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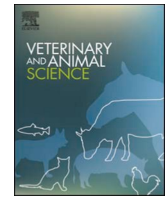

Effect of dietary methionine to crude protein ratio on performance of Ross 308 broiler chickens aged 22 to 42 days

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ABSTRACT

An experiment was conducted to determine the effect of dietary methionine to crude protein (CP) ratio on the performance of male Ross 308 broiler chickens aged 22 to 42 days. The diets were isocaloric and isonitrogenous but with different methionine-to-CP ratios. The diets, based on methionine to crude protein ratios, were $M_{0.020}$ (0.020), $M_{0.025}$ (0.025) $M_{0.030}$ (0.030), $M_{0.040}$ (0.040), or $M_{0.045}$ (0.045). A complete randomized design was used. A quadratic type of equation was used to determine dietary methionine to CP ratios for optimal performance of the chickens. Dietary methionine to CP ratio had no effect ($P > 0.05$) on feed intake, live weight gain, live weight, feed efficiency, metabolizable energy intake, nitrogen retention, abdominal fat pad weight, breast meat nitrogen and methionine contents, and meat flavour and shear force values of the chickens, but it affected ($P < 0.05$) CP digestibility, carcass and breast weights, and breast meat tenderness and juiciness. Methionine to CP ratios of 0.039, 0.038, 0.050, and 0.050 were calculated to result in optimal CP digestibility, carcass weight, breast meat tenderness, and juiciness, respectively. These results may imply that dietary methionine to CP ratio requirements for broiler chickens will depend on the production parameter of interest.

Introduction

Broiler chicken carcass weight and composition are important in the broiler industry (Ng'ambi et al., 2009; Rezaei et al., 2004). Chickens cannot synthesize sufficient amounts of methionine to sustain normal body functions (NRC, 1994; Pokoo-Aikins et al., 2022). Methionine is a precursor of cysteine (Ojano-Dirain & Waldroup, 2002). It is important for growth, plays an essential role in energy production and boosts the liability, performance, and feed efficiency utilization in chickens (Rehman et al. 2019). Methionine may reduce chicken carcass fatness via its role in carnithine synthesis (Schutte et al. 1997). NRC (1994) suggested a total methionine amount of 0.4 % in a diet of 20 % crude protein (CP) or methionine to CP ratio of 0.020, for optimal performance of 22 to 42 days old broiler chickens. Ojano-Dirain and Waldroup (2002) found that dietary methionine to CP ratios of 0.19, 0.022, and 0.025 optimized growth, live weight, and carcass weight, respectively, of 22 to 42-day-old broiler chickens. Whereas Shen et al. (2015) reported that supplementation of either L-Met or DL-Met has beneficial effects on villus development and reduced protein oxidation in duodenum. Heidari et al. (2018) observed a decreased body weight and weight gain, feed intake and increased feed conversion ratio in overall rearing period of Ross 308 broiler chickens. However, higher, and lower methionine to CP ratios for optimal broiler chicken performance have been reported by other authors (NRC, 1994; Cobb 2012; KFSF 2012; Ross, 2014). Thus, there is need for further studies to ascertain methionine to CP ratios for optimal broiler chicken performance. Zhai et al. (2016) reported no effect on meat sensory attributes with an increase in methionine to CP ratio in the diet of broiler chickens. Diets with low methionine to CP ratios result in poor feed efficiencies and low carcass weights of the chickens (NRC, 1994; Pokoo-Aikins et al., 2022). Thus, data on methionine to CP ratio requirements for optimal production results in some carcass and meat characteristics of Ross 308 broiler chickens from 22 to 42 days of age is inconclusive. The discrepancies may be due to breed improvements resulting in higher methionine requirements (NRC, 1994; Vieira and Angel 2012; Pokoo-Aikins et al., 2022). Thus, to match breed improvements, there is need to continuously determine methionine requirements for optimal carcass and meat characteristics of Ross 308 broiler chickens. This experiment determined dietary methionine to CP ratio levels for optimal broiler chicken performance.

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Materials and methods

The experiment was performed at the University of Limpopo, South Africa (27.55S, 24.77E). An ethical clearance certificate Number AREC/13/2017:PG was procured from the nationally registered University of Limpopo Animal Research and Ethics Committee before the commencement of the study.

This study determined methionine to CP ratio levels for optimal performance of male Ross 308 broiler chickens aged 22 to 42 days. A total of 150 chickens, weighing an average of 637 ± 12.0 g each, were used in a completely randomised design (SAS, 2008), having 5 treatments and replicated 3 times, resulting in a total of 15-floor pens with 10 birds each. An open-sided structure was used to house the chickens. For proper ventilation long axis was situated along an east-west direction in one m^2 pen of wire mesh. Natural (V-shaped windows) and artificial means (supplying fans) were used as ventilation mechanisms to enhance the birds' microclimatic conditions and to maintain the natural convection act. Moreover, the house had temperatures maintained at 30 to 33 °C during the starter and 23 to 25 °C at the grower phase. Two weeks before the start of the experiment, paraformaldehyde was used to disinfect the poultry house. Lighting was provided 24 h daily utilizing natural lighting and artificial lighting using 175-watt infrared ruby lamps. The bedding for the chickens was prepared using wood-shaved sawdust and it was changed weekly. The diets contained 12 MJ/kg DM and 200 g CP/kg DM. The diets had different levels of methionine to CP ratios of 0.020 (Diet $M_{0.020}$), 0.025 (Diet $M_{0.025}$),0.030 (Diet $M_{0.030}$), 0.040 (Diet $M_{0.040}$) or 0.045 (Diet $M_{0.045}$) (Table 1). Before the start of the experiment, the chickens were fed a commercial diet containing 220 g of CP/kg DM and 12 MJ/kg DM. During the experiment, the chickens were offered *ad libitum* feed and water.

Live weights were taken at the start of the experiment and then weekly thereafter. Live weight gains per chicken were calculated. Daily feed intakes were measured throughout the experiment. The feed conversion ratio (FCR) was calculated as feed consumed divided by the live weight gain of the chickens. Digestibility was conducted in specially designed metabolic cages having separated watering and feeding troughs when the chickens were 35 to 42 days old. At 42 days of age, all the remaining chickens per pen were slaughtered for determination of carcass characteristics.

Breast meat sensory attributes (tenderness, flavour, and juiciness) were determined using a 5-point ranking scale (Table 2) (American Meat Science Association, 1995).

Broiler chicken performance data was analysed using GLM procedures of the statistical analysis of variance Version 9.3.1 software program (SAS, 2008). The Turkey test (5 %) was used for mean separations (SAS, 2008). The model was $Y_{ij} = \mu + T_i + e_{ij}$, where $Y_{ij} = j^{th}$ is the observation of the i^{th} treatment level; μ = the overall mean; T_i = the effect of the i^{th} treatment level, and e_{ij} = random error.

Table 1
Diet ingredients.

Feed ingredient	Treatment				
	$M_{0.020}$	$M_{0.025}$	$M_{0.030}$	$M_{0.040}$	$M_{0.045}$
Maize (%)	55.00	55.00	55.00	55.00	55.00
Maize gluten 60 (%)	1.99	1.70	1.42	0.87	0.60
Wheat bran (%)	2.56	2.47	2.38	2.20	1.77
Soybean 46 (%)	29.35	29.54	29.73	30.09	30.37
Lysine HCL (%)	0.10	0.10	0.10	0.10	0.10
Methionine (%)	0.08	0.19	0.29	0.50	0.61
Threonine (%)	0.05	0.05	0.05	0.05	0.05
Premix (%)	0.10	0.10	0.10	0.10	0.10
Limestone (%)	1.77	1.76	1.76	1.76	1.75
Sodium chloride (%)	0.50	0.50	0.50	0.50	0.50
Monocalcium phosphate (%)	1.62	1.63	1.63	1.63	1.64
Sodium bicarbonate (%)	0.30	0.30	0.30	0.30	0.50
Oil – Sunflower (%)	6.58	6.66	6.74	6.90	7.01
Total	**100**	**100**	**100**	**100**	**100**

Table 2
Sensory attribute evaluation scores.

Score	Sensory attributes		
	Tenderness	Juiciness	Flavour
1	Too tough	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

Source: American Meat Science Association (1995).

The following quadratic equation was used to determine dietary methionine to CP ratios for optimal performance of the chickens (SAS, 2008):

$$Y = a + b_1 x + b_2 x^2 + e$$

Where Y = optimal performance; a = intercept; b = coefficients of the equation; × = methionine to CP ratio; $-b_1/2b_2$ = methionine to CP ratio for optimal response, and e = the error.

Results

The diets had different ($P < 0.05$) total methionine levels leading to different methionine to crude protein (CP) ratios of 0.020 (diet $M_{0.020}$), 0.025 (diet $M_{0.025}$), 0.030 (diet $M_{0.030}$), 0.040 (diet $M_{0.040}$) or 0.045 (diet $M_{0.045}$) and had similar ($P > 0.05$) nutrient composition (Table 3).

Methionine to CP ratio had effect ($P < 0.05$) on diet CP digestibility (Table 4).Chickens on diets with methionine to CP ratios of 0.030, 0.040, or 0.045 had higher ($P < 0.05$) CP digestibility values than those on diets with methionine to CP ratios of 0.020 or 0.025. However, broiler chickens on diets containing methionine to CP ratios of 0.030, 0.040, or 0.045 had similar ($P > 0.05$) CP digestibility values. Similarly, chickens on diets having methionine to CP ratios of 0.020 or 0.025 had the same ($P > 0.05$) CP digestibility values. A dietary methionine to CP ratio of 0.039 was calculated to result in optimal CP digestibility by the chickens ($Y = -15.70 + 3702.078x + -48{,}077.922\times^2$, $r^2 = 0.834$). Methionine to CP ratio had no effect ($P > 0.05$) on intake, live weight gain, feed efficiency (FCR), ME intake, and N-retention of male chickens (Table 4).

The diet methionine to CP ratio had an effect ($P < 0.05$) on the carcass and breast meat weights of the chickens (Table 5). Male chickens on diets containing methionine to CP ratios of 0.040 or 0.045 had heavier ($P < 0.05$) breasts than those on diets with methionine to CP ratios of 0.020, 0.025, or 0.030. However, similar ($P > 0.05$) breast weights were observed from chickens on diets with methionine to CP ratios of 0.040 or 0.045. Likewise, similar ($P > 0.05$) breast weights were observed from chickens on diets with methionine to CP ratios of

Table 3
Nutrient composition of the diets.

Nutrient*	Diet				
	$M_{0.020}$	$M_{0.025}$	$M_{0.030}$	$M_{0.040}$	$M_{0.045}$
Dry matter (g/kg)	889 ± 4.2	890 ± 4.1	890 ± 4.2	891 ± 5.0	891 ± 5.2
Energy (MJ/kg DM feed)	16 ± 0.3	16± 0.2	16 ± 0.2	16 ± 0.2	16 ± 0.2
Crude protein (g/kg DM)	200 ± 1.5	200 ± 1.5	200 ± 1.5	200 ± 1.5	200 ± 1.5
Total methionine (g/kg DM)	4^a ± 0.19	5^b ± 0.19	6^c ± ± 0.20	8^d ± 0.29	9^e ± 0.29
Total methionine to CP ratio	0.020^a ± 0.0020	0.025^b ± 0.0010	0.030^c ± 0.0020	0.040^d ± 0.0010	0.045^e ± 0.0011

* : Values written as mean ± standard error (SE)

Table 4
Effect of methionine to CP ratio on feed intake, live weight gain, FCR, CP digestibility, ME intake, and N-retention of male broiler chickens aged 22 to 42 days.

Parameter*	Diet#				
	$M_{0.020}$	$M_{0.025}$	$M_{0.030}$	$M_{0.040}$	$M_{0.045}$
Feed intake (g DM/bird/day)	138 ± 4.10	137 ± 5.83	136 ± 3.63	140 ± 2.83	144 ± 8.97
Live weight gain (g/bird/day)	75.0 ± 3.67	77.3 ± 6.03	78.3 ± 4.93	82.3 ± 5.10	83.7 ± 9.03
FCR (g:g)	2.1 ± 0.20	2.0 ± 0.10	2.0 ± 0.10	1.9 ± 0.19	1.9 ± 0.18
CP digestibility (%)	39.8[b] ± 7.52	43.7[b] ± 1.96	56.0[a] ± 6.00	52.7[a] ± 2.00	54.8[a] ± 2.55
ME intake (MJ/kg DM)	11.4 ± 0.20	11.5 ± 0.26	11.6 ± 0.30	11.6 ± 0.28	11.5 ± 0.26
N-retention (g/bird/day)	29.6 ± 5.85	26.0 ± 8.25	40.9 ± 7.24	34.0 ± 4.90	39.2 ± 4.0

* : Values written as mean ± standard error (SE).
a,b : Values having different superscripts in the same row indicate significant differences between treatment means ($P < 0.05$).
\# : Treatments were dietary methionine to CP ratios of 0.020 (diet $M_{0.020}$), 0.025 (diet $M_{0.025}$), 0.030 (diet $M_{0.030}$), 0.040 (diet $M_{0.040}$) or 0.045 (diet $M_{0.045}$).

Table 5
Effect of dietary methionine to CP ratio on live weight, carcass weight, abdominal fat pad, breast meat weight, and breast nitrogen content of male chickens aged 42 days.

Parameter*	Diet#				
	$M_{0.020}$	$M_{0.025}$	$M_{0.030}$	$M_{0.040}$	$M_{0.045}$
LWT (g/bird)	2226 ± 51.1	2298 ± 111.4	2328 ± 37.4	2385 ± 6.5	2423 ± 146.8
Carcass weight (g)	1533[b] ± 38.1	1601[a] ± 30.8	1635[a] ± 60.6	1708[a] ± 65.0	1649[a] ± 46.8
Abdominal fat pad (g)	59 ± 0.2	59 ± 0.2	59 ± 0.2	59 ± 0.2	59 ± 0.2
Breast meat yield (g)	553[b] ± 25.3	538[b] ± 32.9	524[b] ± 39.0	629[a] ± 25.1	601[a] ± 4.9
Breast meat N (g/kg DM)	37 ± 1.8	37 ± 1.9	38 ± 1.9	39 ± 2.0	39 ± 2.1
Breast meat methionine (g/kg DM)	8.8 ± 0.1	8.8 ± 0.1	8.9 ± 0.1	8.9 ± 0.1	8.9 ± 0.1

* : Values written as mean ± standard error (SE).
a, b, c : Values having different superscripts in the same row indicate significant differences between treatment means ($P < 0.05$).
\# Treatments were dietary methionine to CP ratios of 0.020 (diet $M_{0.020}$), 0.025 (diet $M_{0.025}$), 0.030 (diet $M_{0.030}$), 0.040 (diet $M_{0.040}$) or 0.045 (diet $M_{0.045}$).

0.020, 0.025, or 0.030. Male Ross 308 broiler chickens on diets with methionine to CP ratios of 0.025, 0.030, 0.040 or o.045 had heavier ($P < 0.05$) carcass weights compared to those from chickens on a diet with methionine to CP ratio of 0.020. However, broiler chickens on diets with methionine to CP ratios of 0.025, 0.030, 0.040, or o.045 produced carcasses with similar ($P > 0.05$) weights. A dietary methionine to CP ratio of 0.038 was calculated to result in optimal male Ross 308 broiler chicken carcass weight ($Y = 999.25 + 35{,}767.208x + -467{,}207.79 \times^2$, $r^2 = 0.931$). The methionine to CP ratio did not affect ($P > 0.05$) live weight, fat pad weight, and breast meat N and methionine contents of male chickens (Table 5).

The diet methionine to CP ratio had an effect ($P < 0.05$) on meat tenderness and juiciness of the chickens (Table 5). However, chickens on diets having a methionine to CP ratio of 0.045 produced meat with higher ($P < 0.05$) tenderness values than those from chickens on diets with methionine to CP ratios of 0.020 or 0.025. Chickens on diets containing methionine to CP ratios of 0.020, 0.025, 0.030, or 0.040 produced meat with similar ($P > 0.05$) tenderness values. Likewise, meat from chickens on diets having methionine to crude protein ratios of 0.030, 0.040, or 0.045 had the same ($P > 0.05$) tenderness values. Broiler chickens on diets with methionine to CP ratios of 0.030 or 0.045 produced meat with better ($P < 0.05$) juiciness values than the meat produced by chickens on diets containing methionine to CP ratios of 0.020 or 0.025. Chickens on diets with methionine to CP ratios of 0.02, 0.025, or 0.040 produced meat with similar ($P > 0.05$) juiciness values. Dietary methionine to crude protein ratios used in the present study had no effect ($P > 0.05$) on chicken meat flavour and shear force values (Table 6). A dietary methionine to CP ratio of 0.050 was calculated to result in optimal chicken meat tenderness and juiciness (Table 7).

Discussion

The diets used in the present study contained 20 % CP and 16 MJ of energy per kg DM, likely meeting protein and energy requirements for 22 to 42-day-old broiler chickens (NRC, 1994). The diets had similar nutrients except dietary methionine to CP ratio. The diets contained dietary methionine to CP ratios of 0.020, 0.025, 0.030, 0.040 or 0.045. Increasing dietary methionine to CP ratio from 0.020 to 0.045 did not significantly affect intake, ME intake, feed efficiency, nitrogen retention, and live weight gain of male Ross 308 broiler chickens, possibly indicating that methionine to CP ratios required for optimization of these parameters were met. NRC (1994) suggested a total methionine amount of 0.4 % in a diet of 20 % crude protein (CP) or methionine to CP ratio of 0.02, for optimal performance of 22 to 42 days old broiler chickens. Ahmed and Abbas ` (2011) observed that dietary methionine levels of 110 and 130 % above those of NRC (1994) levels improved the feed intake of broiler chickens. Pillai et al. (2006), Saki et al. (2007), Mohammadi et al. (2009) and Sigolo et al. (2019) reported that increasing methionine levels in a diet above those recommended by NRC (1994) did not increase feed intake. However, Ojano-Dirain and Waldroup (2002) reported a decline in feed intake with an increasing dietary methionine to CP ratio. Chen et al. (2013) observed that a higher concentration of dietary methionine level of 5.9 g/kg DM (methionine to CP ratio of 0.03) improved the growth performance of 22 to 42-day-old broiler chickens. Similarly, several researchers (Ahmed & Abbas, 2011; Osti & Pandey, 2004; Pillai et al., 2006) have reported higher broiler chicken growth rates with increased dietary methionine to CP ratios. Meirelles et al. (2003) observed that increasing dietary methionine to CP ratio above those of NRC (1994) did not improve the FCR of 22 to 42-day-old broiler chickens. However, other authors (Ahmed & Abbas, 2011; Café & Waldroup, 2006; Pillai et al., 2006) reported that increasing the dietary methionine to CP ratio above those recommended by NRC (1994) improved the FCR of broiler chickens. Several authors

Table 6
Effect of diet methionine to CP ratio on broiler chicken meat tenderness, juiciness, flavour, and shear force values.

Variable*	Treatment #				
	$M_{0.020}$	$M_{0.025}$	$M_{0.030}$	$M_{0.040}$	$M_{0.045}$
Tenderness	3.5[b] ± 0.15	3.5[b] ± 0.37	3.8[ab] ± 0.10	3.8[ab] ± 0.06	3.9[a] ± 0.06
Juiciness	3.3[b] ± 0.13	3.3[b] ± 0.26	3.7[a] ± 0.24	3.6[ab] ± 0.15	3.8[a] ± 0.15
Flavour	3.2 ± 0.15	3.5 ± 0.28	3.5 ± 0.24	3.6 ± 0.28	3.4 ± 0.12
Shear force	11.6 ± 2.52	9.7 ± 4.32	11.1 ± 2.02	10.4 ± 0.80	8.2 ± 1.30

* : Values written as mean ± standard error (SE).
a,b : Values having different superscripts in the same row indicate significant differences between treatment means ($P < 0.05$).
\# : Treatments were dietary methionine to CP ratios of 0.020 (diet $M_{0.020}$), 0.025 (diet $M_{0.025}$), 0.030 (diet $M_{0.030}$), 0.040 (diet $M_{0.040}$) or 0.045 (diet $M_{0.045}$).

Table 7
Dietary methionine to crude protein ratio for optimal male broiler chicken meat tenderness and juiciness.

Trait	Formula	r^2	Optimal methionine to CP ratio
Tenderness	$Y = 2.725 + 46.461X + -461.039\times^2$	0.841	0.050
Juiciness	$Y = 2.400 + 54.5455X + -545.45\times^2$	0.745	0.050

(Hickling et al., 1990; Kalinowski et al., 2003; Moran, 1994; Osti & Pandey, 2004; Schutte & Pack, 1995) have reported that methionine levels above NRC (1994) recommendations did not affect the body weight of broiler chickens. However, Café and Waldroup (2006) reported that increasing dietary methionine to CP ratios by 115 % above the NRC (1994) recommendations improved the live body weights of male Ross 308 broiler chickens. Koreleski and Świątkiewicz (2009) observed that increasing dietary methionine to CP ratio above those recommended by NRC (1994) improved nitrogen retention in broiler chickens aged 22 to 42 days.

Methionine to CP ratios used in the present study affected the diet CP digestibility of male broiler chickens. A dietary methionine to CP ratio of 0.039 was calculated to result in optimal CP digestibility by male Ross 308 broiler chickens. The methionine to CP ratio of 0.039 that optimized CP digestibility in the present study is above those of NRC (1994), possibly due to differences in genotypes of the chickens used. Methionine influences the chicken's ability to absorb amino acids in the intestines (NRC, 1994; Pokoo-Aikins et al., 2022), and hence it affects feed digestibility. Crystalline amino acids increase the availability of amino acids for absorption when compared with amino acids in intact proteins, which is the reason reducing the CP with supplementation of amino acids would not be detrimental to the broiler performance (Abbasi et al., 2014). This indicates that small fluctuations of amino acids in the diet can affect gene expression in the small intestine as mucins play an important part in the intestine of the chickens not only as a defence mechanism but also displays capabilities of digesting and absorbing nutrients for the body (Teng et al., 2023).

Dietary methionine to CP ratios of 0.020, 0.025, 0.030, 0.040, or 0.045 used in the present study did not affect broiler chicken live weight, abdominal fat pad weight, and meat N and methionine contents, indicating that methionine to CP ratios required for optimization of these parameters were met. Drazbo et al. (2015) reported improved carcass weights of male broiler chickens on higher than NRC (1994) dietary methionine to CP ratios. Similarly, Nasr (2011) observed that broiler chickens on diets containing higher methionine to CP ratios than those recommended by NRC (1994) had higher carcass, breast, thigh, and drumstick weights. Differences between the experiments may be due to different broiler chicken genotypes and diets used (NRC, 1994). A dietary methionine to CP ratio of 0.034 optimized breast meat yield in the present study. This is higher than the calculated NRC (1994) methionine to CP ratio of 0.019. The differences may be due to differences in chicken genotypes (NRC, 1994). Methionine is important for protein synthesis in chickens, and it also influences amino acid absorption in small intestines (NRC, 1994; Pokoo-Aikins et al., 2022; Shen et al., 2015).

Dietary methionine to CP ratios of 0.020 to 0.045 did not significantly affect chicken meat flavour and shear force values, possibly indicating that these ratios met the requirements for optimal meat flavour and shear force values. Jiao et al. (2010) indicated that higher levels of dietary methionine reduced shear force values of broiler chicken meat. In the present study, both meat tenderness and juiciness were optimized at a methionine to CP ratio of 0.050, possibly indicating that methionine to crude protein ratios for optimizing chicken meat tenderness and juiciness are different from those that optimize meat flavour and shear force values. Pokoo-Aikins et al. (2022) also indicated that broiler chickens have different methionine levels for optimal responses in meat sensory attributes. Zonenberg and Drazbo (2018) reported better meat flavour, tenderness and juiciness values for male broiler chickens on diets having methionine to CP ratios of 0.004, 0.004, and 0.012 (calculated from their results), respectively. Amino acids are thought to play major roles in eliciting the characteristics of juiciness and flavour of food Vaikundamoorthy et al. (2019) . Lengkidworraphiphat et al. (2021) reported that free glutamic acid, 5′-inosinic acid, and potassium ions are the main taste-active components in chicken meat. In an isocaloric and isonitrogenous diet, increasing dietary methionine to CP ratio from 0.020 to 0.045 did not significantly affect intake, live weight gain, ME intake, N-retention, live weight, carcass weight, abdominal fat pad weight, breast meat N and methionine contents, and meat flavour and shear force values of male Ross 308 broiler chickens aged 22 to 42 days, possibly indicating that dietary methionine to CP ratios required for optimization of these parameters were met. Dietary methionine to CP ratio of 0.034, in a diet of 16 MJ and 220 g CP/kg DM, was calculated with the use of quadratic equations to result in optimal male chicken carcass weight. However, optimal meat tenderness and juiciness required a higher methionine-to-CP ratio of 0.050. The methionine to CP ratios of 0.034, 0.050, and 0.050 required for optimal carcass weight, and meat tenderness and juiciness, respectively, were higher than those of NRC (1994). The possible explanation for higher ratios may be related to the changes in the genotypes of the chickens (Han and Baker 1991; NRC, 1994).

Conclusion

It is concluded that dietary methionine to CP ratio requirement levels for broiler chickens will depend on the production variable of interest. However, the findings of the current study are limited to the conventional Ross 308 chicken breeds and cannot be generalised to other chicken breeds due to different genetic makeup. Furthermore, results are limited to the inclusion levels used in this study. However, further investigations are needed to ascertain the findings of this research.

Ethics statement

This study was performed in line with the principles of the Declaration of Helsinki. An ethical clearance certificate Number AREC/13/2017:PG was obtained from the nationally registered University of Limpopo Animal Research and Ethics Committee before the commencement of the study.

Data availability

The datasets generated and analysed during the current study are available in the University of Limpopo library repository.

CRediT authorship contribution statement

Ng'ambi Jones Wilfred: Writing – review & editing, Visualization, Supervision, Resources, Project administration, Methodology, Funding acquisition, Conceptualization. **Paledi Mashego Queen:** Writing – review & editing, Supervision, Software, Project administration, Methodology, Investigation, Formal analysis, Conceptualization. **Manyelo Tlou Grace:** Writing – original draft, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Tyasi Thobela Louis:** Writing – review & editing, Methodology, Formal analysis, Data curation, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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