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Full Length Research Paper

Quality and sensory evaluation of the dark and white meat of broilers fed diets varying in nutrient density from 16 to 37 days of age

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The aim of this research was to evaluate the meat quality of different broiler strains fed with diets from 16 to 37 d that differed in nutrients density, such as amino acids, crude proteins, metabolizable energy and microelements. A total of 1500 Avian48 and 1500 Cobb500 day-old chicks were fed a standard commercial diet throughout the starter period from 1 to15 d, while from 16 to 25 d and 26 to 37 d, the broilers were fed diets differing in amino acid, crude protein, metabolizable energy and microelement densities. These diets were iso-caloric and iso-nitrogenous. Two broilers strains, Avian48 and Cobb500, were used in this experiment to test the effect of three dietary treatments (basal diet, plant protein resources with high nutrient density, and poultry by-product meal as the animal protein resource with high density). The results indicated that increasing the nutrient density in the diet improved the meat quality and increased the meat tenderness compared to the control group. However, no differences were detected among the treatments with regard to the muscle color score, shear force and overall consumer acceptability of the breast meat. The dark meat from broilers fed (HND) from 26 to 37 d of age had higher (P≤0.01) protein and lower (P≤0.01) fat percentages compared to other treatments.

Key words: Broiler fillet, nutrient density, cooking loss, sensory evaluation, muscles color.

INTRODUCTION

Primary breeding companies have been encouraged to develop high-yielding broilers due to the high demand for breast fillets and value-added products (Petracci et al., 2015; Kijowski et al., 2014). For newly developed broiler strains, companies advocate high nutrient density diets. Approximately 60% of the total feed consumption occurs after the 3rd week from hatching in the 1.75 - 2 kg broiler market. New broiler strains, which were selected for a high breast meat yield, respond positively to high amino acid density diet formulations throughout the course of their production (Kidd et al., 2004, 2005; Corzo et al., 2005; Vieira and Angel, 2012). Genotypic selections by the primary poultry breeding companies have resulted in great improvements in the growth rate and feed conversion, as well as in the breast meat yield of broiler chicks compared to the broilers of previous decades (Dozier et al., 2008). As a result, it was concluded that modern broilers will require higher dietary amino acid concentrations to optimize performance and breast meat production compared to the broilers of past years (Kidd et al ., 2004; Dozier et al., 2006; Tahira et al., 2018).

Finally, information is lacking in developing countries concerning diets with a high density of crude protein, energy, microelements and amino acids in the growing and finishing phases of feeding. Therefore, this research was carried out to evaluate the effects of amino acid, crude protein, energy and microelement densities on broiler meat quality, which were evaluated through the

Table 1. Ingredients and calculated analysis of the experimental diets.

Diets ingredients	Starter (1-15)		Grower (16-25)			Finisher (26-35)		
Feed type	**Plant**	**Animal**	**Control**	**Plant**	**Animal**	**Control**	**Plant**	**Animal**
Yellow corn	55.6	55.6	60.65	59.0	59.0	63.7	62.8	62.8
Soybean meal (48% CP)	27.4	27.4	27.20	24.9	24.9	23.8	22.7	22.7
Corn gluten meal (62%CP)	10.0	7.50	5.00	8.00	5.30	4.40	6.00	3.80
Poultry by product meal (62%CP)	-	2.50	-	-	2.70	-	-	2.20
Wheat bran	1.50	1.50	-	1.00	1.00	-	-	-
Soya oil	1.20	1.20	3.00	3.20	3.20	4.10	4.5	4.50
Dicalcium phosphate	1.60	1.64	1.60	1.45	1.45	1.50	1.45	1.45
Limestone	1.26	1.26	1.30	1.16	1.16	1.32	1.26	1.26
Lysine	0.24	0.17	0.14	0.25	0.20	0.14	0.25	0.21
Methionine	0.13	0.14	0.11	0.13	0.15	0.07	0.12	0.14
Salts	0.42	0.42	0.38	0.16	0.19	0.38	0.27	0.29
Vitamins premix[1]	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Minerals premix[2]	0.30	0.30	0.27	0.40	0.40	0.24	0.30	0.30
Coccidiostat[3]	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06
Antibiotic[4]	0.07	0.09	0.08	0.08	0.08	0.08	0.08	0.08
Anti-mycotoxin[5]	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Vitamin C	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01
Measured Percentages								
Crude protein (%)	23.3	23.3	20.1	21.2*	21.2*	18.2	19.2*	19.2*
ME (kcal/kg)	3000	3000	3100	3150*	3150*	3200	3250*	3250*
Lysine (%)	1.32	1.32	1.10	1.25*	1.25*	1.00	1.18*	1.18*
Methionine (%)	0.60	0.60	0.48	0.56*	0.56*	0.42	0.51*	0.51*
Zinc (mg)	100	100	90.0	133.3*	133.3*	66.7	100*	100*

[1]Each 1 kg of vitamins contain: Vit. A; 15000000 IU, Vit. E: 100000 mg, Vit. Bl: 3000 mg. Vit. B2: 160000 mg, Vit.B6: 4000 mg, Vit, B12: 30 mg, Niacin: 55000 mg, Pantothenic acid: 15000 mg, Vit. K: 50000 mg, Vit. D3; 3000000 IU, Biotin: 250 mg and Folic acid: 2000 mg. [2]Each 3 kg of minerals contain: Choline: 7500000 mg, Copper: 10000 mg, Iodine: 2000 mg, Iron: 60000 mg, Manganese: 120000 mg, Zinc: 100000 mg, and selenium: 400 mg, cobalt: 500 mg. [3]Salinomycin sodium premix, Sacox (Intervet Inc., Millsboro, DE). [4]Starter and growing periods: oxytetracycline (Intervet Inc., Millsboro, DE). NJ); finisher period: virginiamycin, Stafac-20 (Phibro Animal Health, Fairfield, NJ). [5]Mycofix® Select, feed additives that protect broiler health by deactivation of mycotoxins. *Condensed nutrients under experimental study.

color, tenderness and sensory acceptability of white meat and the chemical composition of dark meat for the different broiler strains reared from 16 to 37 days of age.

MATERIALS AND METHODS

Dietary treatments

All of the broilers (Avian48 and Cobb500) were fed a standard commercial diet throughout the starter period from day 1 to day 15 according to NRC (1994). During the growing period (day 16 to day 25) and the finishing period (day 26 to day 37), the broilers were fed diets differing in amino acid, crude protein, metabolizable energy and microelement densities. Three treatments were used: the first treatment was the basal diet, which was used as the control, the second treatment was a diet containing plant protein resources with high nutrient density (HND), and the third treatment was a diet containing poultry by-product meal as the animal protein resource (APR) with high density. The feed ingredients of the experimental treatments are shown in Table 1.

Bird husbandry

A total of 1500 Avian48 and 1500 Cobb500 day-old chicks were obtained from Ismailia/Misr Poultry Company and were distributed into the three treatment groups in 60 floor pens; each treatment was replicated 10 times. Fifty broilers were placed in each pen (one bird per 0.09 m^2). The chicks were vaccinated in the hatchery to detect diseases, namely Marek’s disease, Newcastle disease, and infectious bronchitis. Each pen had a hanging feeder, a nipple-drinker line and a buildup litter. The chicks had free access to both feed and water. The starter diets were provided from 1 to 15 days of age in the form of crumbles, while the grower and the finisher diets were provided from 16 to 25 and 26 to 37 days of age, respectively, in the form of 3 mm and 5 mm pellets, respectively. Ambient temperature and photoperiod programs were maintained.

Sample preparation for dark and white meat quality tests

Boneless and skinless breast and bone-in thigh muscles were removed from the carcass at 4 h postmortem. A total of 120 breasts and thighs were placed into individually marked Ziploc bags and were then cooled (2°C) overnight. Each breast was divided into right and left halves at 24 h postmortem. Of these samples, eight breasts (right side of the carcass) per treatment per replication were evaluated for muscle color.

Breast samples

Individual breast samples were vacuum-packaged using a Turbovac 320-ST-S (Inject Star of the Americas, Inc., Brookfield, CT) in 15.2 × 20.3 cm, 3 mil vacuum pouches (item # 75001815, Rebel Butcher Supply Co. Inc., Flowood, MS). The breast samples were then kept frozen (-23°C) to conduct proximate analysis for the determination of cooking loss and shear force (n=10 with 4 subsamples per treatment). The breasts from the left side of the carcasses per treatment per replication were vacuum packed (4 /bag) and kept frozen (-23°C) for consumer sensory acceptability tests. The ground samples (10-15 mm thick) were tightly packed in 140 mm sample containers prior to analysis. Four random thigh meat samples per treatment per replication were used to determine the fat, protein, ash and moisture content in accordance with the methods of the Association of Official Analytical Chemists (A.O.A.C, 2000). The frozen samples were thawed for 24 h at 2°C and were then ground using a Cabelas PRO 450, Sidney, NE 69160 meat grinder that was fitted with a 3 mm cutting plate. The samples were then placed in labeled Ziploc brand freezer bags (S.C. Johnson and Son Inc.) and frozen (-23°C) for proximate analysis.

Color measurement

Color measurements were undertaken for each breast by a Hunter Lab Ultra Scan (VIS) Sensor (Hunter Lab Associates Laboratory, Inc.) on deboned breast meat fillet samples. Three measurements were taken at three different sites for each sample on the medial portion of the pectoralis major muscle, and the mean values were calculated. The color for each sample was expressed in terms of the CIE values for lightness (L*), redness (a*), and yellowness (b*).

Chroma (C, indicating intensity or saturation of the color) and hue (H, angle indicating the pure spectrum color) were also measured (Lilly et al., 2010; Saenmahayak et al., 2012).

Cooking loss

The frozen breast fillet samples (n=10 with 8 subsamples) were thawed at 2°C for 24 h. The thawed breast fillet samples were weighed and arranged in wire oven racks and cooked in a preheated convection oven (177°C) until the desired internal temperature was reached. The breast fillets were cooked to an internal temperature of 77°C, removed from the oven, allowed to cool to an internal temperature of 24°C and reweighed. The cooking loss (%) was calculated as the difference between the weight of the raw and cooked fillet divided by the raw fillet weight x 100 (Saenmahayak et al., 2007).

Allo-Kramer shear force determination

The tenderness was assessed using the procedure described by Sams et al. (1990) and Cavitt et al. (2005). The same breast samples that were used for cooking loss determination were used for the Allo-Kramer shear force determinations. The Allo-Kramer shear force (kg of force per gram of meat) was determined on two adjacent (4 x 2 x 0.7 cm) strips cut from the medial zone of the cooked breast parallel to the direction of the muscle fibers using a 10 kg load transducer and a crosshead speed of 2 mm/s.

Sensory analysis

Three consumer-based sensory panels (n=10 panelists/ replication) were performed to evaluate the acceptability of the breast meat from the broilers that were fed diets differing in amino acid, crude protein, metabolizable energy and zinc contents. The participants were recruited by an advertising sign, emails and a verbal personal invitation. The breasts were thawed at 2°C for 24 h before sensory evaluation and were vacuum packed using Cryovac 10K OTR vacuum bags (Cryovac, Duncan, SC). The samples were sous vide cooked for approximately 15 to 20 min at 98°C in a pot of water to an internal temperature of 77°C, as determined using meat thermometers (78631, Farberware, Westbury, NY) to verify the temperature. The breasts were cooled for approximately 15 min at room temperature and were cut into 2.5 x 2.5 x 2.5 cm cubes and kept warm (60 - 70°C) in a 8-quart chafer dish (53042, Polarware Co., Kiel, WI) until the panelists evaluated the samples. Random numbers were assigned to identify the samples. The

Table 2. Breast muscle color, shear force and cooking loss values and their interaction as affected by the strain and diet density at 37 days of age.

Treatments	Muscles color score					Shear force (kg/gm)	Cooking loss (%)
	a* Redness	b* Yellowness	L* Lightness	C* Chroma	h Hue		
Strain							
Avian 48	7.562	17.908	63.040	19.748	65.463	640.156[b]	23.500
Cobb 500	7.247	16.982	64.644	18.593	66.344	732.433[a]	23.644
SEM	0.444	0.720	1.057	0.888	1.180	24.369	0.085
Diet density							
Control	7.560	17.435	63.713	19.012	66.540	655.517	24.017[a]
Plant diet	7.618	18.045	63.365	20.038	64.887	715.467	23.100[c]
Animal diet	7.035	16.855	64.448	18.462	66.285	687.900	23.600[b]
SEM	0.543	0.881	1.295	1.088	1.445	29.846	0.105
Test of significance							
Strain	ns	ns	ns	ns	ns	*	ns
Diet density	ns	ns	ns	ns	ns	ns	***
Strain* Diet density	ns	ns	ns	ns	ns	ns	***
Interaction							
Avian 48*Control	8.243	18.580	62.703	20.327	66.060	584.167	24.300[a]
Avian 48*Plant diet	7.640	17.617	62.650	19.750	63.793	644.500	22.000[d]
Avian 48*Animal diet	6.803	17.527	63.767	19.167	66.537	691.800	24.200[a]
Cobb 500*Control	6.877	16.290	64.723	17.697	67.020	726.867	23.733[b]
Cobb 500*Plant diet	7.597	18.473	64.080	20.327	65.980	786.433	24.200[a]
Cobb 500*Animal diet	7.267	16.183	65.130	17.757	66.033	684.000	23.000[c]
SEM	0.769	1.246	1.831	1.539	2.044	42.208	0.148

SEM = standard error of the mean, * Significant at P≤ 0.05, ** Significant at P≤ 0.01, *** Significant at P≤ 0.001, ns not significant. Different letters (a, b) in the same column indicate significant differences P≤ 0.05

samples were randomized to remove bias. Each panelist was asked to evaluate 6 coded chicken breast samples (1 sample/treatment) for appearance, color, texture, flavor, juiciness and overall acceptability using a nine-point hedonic scale, where 1 = extremely dislike, 5 = neither like nor dislike, and 9 = extremely like (Meilgaard et al., 2007). The acceptability of the texture was defined as the product likeability irrespective of tenderness. The acceptability of the appearance was defined as the product likeness irrespective of the color and moisture content. The acceptability of the flavor was defined as the product likeness irrespective of the flavor (taste). The acceptability of the juiciness was defined as the product likeness irrespective of the juiciness. Water and unsalted crackers were provided, and panelists were asked to expectorate and rinse their mouths between each sample.

Statistical analysis

Analysis of variance of the obtained data was performed using the General Linear Model (GLM) procedure according to SPSS, 17 (2008). The means were compared using the Duncan multiple range test (Duncan, 1955) at the 0.05 probability level.

The statistical model used was as follows:

$$Y_{ijk} = \mu + S_i + R_j + (SR)_{ij} + e_{ijk}$$

where Yijk are values of the dependent variable, µ is the general mean, S is the strain effect, R is the feed type effect, $(SR)_{ij}$ = strain × feed type interaction, and eijk = experimental error.

RESULTS

The effects of the strain (Avian 48, Cobb 500), diet density and their interaction on the meat quality at 37 days of age are presented in Tables 2 to 4.

Muscle color

The data presented in Table 2 show that there were no significant differences in the muscle color score L*, a* and b* (lightness, redness, yellowness) as a result of the

Table 3. Sensory evaluation of breast meat as affected by the strain, diet density and their interaction at 37 days of age.

Treatments	Appearance	Color	Flavor	Tenderness	Juiciness	Overall acceptability
Strain						
Avian 48	8.56	8.53	8.13	8.26^{a}	8.03	8.10
Cobb 500	8.30	8.36	8.23	7.86^{b}	8.00	8.13
SEM	0.114	0.117	0.137	0.136	0.15	0.128
Diet density						
Control	8.35	8.60	8.45^{a}	7.85^{b}	8.10	8.10
Plant diet	8.45	8.35	8.00^{b}	8.40^{a}	8.10	8.25
Animal diet	8.50	8.40	8.10^{b}	7.95^{ab}	7.85	8.00
SEM	0.140	0.143	0.167	0.167	0.192	0.157
Test of significance						
Strain	ns	ns	ns	*	ns	ns
Diet density	ns	ns	*	*	ns	ns
Strain*Diet density	ns	ns	*	*	ns	ns
Interaction						
Avian 48*Control	8.40	8.50	8.50^{a}	7.7^{bc}	8.00	8.00
Avian 48*Plant diet	8.60	8.40	7.90^{b}	8.7^{a}	8.20	8.40
Avian 48*Animal diet	8.70	8.70	8.00^{b}	8.4^{ab}	7.90	7.90
Cobb 500*Control	8.30	8.70	8.40^{ab}	8^{abc}	8.20	8.20
Cobb 500*Plant diet	8.30	8.30	8.10^{b}	8.1^{abc}	8.00	8.10
Cobb 500*Animal diet	8.30	8.10	8.20^{b}	7.5^{c}	7.80	8.10
SEM	0.198	0.202	0.237	0.236	0.271	0.222

SEM = standard error of the mean, * Significant at P≤ 0.05, ** Significant at P≤ 0.01, *** Significant at P≤ 0.001, ns not significant. Different letters (a, b) in the same column indicate significant differences P≤ 0.05.

influence of the strain. Table 2 shows that no differences existed among breast meat color from the broilers fed with HND diets at 16-37 days of age. The treatments values reflected the main characteristics of the normal breast meat at 24 h post-mortem, indicating that all of the broiler breast meat was of good quality. Additionally, there were no significant differences in the muscle color scores due to the interaction between the diet density and strain (Table 2).

Shear force

The data in Table 2 indicates the presence of significant (P≤ 0.05) differences in the shear force of the breast meat due to the strain effect. There were no significant differences (P>0.05) in the tenderness of the breast meat of broilers that were fed diets that differed in nutrient content. The data indicated that increasing the amino acids, crude protein, metabolizable energy and zinc content had no influence on the Allo-Kramer shear force or the total energy and, therefore, would have an insignificant effect on the meat quality or sensory acceptability. In addition, the data did not show any significant differences in the shear force of the breast meat due to the effect of the diet content X strain interaction (Table 2).

Cooking loss

The data presented in Table 2 do not show any significant differences in the cooking loss due to the strain effect. However, cooking loss was highly affected (P≤ 0.001) by the diet content, HND, APD and the control. The HND group had the lowest percentage of cooking loss of all of the experimental groups. The cooking loss ranged from 23.1% for the plant diet density group to 24.017% for the control diet. As shown in Table 2, the cooking loss was significantly affected (P≤ 0.001) by the interaction between the diet density (HND, APD and control) and the strain.

Sensory evaluation

The effects of the strain (Avian 48, Cobb 500), the diet density of the APD, the control and their interaction on the sensory evaluation at 37 days of age are given in Table 3. There were significant differences (P≤0.05) in the breast meat tenderness due to the strain effect. Avian 48 strain recorded higher values for breast meat tenderness than the Cobb 500 strain. However, there were no significant differences in appearance, color, flavor, juiciness and overall acceptability for the breast meat due to strain effect. As shown in Table 3, there

Table 4. Chemical composition of the thigh meat as affected by the strain, diet density and their interaction at 37 days of age.

Treatments	Moisture (%)	Protein (%)	Fat (%)	Ash (%)
Strain				
Avian 48	66.88	68.10	38.24	2.81
Cobb 500	67.14	67.34	38.17	2.86
SEM	0.69	0.73	0.74	0.08
Diet density				
Control	64.86^{b}	65.55^{b}	40.01^{a}	2.91
Plant diet	69.03^{a}	71.38^{a}	35.04^{b}	2.91
Animal diet	67.15^{ab}	66.22^{b}	39.56^{a}	2.69
SEM	0.84	0.90	0.915	0.09
Test of significance				
Strain	ns	ns	ns	ns
Diet density	*	**	**	ns
Strain* Diet density	ns	ns	ns	*
Interaction				
Avian 48*Control	66.10	66.53	39.85	2.78^{ab}
Avian 48*Plant diet	68.02	70.22	36.36	2.77^{ab}
Avian 48*Animal diet	66.54	67.54	38.50	2.90^{ab}
Cobb 500*Control	63.62	64.58	40.18	3.05^{a}
Cobb 500*Plant diet	70.03	72.55	33.73	3.05^{a}
Cobb 500*Animal diet	67.77	64.89	40.61	2.49^{b}
SEM	1.19	1.27	1.29	0.138

SEM = standard error of the mean, * Significant at P≤ 0.05, ** Significant at P≤ 0.01, *** Significant at P≤ 0.001, ns not significant. Different letters (a, b) in the same column indicate significant differences P≤ 0.05.

were significant differences (P≤0.05) in breast meat tenderness and flavor as a result of the effect of the diet density (plant diet density, animal diet density, control). The plant diet density group had a higher value for breast meat tenderness and a lower value for breast meat flavor than the other experimental groups. There were no significant differences in the appearance, color, juiciness and overall acceptability for the breast meat due to the diet density effect. The data presented in Table 3 indicate differences (P≤0.05) in the breast meat tenderness and flavor due to the interaction between the diet density (plant diet density, animal diet density, control) and the strain. Meanwhile, no significant differences were observed in the appearance, color, juiciness and overall acceptability of the breast meat as a result of the interaction between the diet density and the strain.

Chemical analysis

The effects of the strain (Avian 48, Cobb 500), the diet density (HND, APD and control) and their interactions on the chemical analysis at 37 days of age are shown in Table 4. The data indicated no differences in the chemical analysis for dark meat samples due to the strain effect. In addition, there were significant differences (P≤0.01) in the dark meat analysis due to the diet density effect. The dark meat from broilers that were fed plant diets formulated with a high nutrient density at 16 to 37 days of age had the highest protein and the lowest fat percentage among the treatments. The dark meat from the control diet and the animal diets formulated with a high nutrient density fed at 16 to 37 days of age had lower (P≤0.01) protein and higher fat percentages than the plant diets formulated with a high nutrient density that were fed at 16 to 37 days of age. Furthermore, there were significant differences (P≤0.01) in the moisture percentage of the dark meat from broilers fed with HND at 16 to 37 days of age, which followed the same trend as the protein percentage. There were no significant differences in the ash percentage due to the impact of the diet density (HND, APD and control). The data in Table 4 reveal significant differences (P≤0.05) in the ash percentage due to the interaction between the diet density (HND, APD and control) and the strain; however, there were no differences in the moisture, protein and fat percentage as a result of the impact of the interaction between the diet density and the strain.

DISCUSSION

The increase in the demand for breast fillets and value-added products over the last 10 years has contributed to increasing markets for broilers. Modern broilers in the poultry industry may reach their target weight in fewer days than in traditional production systems. Due to genetic improvements, broilers were found to consume less feed per unit of body weight gain (Dozier III et al., 2001, 2007). The progress that was noticeable in the poultry industry in the last few decades was mainly due to the impressive improvements in all areas of broilers and laying hens, i.e., management, health, and nutrition, but poultry breeding has been the primary area responsible for these successes in the live performance and meat yields of broilers.

The data presented in Table 1 show no differences in the muscle color score L*, a* and b* (lightness, redness, yellowness) as a result of the influence of the strain. This suggests that no differences existed among the breast meat from broilers fed diets formulated with a high nutrient density at 16-37 days of age to L*, a* and b*. These values are in line with the characteristics of the 24 h post-mortem normal breast meat, indicating that all broiler breast meat in this study is of good quality. There are also non-significant differences in the muscle color scores L*, a* and b* as a result of the impact of the interaction between the type of feed and the strain; these results are shown in Table 1.

The values reported in this study were higher than those reported by Battula et al. (2008), Schilling et al. (2008) and Corzo et al. (2009), who observed L* (lightness) values of approximately 55 and a* (redness) values of approximately 1.6, while b* (yellowness) values that were higher than Schilling et al. (2008) and Corzo et al. (2009) were reported to have values ranging from 4.9 to 6.0.

Furthermore, the breast muscles were significantly different (P<.05) in the shear force as a result of the strain influence. There were no significant differences (P>0.05) in the tenderness of the breast meat of the broilers fed diets that varied in nutrient density (Table 1). Statistical analysis indicated that the increases in amino acids, crude protein, metabolizable energy and zinc density were not associated with an increase in the Allo-Kramer shear force or total energy and, therefore, would be unlikely to affect the meat quality or sensory acceptability. Moreover, there are no significant differences in the shear force of the breast muscle meat as a result of the impact of the interaction between the type of feed and the strain, as shown in Table 1.

The data indicated that the increase in the amino acid density had an insignificant effect on the Allo-Kramer shear force and the total energy of the meat samples; thus, it would not have any significant effect on the meat quality or sensory acceptability. The Allo-Kramer shear force values varied between 655.5 and 715.4 mJ/gm as a result of the effect of the type of feed (HND, APD and control); these values were higher than those reported by Lilly et al., 2010. This value indicates the tenderness of the breast meat; thus, it would be highly acceptable to consumers (Schilling et al., 2003, 2010; Battula et al., 2008; Corzo et al., 2009).

The data concerning cooking loss as a result of the influence of strain were not significant. The cooking loss was significantly affected (P≤ 0.001) by the feed type (HND, APD and control), and the plant diet density group had the lowest percentage of cooking loss compared to the experimental groups fed with other diets (HND, APD and control). The cooking loss ranged from 23.1% for the plant diet density group to 24.017% for the control diet without any density effect. The data in Table 1 revealed that the cooking loss was highly affected (P≤ 0.001) by the interaction between the type of feed (HND, APD and control) and the strain. The cooking loss varied between 21.5 and 22.3% for the excessive treatment and the low treatment, respectively, which lies within the range of parameters for chicken breast cooking loss reported by Meek et al. (2000) and Battula et al. (2008), but is slightly higher than that reported by Schilling et al. (2008, 2010) and Corzo et al. (2009).

Insignificant differences (P>0.05) were found for the appearance, juiciness, color and overall acceptability of the broiler breast meat between the different nutrient density treatments. On the other hand, significant differences (P≤0.05) were observed in the properties of the breast meat tenderness and flavor (Table 2). The breast meat from chicks fed with high density diet was significantly lower (P<0.05) in flavor acceptability compared to the breast meat from chicks fed with adequate amino acid density diets. This indicates that increasing the amino acid density in the diet may negatively affect consumer’s acceptability of the flavor. The mean acceptability scores varied between “moderately like” to "very much like” for all of the studied treatments for the appearance, aroma, texture and overall acceptability, indicating that consumers have a high degree of acceptability of the broiler breast meat irrespective of the amino acid density in the feed. The results of the current study are similar to the results of sensory acceptability of the breast meat from those in previous research when a 9-point hedonic scale was used (Lilly et al., 2010). Significant differences were recorded (P<0.05) in most of the traits of the thigh meat samples from broilers that were fed with adequate amino acid diet. These thigh meat samples had significantly higher (P<0.05) fat and a significantly lower (P<0.05) percentage of moisture than the samples of the other amino acid densities. The dark meat samples from the adequate amino acid diet also had a significantly lower (P<0.05) protein percentage than those from the high or excessive amino acids diets (Table 3). These results are in agreement with previous studies, revealing that the carcass parameters, such as fat, decrease when the amino acid density increases (Lilly et al., 2010; Corzo et al., 2005). In addition, the proximate analysis values of the dark portions of the broilers from the current study were similar to those previously reported by Schilling et al. (2010) for different strains of broilers that were fed at varying levels of DDGS in the diet.

Conclusion

In conclusion, feeding broilers on grower and finisher diets with high density of lysine, methionine, crude protein, metabolizable energy and microelements from 16 to 37 days of age led to an increase in the breast fillet yield and improved the meat quality to levels that meet consumer demand. Broiler companies may try to use different diet formulations that vary in nutrient density; however, the decision regarding the correct formulation must be based on feed costs and broiler meat prices. Further studies are need to evaluate the supplementation of chicken feed by functional ingredients to improve the nutritional value of broilers meat, thus making broilers meat rich in ingredients that are beneficial to human health. Further studies are also needed to test the impacts of amino acids density on broilers performance and meat quality.

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