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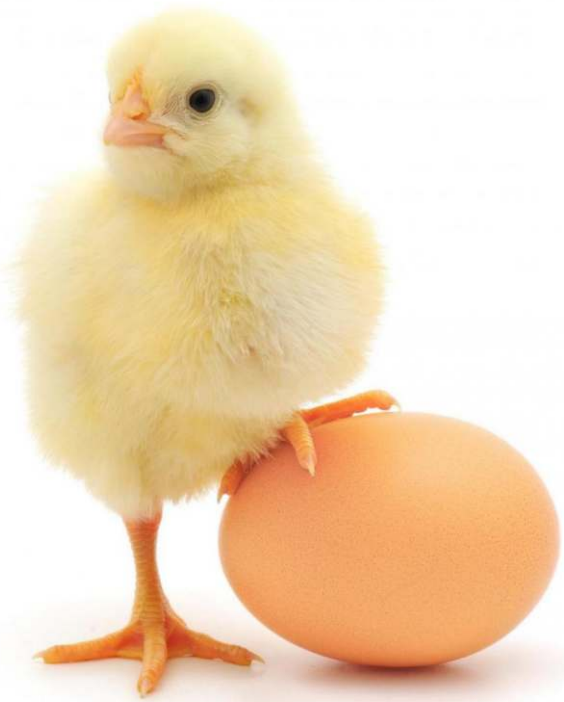

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Influence of Stocking Density and Feed Pellet Quality on Heat Stressed Broilers from 6 to 8 Weeks of Age

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Abstract: Experimentation examined the advantages of decreased pen stocking density of male broilers reared in a summer environment from 6 to 8 weeks of age while receiving either a whole pellet or crumbed feed. Whole pellets led to improved body weight gain as did reduced stocking density; however, mortality due to sudden death syndrome increased when both advantages were combined. Neither treatment significantly affected feed conversion. Males fed pellets had chilled carcasses with increased abdominal fat, whereas amounts of fillets and tenders were similar to those given crumbs. Conversely, expanding the area available for each bird enabled improved recovery of fillets and tenders without altering abdominal fat. Light reflectance of fillets measured 48 h post-mortem revealed a higher L* (lightness) and lower a* (redness) with birds that had received pellets than crumbs, whereas reduced stocking density increased b* (yellowness) values without altering L* and a*. Improving the stability of pelleted feed and reducing pen stocking density enhanced the overall production of heat stressed broilers, but each factor did so in an independent and different manner.

Key words: Breast meat, broiler production, heat stress, pellet quality, stocking density

Introduction

Broilers encountering high ambient temperature generally reduce feed intake together with body weight gain as the extent of panting and work to maintain body temperature increases. Repercussion from high temperatures escalates with broiler age, and loss in breast meat yield is known to be particularly vulnerable. Reduced stocking density and improved pellet quality of feed are strategies that can alleviate heat stress.

Reduced airflow among birds at high stocking density not only diminishes their convective heat loss but increases exposure to environmental ammonia (Puron *et al.*, 1995). Providing feed as a particulate favorable for prehension minimizes the work of consumption. Abdelsamie *et al.* (1983) reported an improved body weight gain of broilers grown in the tropics to 56 days of age when feed was offered as pellets compared to mash. Such advantage from pelleted feed on broiler performance can also occur in the absence of heat stress when protein is sufficient and balanced (Proudfoot and Hulan, 1982; Proudfoot *et al.*, 1982; Scheideler, 1992; Nir *et al.*, 1994). Improvements attributable to feed pellets *per se* not only involve a lessened work of prehension and feed wastage but minimization of microbial threats and competitive activities that reduce net availability of metabolizable energy (Moran 1989; Behnke, 1994). Additional heat arising when birds are consuming small particulates is expected to further impair the performance of broilers concurrently experiencing high environmental temperatures.

The objective of the present experiment was to characterize the response of heat-stressed broilers to obvious differences in pen stocking density and pellet quality of the feed.

Materials and Methods

Seven hundred (Ross x Ross 308) one-day-old males were distributed among 32 floor pens (4.12m^2 /pen) of an open-sided house having thermostatically controlled heating, curtains and cross ventilation. Each pen had one bell water font and one cylindrical feeder. All birds received common feeds and management until 42d of age, whereupon remaining birds were redistributed such that alternate pens had 3.1 and 6.7 birds/m^2 (13 and 28 birds/pen, respectively) corresponding to low and high stocking density. Mortality was gross necropsied to ascertain the incidence of sudden death syndrome, ascites, and leg problems during the 2 weeks of experimentation.

Feed provided from 6 to 8 weeks of age was formulated to nutritionally support optimal performance and included 0.50% gelatin to improve large particulate stability after steam pelleting (Table 1). Feed was offered as either a whole pellet or crumb after pellets were passed between 1 cm rolls. A representative feed sample was taken directly from each feeder for measurement of particulate size distribution using progressive diameter sieves (Canadian Committee on Agricultural Engineering, 1971). Sieving pellets after timed tumbling provided an estimate of their durability (American Society of Agricultural Engineers, 1992).

At 57d of age, all birds were on-line processed using a scaled down version of a commercial plant and involved

Table 1: Broiler feed offered to males from 42 to 57 days of age

Composition Ingredients	%
Corn	70.68
Soybean meal (48.5% CP)	23.17
Gelatin[1]	0.50
Poultry fat	2.00
Dicalcium phosphate	1.54
Limestone	0.91
Vitamin-mineral mixes[2]	0.50
Salt	0.35
DL-Methionine	0.18
L-Lysine sulfate[3]	0.08
L-Isoleucine	0.03
L-Threonine	0.04
L-Tryptophan	0.02
Calculated analyses Nutrient	**%**
Dry matter	87.86
Crude protein	17.98
Calcium	0.75
Available Phosphorous	0.40
Lysine	0.95
TSAA	0.75
Threonine	0.72
Tryptophan	0.20
Isoleucine	0.70
Arginine	1.11
[ME, kcal/kg]	3,150

[1]100 Bloom bone gelatin, Kind and Knox, Sergeant Bluff, IA 41054. [2]Vitamin mix, 0.25% (supplied per kilogram of complete feed: vitamin A, 7500 IU (retinyl acetate); vitamin D_3, 2500 IU (cholecalciferol); vitamin. E, 8 IU (DL-α-tocopheryl acetate); vitamin K_2, 2 mg; cobalamin, 0.02 mg; riboflavin, 5.5 mg; niacin, 37 mg; pantothenic acid, 13 mg; folic acid, 0.5 mg; pyridoxine, 2.2 mg; thiamine, 1 mg; biotin, 0.1 mg; choline, 500 mg; ethoxiquin, 125 mg) and micromineral mix, 0.25% (supplied the following per kg of complete feed: Mn, 66 mg; Zn, 55 mg; I, 0.3 mg; Fe, 6 mg; Cu, 6mg; Se, 0.15 mg. [3]Biolys (60% L-lysine), Degussa-Huls, Inc., Kennesaw, GA 30144.

a 9-min kill line followed with a 7-min evisceration line. Resulting warm carcasses were static chilled in slush ice for 4 h, and then depot fat was removed from the abdominal cavity. Fillets (*Pectoralis major*) and tenders (*Pectoralis minor*) were removed from the front half of each carcass placed on stationary cones by experienced commercial personnel the following day. Fillets originating from the right side of the carcass were evaluated by light reflectance (CIE L*a*b* scale) 24h after their removal from the carcass by means of a Miniscan XE hand-held spectrophotometer (illuminant D65, standard 10º observer, Hunter Lab, Reston VA 20190). Measurements were performed at thickest part of the muscle surface that had been adjacent to the skin.

Pens having either low or high stocking density were alternately provided with either whole pellets or crumbed feeds to create a 2 x 2 factorial arrangement of treatments. Data were evaluated by ANOVA in a completely randomized design. Mortality percentages were transformed to arcsine of their square root for analyses.

Results

Feeds used prior to 42 days of age were common to all treatments when stocking density among pens had been similar. Live performance from chick placement until the start of experiment at 42 days of age was favorable (Table 2). Treatments imposed from 42 to 57 days of age were extreme in order to be definitive in their effects. Crumbing the feed provided an obvious difference in the size distribution of particulates from that after pelleting (Table 3). Pelleted feed had approximately 83% particulates equal and greater than 2.36 mm *versus* no more than 17% when crumbed. Attaining low and high stocking densities involved moving males at 42 days of age such that average weight among pens and distribution of individual weights within each pen were similar (Table 4).

Heat stress encountered throughout the 42 to 57 days of experimentation based on subjective observation of panting as well as average temperature and humidity measurements was not extensive to enable reasonable live performance (Table 5).

Feed form and stocking density had effects on broiler performance that were largely independent of each other. By providing either large particulates or reducing bird numbers per unit pen area improved final weight at 57d and interim gain from 42 days of age that was additive when combined. However, feed conversion was not altered to a statistically significant extent ($P>0.05$). Mortality was one measurement where pellet quality and stocking density did not elicit independent effects. Feeding pellets accentuated mortality that was largely due to sudden death syndrome. Although stocking density in itself did not alter mortality, reducing the number of birds per unit area accentuated deaths occurring when pelleted feed was accessible.

Fatness and meat yield of the carcass responded to pellet quality and stocking density in an opposite manner (Table 5). Abdominal fat weight increased when broilers had received feed where pellets overwhelmingly predominated and removing this fat eliminated the advantage in carcass weight from broilers that had been given crumbs. Amounts of breast fillets and tenders were similar, regardless of feed particulate size distribution. Conversely, stocking density did not affect abdominal fat, whereas birds housed at 3.1 birds/m^2 had heavier carcasses as well as amounts of fillets and tenders compared to those housed at 6.7 birds/m^2.

Light reflectance of fillets was measured 48h post-

Table 2: Live performance of broiler males 0-42 days of age that preceded formal experimentation

Basis	g Body weight		Period F/G	Mortality % of total
	Final	Gain		
	0-14 days of age (23 ± 3 °C & 72 ± 16% RH)[2,3]			
Average	419	378	1.50	2.8
SEM	1.4	1.4	0.025	0.54
	14-32 days of age (20 ± 5 °C & 71 ± 15% RH)[4]			
Average	1771	1354	1.64	4.2
SEM	7.6	7.2	0.009	0.62
	32-42 days of age (24 ± 4 °C & 74 ± 12% RH)[5]			
Average	2641	870	2.16	8.9
SEM	12.8	8.7	0.002	1.01

[1]Values represent 32 total pens each with 25 chicks at one day of age (41 ± 0.1g).
[2]Temperatures and relative humidity ± standard deviation.
[3]Feed 0 to 14 days was formulated to contain: % CP = 21.5; kcal ME/g = 3.15; % Lys = 1.25; % TSAA = 0.90.
[4]Feed 14 to 32 days was formulated to contain: % CP = 19.5; kcal ME/g = 3.20; % Lys = 1.10; % TSAA = 0.85.
[5]Feed 32 to 42 days was formulated to contain: % CP = 17.5; kcal ME/g = 3.25; % Lys = 0.95; % TSAA = 0.75.

Table 3: Size distribution and pellet durability of experimental broiler feeds accessible to males reared at differing stocking densities from 42 to 57 days of age[1,2]

Feed form	Stocking density birds/m[2]	Size, % of total[3]			Pellet[4] % durable
		Coarse	Medium	Fine	
Crumb	6.7	17.2	75.2	7.6	-
	3.1	17.9	74.0	8.1	-
Pellet	6.7	84.0	14.4	1.6	66.1
	3.1	81.5	16.6	1.9	65.1
	SEM	2.31	2.26	0.50	1.84
	Feed form	***	***	***	-
	Stocking density	NS	NS	NS	NS
	Interaction	NS	NS	NS	-

[1]Values represent average measurements on representative feeds from 8 replicate pens. [2]Corresponds to pens (4.12 m^2) having 28 and 13 broilers at 42 days of age and the start of experimentation. [3]After 2 minutes of sieving and retention on the respective size screens: Coarse: = 2.36 mm; medium: = 1.18 mm and = 0.6 mm; fine = 300 µm. [4]Percentage of pellets that were obtained on a 2.36 mm screen after a 5-minute feed screening followed by a 10-minute rotary tumbling. ***, $P \leq 0.001$.

mortem. Values for lightness (L*) and redness (a*) were greater from birds fed with pellets than crumbs while yellowness (b*) was unaffected; however, b* increased in response to decreased stocking density while L* and a* remained similar. Although extent of changes are of minimal commercial importance, their nature and direction suggest that feed pellet integrity and stocking density are operating in a different manner.

Discussion

The benefits from maintaining whole pellet integrity on live performance are well established, regardless of environment (Proudfoot and Hulan, 1982; Abdelsamie *et al.*, 1983; Scheideler, 1992; Hamilton and Proudfoot, 1995; Munt *et al.*, 1995; Nir *et al.*, 1995; Engberg *et al.*, 2002). Pellet integrity is also known to increase abdominal fat (Scheideler, 1992 and Nir *et al.*, 1994) by the amount of heat that had been lost to maintenance activities, particularly time eating (Reddy *et al.*, 1962; Nir *et al.*, 1994).

Improved live performance by increasing area available to each bird is solely due to improved heat dissipation but multifaceted (Grashorn and Kutritz, 1991; Cravener *et al.*, 1992; Hyankova *et al.*, 1992; Martrenchar *et al.*, 1997). Absence of increasing deaths with reduced stocking density of broilers subject to heat stress has largely been rationalized as a continued avoidance of sudden death and ascites from favorable development (Cravener *et al.*, 1992; Lewis *et al.*, 1997; Martrenchar *et al.*, 1997; Feddes *et al.*, 2002). Superimposing additional growth realized from improved stocking density to that provided by pellets appeared to be sufficient in present experimentation to aggravate these deaths. Increased sudden death and ascites mortality is often associated to consumption of pelleted feed (Proudfoot and Hulan, 1982; Proudfoot *et al.*, 1982; Hamilton and Proudfoot, 1995; Munt *et al.*, 1995; Nir *et al.*, 1995).

Table 4: Live performance of broiler males receiving whole pellet and crumbed feeds between 42 and 57 days of age while reared at widely different stocking densities and confronted with high environmental temperatures[1]

Feed form	Stocking density birds/m^2	g Body weight At day 57	g Body weight 42-57d	Daily Feed Intake	F/G[2] 42-57d	Mortality, % 42-57d[3] Total	SDS	ASC	Other
Crumb		3785	1117	208	2.81	7.97	0.7	1.8	5.48
Pellet		3874	1206	219	2.74	13.24	2.6	2.8	7.16
	6.7	3780	1112	206	2.79	12.07	1.4	2.2	7.83
	3.1	3878	1210	221	2.75	9.14	1.9	1.4	4.81
Crumb	6.7	3729	1061	202	2.85	12.1	1.4	2.7	8.1
	3.1	3840	1172	215	2.77	3.9	0.0	1.0	2.9
Pellet	6.7	3831	1163	211	2.74	12.1	1.4	1.8	7.6
	3.1	3916	1248	226	2.73	14.4	3.9	3.9	6.7
	SEM	22.5	22.5	4.5	0.077	2.39	0.84	1.29	1.83
	Feed form	***	***	*	NS	**	*	NS	NS
	Stocking density	***	***	*	NS	NS	NS	NS	NS
	Interaction	NS	NS	NS	NS	**	0.09	NS	NS

[1]Values represent the least square means of 8 replicate pens (4.12 m^2/pen) each with either 28 or 13 broiler males at 42 days of age and the start of experimentation. Average temperature and relative humidity were 25 ± 4°C and 71 ± 11%, respectively.
[2]Feed conversion corrected for mortality. [3]Percentages of mortality in total and attributed to sudden death syndrome (SDS), ascites (ASC), and other causes. ANOVA was performed using arcsine square root transformation of the percentages. The SEM's provided are estimates from ANOVA on actual values. *$P \leq 0.05$, **$P \leq 0.01$, ***$P \leq 0.001$.

Table 5: Carcass characteristics of broiler males at 57 days of age that had received whole pellet and crumbed feeds from 42 days while reared at widely different stocking densities and confronted with high environmental temperatures[1]

Feed form	Stocking density birds/m^2	Abdominal fat[2] g Wt	Abdominal fat[2] % carcass	Carcass w/o abdominal fat[3] g Wt	Carcass w/o abdominal fat[3] % live	Fillets[4] g Wt	Fillets[4] % carcass	Tenders[4] g Wt	Tenders[4] % carcass
Crumb		58	2.15	2697	70.8	630	23.2	154	5.7
Pellet		63	2.19	2725	70.2	638	23.8	154	5.7
	6.7	60	2.49	2647	70.4	610	23.5	147	5.7
	3.1	61	2.22	2778	70.6	657	23.6	160	5.8
	SEM	2.1	0.087	35.9	0.24	11.2	0.604	3.1	0.164
Feed form		**	0.07	NS	NS	NS	NS	NS	NS
Stocking density		NS	NS	***	NS	***	NS	***	NS
Interaction		NS	NS	NS	NS	NS	NS	NS	NS

[1]Values represent the least square means of carcasses obtained from remaining live broiler males from 8 replicate pens, respective of treatment. [2]Fat removed from the abdominal cavity expressed on an absolute basis and relative to the chilled carcass.
[3]Carcass without neck and giblets after 4 hours of slush-ice chilling and removal of abdominal fat, expressed on an absolute basis and relative to the full-fed live weight. [4]Skinless boneless breast meat cone-deboned from the 24 hour post-mortem carcass expressed on an absolute basis and relative to the chilled carcass without abdominal fat. **$P \leq 0.01$, ***$P \leq 0.001$.

Table 6: Light reflectance of fillets from broiler males at 57 days of age that had received whole pellet and crumbed feeds from 42 to 57 days of age while reared at widely different stocking densities and confronted with high environmental temperatures[1]

Feed form	Stocking density birds/m^2	CIE reflectance[2] L*	a*	b*
Crumb		62.8	5.2	12.7
Pellet		63.5	5.7	12.7
	6.7	63.2	5.4	12.5
	3.1	63.1	5.5	12.8
SEM		0.31	0.17	0.16
Feed form		*	**	NS
Stocking density		NS	NS	*
Interaction		NS	NS	NS

[1]Measurements were at the skin side of fillets from the right half of each carcass. Values represent the least square means of fillets obtained from all broiler males remaining at 57 days of age in each of 8 replicate pens, respective of treatment.
[2]Increasing L*, a*, and b* values correspond to increasing lightness, redness, and yellowness, respectively. *$P \leq 0.05$, **$P \leq 0.01$.

Breast meat development is known to be more active than other body muscles during the 6 to 8 week interval, and considerable by-product heat is generated from protein synthesis. Realizing fillets and tenders with the additional body weight from reduced stocking density was observed by Lewis *et al.* (1997) with broilers not subject to heat stress. Altering stocking density has been documented to have varying effects on the carcass and meat yield (Bilgili *et al.*, 1991; Grashorn and Kutritz, 1991; Reiter and Bessei, 2000; Feddes *et al.*, 2002) that probably relates to concurrent accessibility of balanced dietary protein. A particularly favorable relationship of protein to energy and amino acid balance existed in present experimentation .

References

Abdelsamie, R.E., K.N.P. Ranaweera and W.E. Nano, 1983. The influence of fiber content and physical texture of the diet on the performance of broilers in the tropics. Br. Poult. Sci., 24: 383-390.

American Society of Agricultural Engineers, 1992. Cubes, pellets, and crumbles-Definitions and methods for determining density, durability, and moisture content. Pages 384-386 in American Society of Agricultural Engineers Standard S269.4. American Society of Agricultural Engineers Yearbook of Standards, American Society of Agricultural Engineers, St. Joseph, MI.

Behnke, K.C., 1994. Factors affecting pellet quality. Pages 44-54 in Proceedings of the 1994 Maryland Nutrition Conference. Baltimore, MD.

Bilgili, S.F., W.H. Revington, E.T. Moran and R.D. Bushong, 1991. The influence of diet and stocking density on carcass quality of broilers processed under soft- and hard-scalg conditions. Pages 263-271 in Proceedings of the X^{th} European Symposium on the Quality of Poultry Meat. European Branch of the WPSA. Beekbergen, The Netherlands.

Canadian Committee on Agricultural Engineering, 1971. Size characteristics. Pages 2-10 in Agricultural Materials Handling Manual, Part 3: Processing Equipment, Section 3.2: Size Reduction and Mixing. Information Canada Publishing Division, Ottawa, Ontario, Canada.

Cravener, T.L., W.B. Roush and M.M. Mashaly, 1992. Broiler production under varying population densities. Poult. Sci., 71: 427-433.

Engberg, R.M., M.S. Hedemann and B.B. Jensen, 2002. The influence of grinding and pelleting of feed on the microbial composition and activity in the digestive tract of broiler chickens. Br. Poult. Sci., 43: 569-579.

Feddes, J.J., E.J. Emmanuel and M.J. Zuidhoft, 2002. Broiler performance, body weight variance, feed and water intake, and carcass quality at different stocking densities. Poult. Sci., 81: 774-779.

Grashorn, M.A. and B. Kutritz, 1991. Effect of stocking density on performance of modern broiler breeds. Arch. Geflugelk, 55: 84-90.

Hamilton, R.M.G. and F.G. Proudfoot, 1995. Ingredient particle-size and feed texture- effects on the performance of broiler-chickens. Anim. Feed Sci. Tec., 51: 203-210.

Hyankova, L., L. Dedkova and J. Tlaskal, 1992. The effect of floor space density on the fattening performance of broilers. Zivocisna Vyroba, 37: 607-613.

Lewis, P.D., G.C. Perry, L.J. Farmer and R.L.S. Patterson, 1997. Responses of two genotypes of chicken to the diets and stocking densities typical of UK and 'Label Rouge' production systems .1. Performance, behavior and carcass composition. Meat Sci., 45: 501-516.

Martrenchar, A., J.P. Morisse, D. Huonnic and J.P. Cotte, 1997. Influence of stocking density on some behavioral, physiological and productivity traits of broilers. Vet. Res., 28: 473-480.

Moran, E.T., 1989. Effect of pellet quality on the performance of meat birds. Pages 87-108 in Recent Advances in Animal Nutrition. W. Haresign and D. Cole Eds. Butterworks, London, United Kingdom.

Munt, R.H.C., J.G. Dingle and M.G. Sumpa, 1995. Growth, carcass composition and profitability of meat chickens given pellets, mash or free-choice diet. Br. Poult. Sci., 36: 277-284.

Nir, I., Y. Twina, E. Grossman and Z. Nitsan, 1994. Quantitative effects of pelleting on performance, gastrointestinal-tract and behavior of meat-type chickens. Br. Poult. Sci., 35: 589-602.

Nir, I., R. Hillel, I. Ptichi and G. Shefet, 1995. Effect of particle-size on performance. 3. Grinding pelleting interactions. Poult. Sci., 74: 771-783.

Proudfoot, F.G., H.W. Hulan and K.B. McRae, 1982. The effect of crumbled and pelleted feed on the incidence of sudden-death syndrome among male chicken broilers. Poult. Sci., 61: 1766-1768.

Proudfoot, F.G. and H.W. Hulan, 1982. Effects of reduced feeding time using all mash or crumble- pellet dietary regimens on chicken broiler performance including the incidence of acute death syndrome. Poult. Sci., 61: 750-754.

Puron, D., R. Santamaria, J.C. Segaura and J.L. Alamilla, 1995. Broiler performance at different stocking densities. J. Appl. Poult. Res., 4: 55-60.

Reddy, C.V., L.S. Jensen, L.H. Merrill and J. McGinnis, 1962. Influence of mechanical alteration of dietary density on energy available for chick growth. J. Nutr., 77: 428-32.

Reiter, K. and W. Bessei, 2000. The behaviour of broilers in response to group size and stocking density. Arch. Geflugelk, 64: 93-98.

Scheideler, S.E., 1992. Pelleting is important for broilers. Zootecnica International, 42-47.

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