Laser environmental enrichment and Spirulina algae moderately improve Ross 708 broiler performance without reducing welfare

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Summary and Implications

Modern commercial broilers are genetically selected for increased growth rate, improved feed efficiency, and a significant proportion of breast muscle tissue. Reducing feed conversion rate and days to market weight are of key interest to the industry from a sustainability perspective. Dietary and environmental interventions that can attain these improvements without negatively impacting animal welfare are being increasingly studied and implemented. In the current study, a previously tested laser enrichment device and a Spirulina algae feed additive were introduced to 600 Ross 708 broilers grown for 7 weeks. Laser enrichment and dietary algae inclusion each increased weight gain during the grower period ($P<0.05$ and $P<0.10$, respectively). Laser enrichment alone increased body weight at d28 by 77g and on d42 by 114g compared to CON (no laser enrichment; $P<0.05$). Neither enrichment nor algae inclusion impacted litter moisture or increased contact dermatitis incidence, indicating a performance benefit without reducing animal-based welfare outcomes.

Introduction

Commercial broilers are genetic hybrids selected for fast rate of growth and high breast yields. This selection has been critical to meet increasing demand for poultry products. However, rapid growth and a disproportionate percent of breast muscle have altered the bird's center of gravity, leading to animal welfare concerns. Predominant issues include leg lameness and lack of activity which can lead to contact dermatitis, further inactivity, and culls. Additionally, protein concentration as well as dietary source may alter litter quality and increase dermatitis incidence. A popular nutritional intervention to improve broiler growth performance and reduce feed costs is to implement complementary protein products into the diet. Spirulina microalgae is increasing in popularity because it is a high quality, sustainable protein source. Such sources of protein to replace corn and soybean inputs into broiler diets are necessary to increase sustainability and production efficiency. The research objective was to validate performance-enhancing effects of the laser enrichment device in conjunction with a Spirulina algae feed ingredient.

Materials and Methods

All bird procedures were approved by the Iowa State University Institutional Animal Care and Use Committee. ***Animals:*** 600 mixed sex Ross 708 broiler chicks were transported from Welp Hatchery (Bancroft, IA, U.S.) and transported to the Poultry Research and Teaching Farm at Iowa State University for a 49d grow-out. Birds were randomly assigned to 20 pens of 30 (1.22 by 2.44 m/pen) divided across 2 rooms in the same barn and weighed upon arrival.

Housing

One room contained 10 LASER pens (+ enrichment device), and the second contained 10 CON pens (no enrichment device). Environmental conditions and management were the same between rooms. Approximately 10 cm of wood shavings were bedded over solid concrete floor, and PVC pipe dividers with mesh sides (1.22 m height) separated pens. Birds were adjusted from 24 h light on d0 (30-40 lux) to 20 h light (20-30 lux) from d8-49. Feed was provided *ad libitum* out of two hanging feeders/pen. Water was provided from a hanging nipple water line.

Treatments

Pens were assigned to diet and evenly split across the LASER and the CON rooms of the barn (n=10 pens/diet): control diet (control), and control diet + 2.5% Spirulina algae ingredient (*Arthrospira platensis*; algae). Forty birds were randomly assigned on d0 as focal birds (n=5 birds/pen in 8 pens; 4 pens/enrichment and diet treatment) and identified with wing-bands. Diets were formulated according to Ross 708 guidelines for starter (d0-d14), grower (d14-28), finisher 1 (d28-42) and finisher 2 (d42-49) phases.

Laser enrichment

Five laser enrichment devices were set-up to cover two adjoining pens each. The enrichment device contained a pair of independent 650 nm red lasers in a 20.5 by 20.5 cm metal box with glass front mounted on a wooden structure (2.4 m height) above the pens. Lasers moved in a random pattern on the pen floor for 4-min "laser periods" at: 05:30, 11:30, 17:30, and 23:30 daily. Barn and research staff did not enter

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the LASER nor CON rooms of the barn during the hours containing the 4-min laser periods.

Performance

All birds were weighed as a pen at the trial's start and at the conclusion of each performance period. Feed disappearance was recorded throughout. Feed intake, weight gain, and feed conversion ratio were calculated by pen and averaged per bird by performance period.

Breast blisters and footpad dermatitis

Focal birds (n=40) were examined weekly for breast blisters and footpad dermatitis through week 6. Both examinations took place at the same day and time by one researcher. Breast blisters were scored present/absent and footpad dermatitis was scored pass/fail using the American Association of Avian Pathologists Paw Scoring system. Focal birds were euthanized at d42 for tissue sample collection, thus week 7 contact dermatitis scores were not included.

Air and litter quality

Ammonia was measured at bird height in the front, middle, and back of each room of the barn on one day/week, week 1-7 with a hand-held ammonia monitor and ammonia test strips. Litter quality was analyzed (pass/fail) weekly in three different, randomly selected pens in the front, middle, and back of each room of the barn according to the National Chicken Council Audit Guidelines.

Statistical analysis

This study was a 2 x 2 factorial design with two enrichment (LASER vs CON) and two dietary (algae vs control) treatments. Data were analyzed using SAS software version 9.4. PROC UNIVARIATE was used to assess the distribution of data prior to analysis. Data were normally distributed, hence were analyzed using PROC MIXED with main effects of enrichment and diet and the resulting interaction. Because most broilers in this study were scored "absent"/ "pass" for contact dermatitis, data could not be statistically analyzed and are presented descriptively. For all measures, a value of $P \leq 0.05$ was considered significant.

Results and Discussion

Performance

Feed intake and body weight were unaffected by either treatment (enrichment or diet). Birds fed the algae diet consumed 92g more than those fed the control diet during the grower period (P=0.10). Body weight at the end of the grower period (d28) was increased by enrichment (P=0.03), with LASER-enriched birds weighing 77g greater than CON. There was a trend for improvement by diet (P=0.06), with algae-supplemented birds weighing 64g more than birds fed the control diet at d28. Similarly, weight gain during the grower period was increased in laser-enriched broilers (P=0.03) by 71g and was significantly increased in algae-fed broilers (P=0.05) by 61g. Following the finisher 1 period (d42) LASER-enriched birds weighed 114g more than CON broilers; there were no differences detected due to algae inclusion. At d49, there was no effect of enrichment nor diet on body weight, but numerically (P=0.10), LASER-enriched birds weighed 101g more the CON birds. Feed conversion ratio (kg of feed consumed/ kg of weight gain) was not impacted by enrichment or diet in the current study. However, FCR was improved numerically in the grower period by 13 points in LASER-enriched broilers compared to CON, and by 4 points in the algae fed-treatment compared to the dietary control (Table 1).

The current research aimed to identify independent and cumulative effects of two unique interventions to improve broiler welfare and sustainable production: environmental enrichment and an algae feed ingredient. Laser enrichment alone increased broiler live weight at the conclusion of the grower and Finisher 1 performance periods. Broilers in the LASER treatment managed this increased BW without sacrificing FCR, the most crucial production outcome in terms of improved sustainability. Maintaining and numerically reducing FCR with increased marketable body weight is a positive production outcome of LASER enrichment. A performance benefit of dietary algae was observed in the grower period alone, with increased weight gain in algae vs. control-fed birds. Growth advantages during the grower period (d14-d28) could be advantageous to smaller bird markets in terms of reducing days to market and increasing sustainability.

Breast blisters and footpad dermatitis

Breast blisters were scored "absent" on all 40 focal birds through weeks 1-6 of the study. Footpad dermatitis was scored "pass" on all focal birds, weeks 1-5. On week 6, seven out of 40 total focal birds received a "fail" score for footpad dermatitis. One affected broiler was in the CON treatment, and 6 were broilers in the LASER treatment. Two of the affected broilers were fed control diets and 5 were fed diets supplemented with algae.

Ammonia concentration and litter quality

Ammonia test strip ranges were the same in both rooms weeks 1-7: 5, 5, 5, 5, 10, 20, and 20ppm, respectively. Using a handheld ammonia monitor at bird height, the readings remained similar between each room of the barn. In the LASER room, readings were: 0, 3, 4, 4, 4, 7, and 9ppm, week 1-7, respectively. In the CON room, readings were: 0, 4, 4, 4, 4, 9, and 9ppm, week 1-7, respectively. Litter passed for friability throughout in the study for both rooms.

Contact dermatitis is an animal welfare and carcass quality issue associated with time spent lying in contact with wet litter. Dermatitis of the breasts and feet cause economic loss of two valuable retail products. Breast blisters were not observed at any point in the current study, likely due to the clean research setting where litter in randomly-selected pens remained dry. A small number of affected footpads were observed on week 6. These scores occurred in a limited number of pens (three pens of twenty), and it is unclear why they were affected. One explanation for dermatitis is ammonia from urea in the litter combining with moisture from excreta or drinkers. As ammonia measured at bird height in both rooms of the barn at week 6 did not surpass 9 ppm using a titrated ammonia monitor, the observed dermatitis may have resulted from increased litter moisture resulting from drinker issues in affected pens that were not randomly-selected pens to be scored week 6. Alternatively, the change in protein source included in the diet may play a role in dermatitis development: two of the affected broilers were control-fed compared to five algae-fed birds. Due to the limited number of affected pens/birds and lack of statistical analysis, we do not consider this minor occurrence of footpad dermatitis an effect of either treatment.

In summary, exposure to a laser enrichment device improved growth performance of Ross 708 broilers in the grower and finisher 1 periods, while Spirulina algae included as a protein source in the diet improved gains during the grower period. Both treatments either maintained or improved FCR, a key outcome for sustainable poultry production, and animal-based outcomes of welfare were maintained throughout the study.

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Table 1. Ross 708 broiler performance measures averaged per bird by performance period[1]. Values presented are enrichment by diet interaction LSMeans (pooled SEM) with p-values shown for main effects of enrichment[2], diet[3], and the resulting interaction

Performance Measure	CON: Control	CON: Algae	LASER: Control	LASER: Algae	Pooled SEM	P-value		
						Enrichment	Diet	Enrichment*Diet
Feed intake (kg)								
Starter	0.38	0.38	0.38	0.40	0.012	0.44	0.60	0.75
Grower	1.21	1.38	1.30	1.32	0.059	0.74	0.10	0.15
Finisher 1	2.25	2.22	2.32	2.31	0.065	0.18	0.79	0.85
Finisher 2	1.26	1.32	1.34	1.33	0.058	0.47	0.62	0.47
Weight gain (kg)								
Starter	0.29	0.30	0.30	0.31	0.009	0.26	0.64	0.85
Grower	0.78[b]	0.89[ab]	0.90[ab]	0.91[a]	0.033	0.03	0.05	0.11
Finisher 1	1.31	1.18	1.28	1.26	0.057	0.64	0.16	0.25
Finisher 2	0.66	0.68	0.65	0.67	0.025	0.58	0.30	0.97
Body weight (kg)								
d14	0.33	0.33	0.34	0.34	0.009	0.25	0.63	0.86
d28	1.11[b]	1.23[ab]	1.24[ab]	1.25[a]	0.035	0.03	0.06	0.10
d42	2.43	2.45	2.55	2.55	0.050	0.02	0.83	0.86
d49	3.09	3.13	3.20	3.22	0.058	0.10	0.57	0.88
FCR								
Starter	1.29	1.29	1.28	1.28	0.013	0.24	0.81	0.66
Grower	1.62	1.55	1.45	1.45	0.116	0.22	0.73	0.78
Finisher 1	1.73	1.90	1.82	1.83	0.082	0.89	0.24	0.34
Finisher 2	1.90	1.94	2.08	1.98	0.070	0.12	0.65	0.31

[1]Starter period indicates weeks 0-2, grower weeks 2-4, finisher 1 weeks 4-6, and finisher 2 week 6-7.
[2]Main effect of enrichment: LASER vs. CON
[3]Main effect of diet: algae vs. control