Indian J. Anim. Res., 53(5) 2019: 628-633
Print ISSN:0367-6722 / Online ISSN:0976-0555

AGRICULTURAL RESEARCH COMMUNICATION CENTRE
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Effect of dietary *Moringa oleifera* seed meal inclusion on performance and carcass quality of female Ross 308 broiler chickens

Jones Wilfred Ng'ambi, Lephai S. Molepo and Muzi Mandla Ginindza*

Department of Agricultural Economics and Animal Production,
University of Limpopo, P/Bag X1106, Sovenga 0727, South Africa.
Received: 10-02-2017 Accepted: 31-08-2017 DOI:10.18805/ijar.B-712

ABSTRACT

The objective of this study was to determine the effect of decorticated *Moringa oleifera* seed meal inclusion level on productivity and meat characteristics of female Ross 308 broiler chickens aged 21 to 42 days. The chickens were fed *ad libitum* isocaloric and isonitrogenous diets but with differing seed meal inclusion levels of 0 (M_0), 5 (M_5), 10 (M_{10}), 15 (M_{15}) and 20 (M_{20}) g/kg DM, in a complete randomized design. Seed meal inclusion had no effect (P>0.05) on intake, growth and live weight but it improved (P<0.05) nitrogen retention of the chickens. Similarly, seed meal inclusion had no effect (P>0.05) on meat nitrogen, ash, pH and colour but it improved (P<0.05) lipid and energy contents of the meat. The results indicate that meat lipids, energy, polyunsaturated fatty acids, tenderness, juiciness and flavour were optimized at different seed meal inclusion levels of 11.10, 12.96, 12.67, 7.50, 15.50 and 19.50 g/kg DM, respectively.

Key words: Broiler chickens, Metabolisable energy, *Moringa oleifera* seed meal, Growth, Meat fatty acid contents, Meat sensory attributes.

INTRODUCTION

Broiler chickens are selected for high feed intake, growth and carcass yield (Richards, 2003). However, improvements in carcass yield have also resulted in excessive carcass fat. Excessive carcass fat is one of the problems faced by the broiler industry since it reduces feed efficiency and carcass quality (Oyedeji and Atteh, 2005). Coronary heart diseases and arteriosclerosis are strongly related to the dietary intake of cholesterol and saturated fatty acids and are among the most important causes of human mortalities (Sacks, 2002). Lipid oxidation is a major cause of meat quality deterioration, resulting in rancidity and the formation of undesirable odours and flavours which lower the functional, sensory and nutritive values of meat products (Bou *et al*., 2004). Thus, excessive carcass fat is not liked by consumers (Macajova *et al*., 2003). The addition of antioxidants, which are organic molecules capable of scavenging the active forms of oxygen involved in oxidation, is a major preventive measure against lipid oxidation in meat (Valenzuela, 1995). Antioxidants get incorporated within cell membranes and protect tissues against oxidation from reactive oxygen species, thus maintaining the overall quality of meat (Deschalzo and Sancho, 2008). Similarly, polyphenols or flavonoids in plants have the affinity to bind to biological polymers and heavy metal ions, terminating free radical chain reactions (Valenzuela, 1995; Milos *et al*., 2000; Botsoglou *et al*., 2002). There is an increasing trend toward replacement of saturated with unsaturated fats, especially polyunsaturated fatty acids, in poultry meat through feed manipulation (Leeson, 1999; Bou *et al*., 2004). *Moringa* (*M.*) *oleifera* seed meal, widely available in many tropical countries, is a good source of antioxidant compounds such as ascorbic acid, flavonoids, phenolics and carotenoids (Anwar and Rashid, 2007; Makkar and Becker, 1997). However, data on the effects of *M. oleifera* seed meal inclusion in the diet on nutritive and sensory values of chicken meat is limited and not clear. The objective of this study was, therefore, to determine the effect of *M. oleifera* seed meal inclusion at finisher stage on productivity and carcass characteristics of female Ross 308 broiler chickens.

MATERIALS AND METHODS

Study site, experimental design, treatments, procedures and data collection: The study was conducted at the University of Limpopo (latitude 27.55°S and longitude 24.77°E) South Africa during the months August and September 2015. The study determined the effect of dietary *M. oleifera* seed meal inclusion level at finisher stage on performance and carcass characteristics of female Ross 308 broiler chickens aged 21 to 42 days. The chickens were raised up to 21 days old before the experiment commenced. Prior to the staring of the experiment the chickens were fed a 22% CP practical diet that would satisfy their nutritional requirements according to NRC (1994). A total of 250 female Ross 308 broiler chickens weighing 558 ± 10g/bird were randomly assigned to 5 dietary treatments with 4 replications, each replicate having 10 chickens. A complete randomized design (SAS, 2008) was used. The experimental diets were isocaloric and isonitrogenous, but with different *M. oleifera* seed meal inclusion levels of 0 (FM_0), 5 (FM_5), 10 (FM_{10}),

*Corresponding author's e-mail: muziginindza@gmail.com

15 (FM_{15}) and 20 (FM_{20}) g/kg DM. Feed compositions of the diets are given in Table 1. The nutrient contents of *M. oleifera* seed meal are indicated in Table 2. Feed and water were offered *ad libitum* throughout the experiment.

The initial live weights of the chickens were taken at the beginning of the experiment and weekly weights were taken thereafter. Weekly feed intakes were determined. Daily mean growth rates and feed conversion ratios were calculated. Digestibility was done when the chickens were between 35 and 42 days. At 42 days of age carcass and breast meat weights were determined. Breast meat samples were analysed for crude protein, fatty acids, pH and sensory attributes. The meat pH was measured (Crison, Basic 20 pH Meter). Breast meat was evaluated for tenderness, juiciness and flavour using a 5-point ranking scale (American Meat Science Association, 1995) (Table 3). Meat colour measurements were according to CIE (1978).

Chemical analysis: Dry matter and nitrogen contents of the diets, refusals, faeces and meat samples were determined as described by AOAC (2008). Neutral and acid detergent fibre

Table 1: Diet composition (g/kg) and nutrient analysis (MJ/kg DM for Gross energy and g/kg DM for crude protein) of the treatments for Ross 308 broiler chickens aged 21 to 42 days.

Feed	Treatment				
	FM_0	FM_5	FM_{10}	FM_{15}	FM_{20}
Yellow Maize	567	567	567	567	567
Sunflower meat	100	100	100	100	100
Full fat soya meal	290	285	280	275	270
Fish meal	10	10	10	10	10
Monocalcium phosphate	13.6	13.6	13.6	13.6	13.6
Limestone	13.6	13.6	13.6	13.6	13.6
Iodised salt	0.5	0.5	0.5	0.5	0.5
DL Methionine	0.3	0.3	0.3	0.3	0.3
L Threonine	0.0	0.0	0.0	0.0	0.0
Vitamin/ mineral premix	5.0	5.0	5.0	5.0	5.0
Moringa oleifera	0.0	5.0	10.0	15.0	20.0
Analysed Nutrients					
Energy (MJ/kg DM)	16.9	16.9	16.9	16.9	16.9
Crude protein (g/kg DM)	200	200	200	200	200

Table 2: Nutrient composition of *Moringa oleifera* seed meal, on dry matter basis.

Nutrient	g/kg DM	mg/kg DM	MJ/kg DM
Protein	199.2	-	-
Ca	25.3	-	-
ADF	281.1	-	-
NDF	482.2	-	-
Ash	86.1	-	-
Mg	27	-	-
P	3.4	-	-
Cu	3.1	-	-
Fe	6.3	-	-
Gross energy	-	-	18.54
Vitamin A- β carotene	-	0.12	-
Vitamin B-choline		-	382 -
Vitamin B_1-thiamin	-	0.06	-
Vitamin B_2-riboflavin	-	0.08	-
Vitamin B_3-nicotinic acid	-	0.3	-
Vitamin C-ascorbic acid	-	124	-

Table 3: Evaluation scores used by the sensory panel.

Score	Meat characteristics		
	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
4	Tender	Juicy	Good flavour
5	Too tender	Too juicy	Very good flavour

Source: American Meat Science Association (1995).

contents were analysed by AOAC (2008) methods. The energy of the diets, excreta samples and meat was determined using an adiabatic bomb calorimeter. Fatty acid and amino acid contents of the diets and meat were analysed by ion-exchange chromatography (HPLC, University of Limpopo). The mineral and vitamin contents were analysed by AOAC (2008) at Labtronics (Pretoria, South Africa).

Statistical analysis: Effect of dietary *M. oleifera* seed meal inclusion level on intake, digestibility, growth rate, mortality rate, feed conversion ratio and carcass characteristics of Ross 308 broiler chickens were analysed using the General Linear Model (GLM) procedure of the statistical analysis of variance (SAS 2008). Duncan test for multiple comparisons was used to test the significance of difference between treatment means ($P<0.05$). Data on fatty acids was presented as the least square means with standard errors. The chicken responses to seed meal inclusion level were modelled using the following quadratic equation:

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

Where Y = optimal nitrogen retention, carcass contents and meat sensory attributes; a = intercept; b = coefficients of the quadratic equation; x = seed meal inclusion level and $-b_1/2b_2$ = x value for optimal response. The quadratic model was fitted to the experimental data by means of the NLIN procedure of SAS (SAS 2008). The quadratic model was preferred because it gave the best fit.

RESULTS AND DISCUSSION

The diets were isocaloric and isonitrogenous but with different inclusion levels of *M. oleifera* seed meal, ranging from 0 to 20 g/kg DM. Moringa seed meal inclusion had no effect ($P>0.05$) on feed intake, growth, feed conversion ratio (FCR), live weight and metabolisable energy (ME) intake of the chickens but it affected ($P<0.05$) nitrogen retention (Table 4). Nitrogen (N) retention of female Ross 308 broiler chickens was optimized at a seed meal inclusion level of 11.50 ($r^2 = 0.286$) g/kg DM feed.

Moringa oleifera seed meal inclusion level hand no effect ($P>0.05$) on N, ash, pH and colour of breast meat of female Ross 308 broiler chickens aged 42 days (Table 5). However, *M. oleifera* seed meal inclusion level improved ($P<0.05$) energy and lipid contents of the meat. Chicken breast meat energy and lipid contents were optimized at different seed meal inclusion levels of 12.96 ($r^2 = 0.937$) and 11.10 ($r^2 = 0.918$) g/kg DM, respectively (Table 8). Saturated, monounsaturated, polyunsaturated to saturated fatty acid ratio and total unsaturated fatty acid contents of the breast meat were not ($P>0.05$) affected by seed meal inclusion level; however, seed meal inclusion improved

Table 4: Effect of *Moringa oleifera* seed meal inclusion level on feed intake, growth rate, feed conversion ratio (FCR), live weight, metabolisable energy (ME) intake and nitrogen retention of female Ross 308 broiler chickens aged 21 to 42 days.

Variable	Treatment					SEM
	FM_0	FM_5	FM_{10}	FM_{15}	FM_{20}	
Intake (g/bird/day)	154	149	150	147	148	1.35
Growth rate (g/bird/day)	51.8	49.8	54.3	55.0	52.0	1.16
FCR	2.97	2.99	2.76	2.67	2.85	0.136
Live weight (g/bird)	1617	1590	1733	1730	1658	22.69
ME (MJ/kg DM)	11.3	10.9	13.0	13.0	12.0	0.28
N-retention (g/bird/day)	2.1^{bc}	1.8^{c}	2.4^{ab}	2.4^{a}	1.8^{c}	0.06

$^{a, b, c}$: Means in the row not sharing a common superscript are significantly different ($P<0.05$).
SE : Standard error of the means

Table 5: Effect of *Moringa oleifera* seed meal inclusion level (g/kg DM feed) on nitrogen, lipid, ash and energy contents, pH and colour of breast meat of female Ross 308 broiler chickens aged 42 days.

Variable	Treatment					SEM
	FM_0	FM_5	FM_{10}	FM_{15}	FM_{20}	
DM (%)	25.4	25.6	26.0	25.8	25.7	0.34
Nitrogen content (%)	44.3	44.3	44.5	44.7	44.8	0.75
Lipids (%)	1.5^{b}	2.1^{a}	2.2^{a}	2.1^{a}	2.0^{a}	0.13
Energy (MJ/kg DM)	410.5^{b}	428.2^{a}	431.4^{a}	430.3^{a}	428.1^{a}	5.75
Ash (%)	1.18	1.17	1.20	1.20	1.21	0.073
pH	5.7	5.7	5.7	5.7	5.7	0.07
Meat colour						
L*	52	52	53	53	53	0.71
a*	5.0	5.1	5.2	5.2	5.1	0.34
b*	5.6	5.6	5.6	5.6	5.6	0.05

$^{a, b, c}$: Means in the row not sharing a common superscript are significantly different ($P<0.05$).
SEM : Standard error of the means.
Meat colour : L* = Meat lightness; a* = Meat redness; b* = Meat yellowness

(P<0.05) polyunsaturated fatty acids (PUFA) in the meat (Table 6). Dietary *M. oleifera* seed meal inclusion level of 12.67g/kg DM (r^2 = 0.990) optimized polyunsaturated fatty acid amounts in broiler chicken meat (Table 8).

Dietary *M. oleifera* seed meal inclusion level improved (P<0.05) chicken meat sensory attributes (Table 7). Meat tenderness, juiciness and flavour were optimized at different seed meal inclusion levels of 7.50 (r^2 = 0.827), 15.50 (r^2 = 0.673) and 19.50 (r^2 = 0.893) g/kg DM, respectively (Table 8).

In an isocaloric and isonitrogenous diet, increasing *M. oleifera* seed meal inclusion level had no effect on diet intake, ME intake, growth, FCR and live weight of female Ross 308 broiler chickens aged 21 to 42 days. However, seed meal inclusion level had effect on N-retention of the chickens. Nitrogen retention was optimized at a seed meal inclusion level of 11.50 g/kg DM feed. However, the increase in nitrogen retention with increased *M. oleifera* seed meal inclusion did not affect growth and live weight of chickens. It is possible that, at tissue level, nitrogen retained was catabolized for energy production (McDonald *et al.*, 2010). 'Mello *et al*. (1987), also, reported that *M. oleifera* seed meal inclusion did not improve feed intake, feed conversion ratio and body weight of broiler chickens aged 22 to 42 days. Similar results on broiler chickens have been reported elsewhere (Ter Meulen *et al*., 1984; Du *et al*., 2007). However, Ossebi (2010) found that *M. oleifera* seed meal inclusion reduced ME intake in broiler chickens. Munguti *et al*. (2006) and Compaore *et al*. (2011) reported that *M. oleifera* seed meal increased ME intake and live weight of broiler chickens.

Moringa oleifera seed meal inclusion level had no effect on female broiler chicken breast meat N, ash, pH, saturated fatty acids, monounsaturated fatty acids, total unsaturated fatty acids, polyunsaturated to saturated fatty acid ratio and colour. However, seed meal inclusion affected meat lipids, energy, polyunsaturated fatty acids, tenderness, juiciness and flavour. Thus, different *M. oleifera* seed meal inclusion levels of 11.10, 12.96, 12.67, 7.50, 15.50 and 19.50

Table 6: Least square means (± SE) for the sum composition of SFA, MUFA, PUFA, TUFA and polyunsaturated to saturated fatty acid ratio in breast meat of female Ross 308 broiler chickens fed diets having different inclusion levels (g/kg DM feed) of *Moringa oleifera* seed meal.

Fatty acids	Treatment				
	FM_0	FM_5	FM_{10}	FM_{15}	FM_{20}
SFA	4.52 ± 0.811	4.95 ± 0.954	7.12 ± 1.934	6.69 ± 1.942	4.83 ± 0.742
MUFA	4.19 ± 0.624	3.94 ± 0.615	6.55 ± 1.516	7.61 ± 3.126	5.89 ± 2.251
PUFA	3.14^b± 0.503	4.77^a ± 0.268	5.34^a ± 1.453	5.64^a ± 0.514	4.82^a ±0.841
TUFA	5.87 ± 0.981	6.95 ± 0.995	8.51 ± 1.851	8.52 ± 2.541	6.83 ± 1.934
P/S	0.69 ± 0.312	0.96 ± 0.213	0.75 ± 0.261	0.84 ± 0.281	1.0 ± 0.472

$^{a, b}$: Means in the row not sharing a common superscript are significantly different (P<0.05).
SFA: Saturated fatty acids; MUFA: Monounsaturated fatty acids; PUFA: Polyunsaturated fatty acids; TUFA: Total unsaturated fatty acids; P/S: Polyunsaturated to saturated fatty acid ratio; SE: Standard error.

Table 7: Effect of *Moringa oleifera* seed meal inclusion level (g/kg DM feed) on breast meat flavour, juiciness and tenderness of female Ross 308 broiler chickens aged 42 days.

Variable	Treatment					SEM
	FM_0	FM_5	FM_{10}	FM_{15}	FM_{20}	
Flavour	2.7^b	2.9^a	2.9^a	3.0^a	2.9^a	0.08
Juiciness	2.9^b	3.1^a	3.1^a	3.0^a	3.0^a	0.05
Tenderness	3.4^b	3.5^a	3.5^a	3.4^b	3.4^b	0.04

$^{a, b, c}$: Means in the row not sharing a common superscript are significantly different (P<0.05).
SEM : Standard error of the means

Table 8: *Moringa oleifera* seed meal inclusion levels (g/kg DM feed) for optimal female Ross 308 broiler chicken meat energy, lipid, PUFA, tenderness, juiciness and flavour.

Variable	Formula	r^2	Optimal meal inclusion level
Energy	$Y = 411.94 + 3.266x + -0.126x^2$	0.937	12.96
Lipids	$Y = 1.551 + 0.111x + -0.005x^2$	0.918	11.10
PUFA	$Y = 3.157 + 0.380x + -0.048x^2$	0.990	12.67
Tenderness	$Y = 3.417 + 0.015x + -0.001x^2$	0.827	7.50
Juiciness	$Y = 2.929 + 0.031x + -0.0014x^2$	0.673	15.50
Flavour	$Y = 2.709 + 0.039x + -0.001x^2$	0.893	19.50

g/kg DM, in a diet of 12 MJ energy and 180 g crude protein per kg DM, supported optimal chicken meat lipids, energy, PUFA, tenderness, juiciness and flavour, respectively. Data on the effect of *M. oleifera* seed meal inclusion levels on meat parameters is currently limited. The current results indicate that seed meal inclusion increased breast meat energy and lipid contents, which could be attributed to increased PUFA contents of the meat. However, the increase in PUFA contents did not affect the ratio of polyunsaturated to saturated fatty acids; though all the treatments had high ratios, ranging from 0.69 to 0.96. In poultry, dietary fatty acids are absorbed unchanged from the intestines and incorporated into tissue lipids. For example, linoleic and alfa linolenic acids cannot be synthesized by chickens and tissue concentrations respond rapidly to dietary changes (Wood and Enser, 1997). It is known that *M. oleifera* seed meal contains high amounts of PUFA and antioxidants (Makkar and Becker, 1997; Annongu *et al*., 2014), which maintain polyunsaturated fatty acid levels in meat and prevent quality deterioration during storage and processing (Wood and Enser, 1997).

Results of the present study indicate that different *M. oleifera* seed meal inclusion levels optimized meat tenderness, juiciness and flavour. The implication of these results is that *M. oleifera* seed meal inclusion levels for optimal meat tenderness, juiciness and flavour will depend on the particular sensory attribute of interest. It is not clear how seed meal inclusion level affected these meat sensory attributes. However, amino acids are thought to play major roles in eliciting the characteristics of juiciness and flavour of food (Kobayashi *et al*., 2009). Lawrie (2006) identified three compounds (free glutamic acid, 5'-inosinic acid and potassium ion) as the taste active components in chicken meat extracts. Glutamic and 5'-inosinic acids are favourites among consumers as they constitute a characteristic taste of chicken meat (Lawrie, 2006). The current results reveal a regulatory effect of *M. oleifera* seed meal inclusion level on chicken meat sensory attributes, which could be attributed to increased free glutamic acid, 5'-inosinic acid and potassium ion, thus resulting in improved meat tenderness, juiciness and flavour. It could also be due to increased PUFA contents of the meat, which tend to significantly increase scores for meat tenderness, juiciness and flavour (Wood and Enser, 1997).

CONCLUSION

In an isocaloric and isonitrogenous diet, increasing *M. oleifera* seed meal inclusion level had no effect on diet intake, ME intake, growth, FCR and live weight and breast meat N, ash, pH, saturated fatty acids, monounsaturated fatty acids, total unsaturated fatty acids, polyunsaturated to saturated fatty acid ratio and colour of female Ross 308 broiler chickens aged 21 to 42 days. However, seed meal inclusion improved meat PUFA, tenderness, juiciness and flavour which were optimized at different seed meal inclusion levels of 12.67, 7.50, 15.50 and 19.50 g/kg DM, respectively. These findings have implications on ration formulation for broiler chickens where *M. oleifera* seed meal is included. However, more studies are needed to ascertain these findings.

ACKNOWLEDGEMENT

The authors wish to acknowledge VLIR-UOS (Grant Number: ZIUS2016AP21) for financial support.

Conflict of Interest Statement: The authors declare that they have no conflict of interest.

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