that chicken meat enters the rigor mortis 5 to 6 h postmortem and thereafter the pH does not change. Schreurs (2000) proved that the chicken breast muscle toughness peaks 6 h after slaughter. Lee et al*.* (2008) also reported that the ultimate pH is reached the same time as the rigor mortis, being early in chickens than in mammals. This may be explained by the faster muscle metabolism and glycogen utilization in chicken breast muscles (Lee et al., 2007). In the breast muscles there are two forms of calpains: µ- calpain and µ/m- calpain. µ/m- calpain is very stable and diminishes little by 24 h postmortem aging, whereas µ-calpain strongly decreases by 6 h postmortem (Lee et al., 2008). After 12 h, µ-calpain activity is hardly detectable which explains why avian muscle tenderizes rapidly. The two forms of calpains in birds are more calcium-sensitive than in their mammalian counterparts, and it may be that µ-calpain is mobilized very soon after slaughter, because, for example, its calcium concentration is very low and below that of the cattle µ-calpain (Lee et al., 2007). Dransfiled (1994) showed that in chickens, 80% of maximum tenderness can be reached after 0.3 days of storage at 1°C. The present study shows that vitamin D_3 supplementation did not improve shear force values of cooked aged male naked neck chicken meat. Bailey and Light (1989) indicated that during cooking of the meat, there is first the increase in toughness between 40 and 50°C, owing to the beginning of denaturation of myofibrillar proteins, and a further increase between 60 and 70°C. This is because of shrinkage of intramuscular or collagen at 65°C. The increases in collagen content and collagen cross-linking in meat, generally, increase the toughness of cooked meat (Foucat and Renou, 2000). When the indigenous chicken muscle is exposed to high temperatures it becomes denser and with more compact fibre arrangements and results in increased shear force values (Wattanachant et al., 2005). No similar studies on chickens were found.

Vitamin D_3 supplementation had no effect on tenderness, juiciness and flavour of unaged male naked neck chicken meat. These results are similar to the observation made by Navid et al. (2011) and Ma et al. (2009) that vitamin D_3 supplementation had no effect on meat tenderness of unaged chicken meat. Not much information on the subject was found in relation to chickens. However, contrary to the present study, Pedreira et al. (2003) observed that vitamin D_3 supplementation improved tenderness, juiciness and flavour of unaged beef steaks. Similarly, Swanek et al. (1999; 1999a) observed that vitamin D_3 supplementation improved tenderness and flavour of unaged beef steaks. In the present study, vitamin D_3 supplementation had no effect on juiciness of aged naked neck chicken meat. This is similar to the results of Pedreira et al. (2003) who observed that vitamin D_3 did not improve meat juiciness of aged beef steers. However, contrary to the current findings Swanek et al. (1999a; 1999b) explained that juiciness of aged beef steers was improved by vitamin D_3 supplementation. In the present study, vitamin D_3 supplementation level improved tenderness and flavour of aged male naked neck chicken meat. Vitamin D_3 supplementation increases calcium content in meat. High calcium content in meat increased the activities of calpains, the intracellular proteases which are responsible for meat tenderization (Rider et al., 2000). The present observation is similar to the findings of Pedreira et al. (2003) who observed that vitamin D_3 supplementation improved tenderness and flavour of aged beef steaks. However, Montgomery et al*.* (2000, 2002) observed no improvement of tenderness and flavour in meat from steers supplemented with vitamin D_3.

Aged naked neck meat tenderness and flavour were optimized at vitamin D_3 supplementation levels of 6830 (r^2 = 0.839) and 9795 (r^2 = 0.657) IU per kg DM feed, respectively. It is interesting to note that meat flavour was optimized at a higher vitamin D_3 supplementation level.

Conclusion

Vitamin D_3 supplementation improved tenderness and flavour of aged male naked neck meat. This offers a solution to the problem of hardiness of indigenous chickens. However, vitamin D_3 did not improve tenderness and flavour of unaged meat. Vitamin D_3 supplementation did not improve the shear force value of unaged and aged male naked neck chicken meat.

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REFERENCES

AOAC (Association of Analytic Official Chemists) (2002). Official Methods of Analysis, 17th Edition. Washington, DC: AOAC.

AMSA (American Meat Science Association) (1995). Research guidelines for cookery, sensory evaluation and instrumental tenderness measurements of fresh meat. National livestock meat board, Chicago, il.

Boleman CT, Ramsey WS, Pell RK, Savell JW (2004). Mechanism of vitamin D_3 on tenderness of lamb, sheep and goat, wool and mohair combines research. pp. 10-18.

Dawson DL, Sheldon BW, Miles JJ (1991). Effect of aseptic processing on the texture of chicken meat. Poult. Sci. 70:2359-2367.

Dransfiled E (1994). Optimization of tenderization, aging and tenderness. Meat Sci. 36: 105-121.

Fanatico AC, Pillai PB, Emmert, JL, Owens CM (2005b). Impact of alternative broiler genotypes and production of meat quality. J. Poult. Sci. 84: 34.

Food and Agriculture Organisation of the United Nations (2010).Organic Agriculture and Genetic Resources for Food and Agriculture: Rearing native Chickens through Organic Agriculture South Africa. [Accessed: 11 May, 2011]. www.fao.org/docrep/FAO/010/a1120e/a1120e04.pdf,

Foucat L, Renou JP, Traope A (2000). Study of water dynamics in hydrated collagen. Biopolymers 53: 218-222.

Karges K, Brooks JC, Gill DR, Breazile JE, Owens FN and Morgan JB (2001). Effect of supplemental vitamin D_3 on food intake, carcass characteristics, and tenderness and muscle properties of beef steers. J. Anim. Sci. 79: 2844-2850.

Kingori AM, Wachira AM, Tuitoek JK (2010). Indigenous Chicken Production in Kenya: A review. Int. J. Poult.Sci, 9: 309-316.

Lee HS, Sante-Lhoutrllier V, Vigouroux S, Briand Y, Briand M (2007). Calpain specificity and expression in chicken tissue. Comp. Biochem. Physiol. 146: 88-93.

Lee HS, Sante-Lhoutrllier V, Vigouroux S, Briand Y, Briand M (2008). Role of calpain in postmortem proteolysis in chicken muscle. J. Poult Sci. 87: 2126-2132.

Ma XianYong; Jiang ZongYong; Lin YingCai; Zhou GuiLian, Zhang HanXing (2009). Effects of Ca and vitamin D_3 on muscle tenderness of yellow chickens and its mechanism. Chinese J. Anim. Nutr. 21: 356-362.

Montgomery JL, Carr MS, Kerth CR, Hilton GG, Price BP, Galyean ML, Horst RL and Miller MF (2002). Effect of vitamin D_3 supplementation level on postmortem tenderization of beef from steers. J. Anim. Sci. 80: 971-981.

Montgomery JL, Parrish FC, Beitz DC, Horst RL, Huff-Lonnergan EJ and Trenkle A H (2000). The use of vitamin D_3 to improve beef tenderness. J. Anim. Sci. 78: 2615-2621.

Morgan JB, Savell JW, Hale DS, Miller RK, Griffin DB, Cross HR and Shackelford SD (1991). National beef tenderness survey. J. Anim. Sci. 69: 3274-3283.

Moula N, Antoine-Moussiaux N, Farnir F, Leroy P (2009c). Evaluation of the production performances of an endangered local poultry breed, the Famennoise. Int. J. Poult. Sci. 8: 389-396.

Navid D, Sheikhlar A, Kaveh K (2011). Influence of the combination of Vitamin D_3 and papaya leaf on meat quality of spent laying hens. Agric. J. 6(4): 197-200

Pedreira MS, Filho AL, Leite VO, Carvalho MH (2003). Quality characteristics of longissimus dorsi muscle for Bos indicus animals treated with vitamin D_3. Sci. Agricola 60: 637-642.

Rider NC, Mikel WB, Behrends JM, Scaletti RW, Xiong YL, Aaron DK (2000). Effects of dietary vitamin D_3 supplementation of cull beef cows on longissimus and semitendinosus muscle tenderness. J. Anim. Sci. 78:16.

SAS (2008). Statistical Analysis Systems User's Guide: Version 9.2 2nd Edn. SAS Institute, Inc., North Caroline, USA.

Savell JW, Smith GC, Dolezal HG, Field TG, Gill DR, Griffin DB, Hale DS, Morgan J B, Norcutt SL, Tatum JD (1991). The final report of the national beef quality audit. National Cattlemen's Beef Association Englewood Company, Colorado, USA.

Schreurs FJG (2000). Postmortem changes in chicken muscle. World's Poult. Sci. J. 56: 319-346.

Scanga JA, Belk KE, Tatum JD, Smith GC (2001). Supranutritional oral supplementation with vitamin D_3, calcium and the effects of beef tenderness. J. Anim. Sci. 79: 912-198.

Swan-Choo K, Siong TE (1996). Development of HPLC method for the simultaneous determination of several vitamins. J. Nutr. 2: 49-65.

Swanek SS, Morgan JB, Elan N A, Gill DR, Stratia CA, Dolezal H G and Ray FK (1999a). Supplemental vitamin D_3 and beef tenderness. Animal Science Research Report, Oklahoma State University, pp. 59-66.

Swanek SS, Morgan JB, Owens FN, Gill DR, Stratia CA, Dolezal HG Ray FK (1999). Vitamin D_3 supplementation of beef steers increases longissimus tenderness. J. Anim. Sci. 77: 874-881.

Wattanachant S, Benjakul S, Ledward DA (2004). Composition, color and texture of Thai indigenous and broiler chicken muscle. Poult. Sci. 83: 123-128.

Wiegand BR, Parrish FC, Morrical DG, Huff-Lonergan EJ (2002). Feeding high levels of vitamin D_3 does not improve tenderness of callipyge lamb loin chops. J. Anim. Sci. 79: 2086-2091.