

2022
2023



RESEARCH SHOWCASE

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This research showcase highlights the cutting-edge research published between September 2022 and August 2023 by the poultry scientists at the University of Alberta.

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CONTINUOUS EXPOSURE TO RED LIGHT INDUCES PHOTORE-FRACTORINESS IN BROILER BREEDER PULLETS

M.J. Zuidhof

KEYWORDS: broiler breeder, spectrum lighting, reproduction, production

ABOUT

In birds, sexual maturation is regulated by the perception of light. A sudden increase in daylength above 12 h allows an increase in the synthesis and release of GnRH-I which results in the development of small white follicles (SWF). At the University of Alberta, a precision feeding (PF) system was developed to allocate feed in restricted portions and durations, improving the BW uniformity and synchronization of the age at sexual maturation. However, the PF system requires access beyond the 8 h of daylight traditionally provided during the pullet phase to ensure all birds can consume their daily allocation. Continuous exposure to supplemental lighting could cause desensitization to a normally stimulatory light signal. Thus, PF systems would benefit from a 24 h supplemental illumination program that does not interfere with the process of photostimulation. The aim of this study was to evaluate the impact of continuous supplemental illumination of feeders with pure green, red, and blue light on the growth and sexual maturation of broiler breeder hens.

APPROACH

At 2 weeks of age (woa), Ross 708 female broiler breeder chicks were distributed throughout 4 identical rooms, each containing 12 visually and optically isolated pens (n = 48 pens), with 10 chicks placed in each pen. This experiment was comprised of a 2 × 4 × 2 factorial arrangement of treatments, with 2 types of main house daytime lights, 4 supplemental light colors, and 2 intensities. At 3 woa, birds were housed in rooms with either 60% red LED daytime light (dtRED) or 60% green LED daytime light (dtGREEN). Supplemental LED strip lighting was placed around the hanging feeder which

could be: monochromatic red (sRED; 630 nm), monochromatic green (sGREEN; 508 nm), monochromatic blue (sBLUE; 450 nm), or no illumination (sCON). Supplemental feeder light could be: high intensity (INT) or low INT. At 20 woa, all birds were photostimulated with 14 h at 30 lux. Each bird was individually weighed weekly. Eggs were collected and recorded daily.

ANALYSIS OF RESULTS

Pairwise differences indicated that hens under sRED, regardless of DTL treatment, were 145-g and 198-g heavier than sBLUE and sGREEN, respectively at 26 woa but did not differ from sCON. From 27 woa through to the end of the study (30 woa), hens under sRED were significantly heavier than all other treatments (P < 0.001). This led to hens under sRED reaching a BW that was over 400 g heavier than hens under any other light. Hens under high INT were less uniform than those under low INT treatment. Age at first egg (AFE) was found to be delayed by approximately 9 d in hens under sRED light compared to all other SFL, regardless of INT. DTL had a significant effect on egg production (P = 0.008) with the rate of lay 3.15% higher throughout the study in hens under dtRED. Concurrent with the delayed entry into lay, sRED had the lowest production rate overall (20.55%; P < 0.001) compared to sBLUE (50.51%), sGREEN (49.37%), and sCON (49.32%). SFL had an effect on cumulative egg production (P < 0.001), with 14 fewer eggs produced per hen housed under sRED compared to the other treatments.

APPLICATION

In the present study, the results indicate that the implementation of 24 h red LED supplemental lighting is detrimental to sexual maturation and early reproductive performance of broiler breeder hens. Conversely, these effects of supplemental lighting on growth and reproduction were not observed under green and blue lights.



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CONVERSION OF PHENOLIC ACIDS IN CANOLA FERMENTATION: IMPACT ON ANTIMICROBIAL ACTIVITY AGAINST SALMONELLA ENTERICA AND CAMPYLOBACTER JEJUNI

D.R. Korver

KEYWORDS: canola meal, phenolic acids, polyphenols, antimicrobial compounds, Lactobacillus, poultry, Salmonella

ABOUT

Canola meal (CM) is a byproduct of oil extraction from canola seeds. CM is used as an animal feed ingredient worldwide due to its high protein content, phosphorus, and low cost. Antinutritional factors such as glucosinolates, fiber, tannins, phytic acid, and phenolic compounds negatively affect CM's nutritive value in animal production systems. However, the antimicrobial activity of phenolic acids may particularly contribute to reducing colonization of the chicken intestine with food-borne pathogens. The nutritive value of CM can be increased by fermentation. Feed fermentation with lactic acid bacteria has shown promise to reducing colonization of the chicken gut with Salmonella and Campylobacter. The aim of this study to identify strains of lactobacilli that ferment CM, to determine the conversion of phenolic compounds during fermentation, and to assess the in vitro antimicrobial activity of canola extracts against intestinal microorganisms.

APPROACH

Black canola seeds were ground, and oil was extracted. The meal was aerated and roasted in a toasting oven at 110 °C for 2 h. The soap pellets were collected and mixed with the roasted CM. The final CM was covered and stored at room temperature. Fermented CM was analyzed for phenolic composition using tandem mass spectrometry (LC-MS/MS) and high-performance liquid chromatography (HPLC). The inhibitory activities of phenolic compound extracts from CM and sinapic acid were determined against 10 indicator strains. Minimum inhibitory concentrations (MIC) were assessed and defined as the concentration that inhibited 50% of bacterial growth.

ANALYSIS OF RESULTS

Fermentation generally increased inhibition by phenolic extracts except for strains of Salmonella and C. jejuni PCJ 481 and 494. Fermenting CM with Lp. plantarum significantly decreased the MIC of phenolic compounds against Ff. sanfranciscensis, L. johnsonii, and S. heidelberg. The sinapic acid concentrations in the samples fermented with Lp. plantarum and Ff. miii FUA3583 were consistently lower than the concentration of sinapic acid in extracts diluted to the MIC, indicating the presence of other compounds that contributed to the inhibitory activity. This result suggested that other than sinapic acid, the reduced phenolic acids but not the decarboxylated metabolites contributed to the antimicrobial activity.

APPLICATION

In conclusion, this study demonstrated that fermentation CM with lactobacilli increased the antimicrobial activity of phenolic acids against Salmonella and Campylobacter. A chicken diet containing lactic-fermented CM thus would thus combine the presence of probiotic lactobacilli and antimicrobial phenolic compounds and could potentially reduce colonization of chicken with Salmonella and Campylobacter.

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WEEK-OLD CHICKS WITH HIGH BACTEROIDES ABUNDANCE HAVE INCREASED SHORT-CHAIN FATTY ACIDS AND REDUCED MARKERS OF GUT INFLAMMATION

D.R. Korver

KEYWORDS: broiler chickens, Bacteroides, gut microbiota, microbial functionality, inflammation

ABOUT

Firmicutes and Bacteroidetes represent more than 90% of the total cecal microbiota in the ceca of matured chickens but have relatively low abundance in the ceca of newly hatched chicks. Limited information is available regarding how differential abundance of this taxa affects gut immune state or functional capacity of the gut microbiota in broiler chickens. The aim of this study was to understand how high and low Bacteroides abundances are associated with early life chicken gut microbial functional capacity, and immune response. This was achieved by sampling and characterizing week-old broiler chickens from commercial production flocks with distinct cecal Bacteroides abundance.

APPROACH

A total of 14 broiler flocks reared under the same condition in similarly engineered broiler production houses were sampled. For each flock, 14,000 Ross 308 broiler chicks were placed at 1 day of age, and fed ad libitum until the end of the production cycle. At day 7, five chicks from each flock were euthanized for sampling. Approximately 300 mg of cecal contents and cecal tonsil tissue were collected for further analyses. Total DNA was extracted from cecal contents. The mean value and standard deviation of Bacteroides relative abundance was calculated. The extracted genomic DNA was also used to measure the abundance of the Bacteroides-Prevotella group in the cecal content using qPCR, targeting the 16s rRNA gene. To examine host response to different Bacteroides relative abundance, cecal tonsils were subjected to RNA extraction, followed by cDNA synthesis and qPCR assay.

ANALYSIS OF RESULTS

The 3 most abundant phyla on the early life chicken cecal microbiome made up over 98% of the population, and included Firmicutes (76.16 ± 15.72%), Bacteroidetes (17.54 ± 16.59%), and Proteobacteria (5.07 ± 6.83%). Low Bacteroides samples were defined as samples with Bacteroides relative abundance lower than 0.7% (mean - SD); whereas high Bacteroides samples were defined as samples with Bacteroides relative abundance higher than 31.9% (mean + SD). As a result, chickens from 11 different flocks were assigned to either the LB or HB group. Specifically, 18 birds with low Bacteroides levels from 6 flocks and 15 birds with high Bacteroides from 6 flocks were identified. Chickens that were not assigned to either group were marked as not assigned (n/a). The average 32-day flock bodyweight (P=0.91) and mortality rate (P=0.93) were similar between flocks that had the majority of birds identified as LB, HB, or n/a. It was observed that HB individuals had higher short-chain fatty acid concentrations in cecal contents. The gut microbiota of the HB group harbored more abundant pathways, than the LB microbiota.

APPLICATION

Results revealed that elevated level of cecal Bacteroides in young chickens had altered the gut microbiome's microbial functional capacity, which promoted the production of SCFA. Coinciding with that, compared to the LB group, chickens from the HB group had lower expression of pro-inflammatory cytokines and higher expressions of anti-inflammatory cytokine and tight-junction protein gene. Consequently, it indicated that elevated cecal Bacteroides may be beneficial to commercial broiler chickens in suppressing gut inflammation through the increment of short-chain fatty acid production.



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EVOLUTION OF MATERNAL FEED RESTRICTION PRACTICES OVER 60 YEARS OF SELECTION FOR BROILER PRODUCTIVITY

V.L. Carney, F.E. Robinson, B.L. Reimer, D.R. Korver, M. J. Zuidhof, M. Afrouzیه

KEYWORDS: broiler breeder, sexual maturity, quantitative feed restriction, genetic progression, feed efficiency

ABOUT

After decades of quantitative genetic selection, modern broiler chickens have substantially greater growth rates, carcass yield and feed. The objectives of the current study were to re-evaluate the growth, efficiency, and yield characteristics of 4 strains of random-bred broiler breeders representing genetics from 1957, 1978, 1995, and 2015 and also to investigate the timing of sexual maturation of female stocks under conditions of ad libitum feeding or nutrient restriction to a modern broiler breeder BW standard. Furthermore, the study evaluated how the degree of feed restriction has changed over the last seven decades to maintain birds on a modern-day broiler breeder target BW.

APPROACH

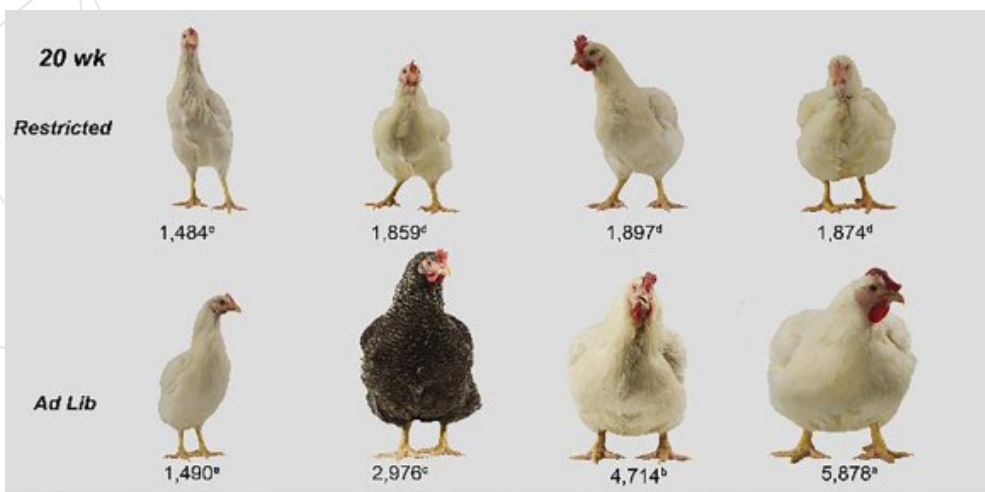
The effect of commercial selection by poultry breeders on the growth, efficiency, and sexual maturity of broiler breeders was studied using 2 University of Alberta Meat Control strains unselected since 1957 and 1978 (AMC-1957 and AMC-1978, respectively) and 2 strains originating from the University of Arkansas; 1995 Random-bred (1995RB) and 2015 Random-bred (2015RB). A study with a 4 × 2 factorial arrangement was conducted with the 4 strains fed at either ad libitum, or restricted levels to achieve a current commercial breeder target BW profile. Growth rate, feed intake, feed efficiency, age at sexual maturity, carcass components, and body conformation were measured. To assess reproductive development, birds were assigned to 2 fates: dissected at photostimulation or dissected after the second oviposition.

ANALYSIS OF RESULTS

At 22.4 wk of age, the restricted-fed AMC-1957, AMC-1978, 1995RB, and 2015RB reached 100, 61, 46, and 38% of their ad libitum-fed counterparts' BW, respectively. During the rearing phase, the amount of feed needed to maintain restricted-fed birds on the target BW was 99.4, 57, 29.5, and 24.9% of their ad libitum-fed counterparts for AMC-1957, AMC-1978, 1995RB, and 2015RB, respectively. Feed restricted birds in the 2015RB had lower heat production relative to the AMC-1957 and AMC-1978, which shows that modern strains utilized feed more efficiently compared to the antique strains. This might be related to the increasing severity of feed restriction of broiler breeders over the past 60 years. Relative to AMC-1957 and AMC-1978 strains, the 1995RB and 2015RB strains had heavier breast muscle and lower fat pad weight.

APPLICATION

Although the pubertal threshold for age and BW have increased over the last 6 decades, changes in selection programs for feed efficiency have resulted in broiler breeders that prioritize nutrient allocation to growth and breast development rather than adipose storage. As a result, feed restricted modern broiler breeders may have marginally sufficient fat resources to support reproduction. Thus, potential strategies to optimize broiler breeder growth trajectory should be considered to alleviate the negative effects of severe feed restriction on broiler breeders. More research is needed to optimize broiler breeder feeding programs.



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Restricted and ad lib weight in 4 different strains
V.L. Carney et al, Poultry Science 101 (2022)

EARLY-LIFE β -GLUCAN EXPOSURE ENHANCES DISEASE RESILIENCE OF BROILER CHICKENS TO A NATURAL CLOSTRIDIUM PERFRINGENS INFECTION

D.R. Korver

KEYWORDS: Innate immunity, Clostridium perfringens, Natural avian infection, Necrotic enteritis

ABOUT

Necrotic enteritis (NE) is a widespread avian disease caused by Clostridium. Infection can decrease broiler performance due to affected gut health. At present, the primary control measure against this infection is the use of in-feed prophylactic antibiotics. We hypothesized that the context in which C. perfringens is first recognized by the innate immune system would impact its downstream capacity to cause necrotic enteritis. The aim of this study was to test this hypothesis.

APPROACH

One-day-old Ross 708 birds (n=108) were allocated in 3 treatments: saline control and C. perfringens (heat-killed) injection with or without β -glucan (1 mg). Intra-abdominal inoculations were performed on all chickens at day 1 of age. We used a natural-exposure infection model to induce NE. Predisposing factors included housing conditions with access to litter, changes in feed composition, coccidial exposure, and a feed withdrawal stress. A Coccivac-B52 vaccine was used as a consistent source of live Eimeria oocysts, and was administered at 15X the recommended dose through oral gavage on day 13. Finally, feed was withdrawn for 24 h on day 18 as an additional stressor that encouraged NE development through changes in nutrient availability and disruption of commensal microbial communities. Six birds per treatment were sampled on each of days 17, 21, and 40. Blood was collected, and birds were euthanized to collect bursa of Fabricius, spleen, liver, and small intestine. Cecal contents were collected for subsequent determination of C. perfringens abundance. Ileum was collected for morphological analysis. The remaining small intestine was examined for NE lesions.



ANALYSIS OF RESULTS

Natural infection model produced subclinical NE. Gross necrotic lesions were found in all treatment groups on days 17, 21, and 40. A majority (85.2%) of sampled animals showed NE specific lesions, and values were limited to low severity scores (1 and 2). Mild clinical manifestations, including diarrhea and bloody feces, were identified during week 3 after the coccidiosis vaccine challenge. No mortalities were observed in response to NE. Day-1 immune priming produced classic acute inflammatory response. Examination of leukocyte recruitment kinetics and activation showed a peak response 12 h after intra-abdominal stimulations. Thus, we selected this time point to confirm activation of the acute inflammatory response following intra-abdominal inoculation with CP and β -glucan. Examination of organ weights during the 40-day production period showed a significant selective reduction in organ weight among CP birds. Inclusion on β -glucan during intra-abdominal immune priming on day 1 prevented this reduction. Inclusion of β -glucan during early-life immune priming improved ileal morphology and prevented reduction in feed efficiency. On day 21 CP+ β -glucan primed birds showed significantly higher villus width compared to saline and CP alone groups.

APPLICATION

We found that early-life exposure to C. perfringens in the presence of β -glucans improved ileal morphology, prevented immune organ weight decline, and maintained feed efficiency upon subsequent C. perfringens infection. Thus, our findings showcase the potential of β -glucans to reduce the negative impact of NE in poultry. Our results suggest enhanced resilience to C. perfringens which may be relevant in industrial settings. In particular, these findings suggest added benefits of β -glucan inclusion in developing poultry NE vaccines.

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PROTECTED BIOFACTORS AND ANTIOXIDANTS REDUCE THE NEGATIVE CONSEQUENCES OF VIRUS AND COLD CHALLENGE WHILE ENHANCING PERFORMANCE BY MODULATING IMMUNOMETABOLISM THROUGH CYTOSKELETAL AND IMMUNE SIGNALING IN THE JEJUNUM

D.R. Korver

KEYWORDS: immunometabolism, kinome peptide array, protected biofactors and antioxidants, cold stress, gut health

ABOUT

Quality and formulation of feed is important to meeting producers' goals of increasing average daily gains (ADG) and reduced feed conversion ratio (FCR) of broilers; especially following government restrictions on antibiotics in many countries. Feed additives can act to improve poultry responses to environmental and immune challenges, and we can improve these responses by understanding their mechanisms of action. The objective of this study was to evaluate and compare the immunometabolic effects and mechanisms of action of 2 feed additives, protected biofactors and antioxidants (P(BF+AOx)), and protected biofactors and antioxidants with protected organic acids and essential oils (P(BF+AOx)+P(OA+EO)) in broilers exposed to an early life cold stress and viral immune stimulation; and to identify their mechanism of action in the broiler gut.

APPROACH

We determined the effects of protected biofactors and antioxidants (P(BF+AOx)), and protected biofactors and antioxidants with protected organic acids and essential oils (P(BF+AOx)+P(OA+EO)) on the immune and metabolic health of Ross 308 broiler chickens. These biofactors and antioxidants were derived from vitamins, and *Aspergillus niger*, *Aspergillus oryzae* and *Bacillus subtilis* fermentation extracts. All Ross 308 chickens were exposed to a double-dose of live bronchitis vaccine at d 0 and environmentally challenged by reducing the temperature from 32°C to 20°C at d 3 for 48 h. Control birds were fed without feed additives in the diet. Each treatment consisted of 12 replicate pens with 30 birds each. Performance data and jejunum samples were collected to evaluate the effects of these treatments on growth, cytokine expression, and protein phosphorylation via kinome peptide array.

ANALYSIS OF RESULTS

The P(BF+AOx) and P(BF+AOx)+P(OA+EO) treatments significantly increased bird weight gain and decreased feed conversion. The kinome peptide array data analysis showed increased activity of cytoskeletal, cell growth and proliferation proteins, and metabolic signaling in the jejunum of P(BF+AOx)+P(OA+EO) treated chickens. There was a significant decrease in IL-6 gene expression in the jejunum of P(BF+AOx)+P(OA+EO) samples compared to control at d 15. P(BF+AOx)+P(OA+EO) treatments in the jejunum showed strong immunomodulatory effects, perhaps to control inflammation. P(BF+AOx)+P(OA+EO) improves gut health via growth and metabolic signaling in the jejunum while inducing stronger immunomodulation.

APPLICATION

Treatment with both P(BF+AOx) and P(BF+AOx)+P(OA+EO) decreased FCR significantly. Performance data should be considered in the context that comparisons were made to a challenge (cold stress and IBV) control. Thus, an increase in performance suggests a decrease in the stress effects of the physiological and environmental challenge. Increased growth performance due to each treatment compared to control may be linked to changes in cell growth and metabolic signaling, P(BF+AOx)+P(OA+EO) appears to induce a unique effect in the growth and metabolic signaling in the gut compared to the P(BF+AOx) treatment.

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MULTIPHASIC MIXED GROWTH MODELS FOR TURKEYS

M.J. Zuidhof

KEYWORDS: genetics, Gompertz, Meleagris gallopavo, poultry

ABOUT

Animal growth models are essential for optimization of feed formulation and breeding programs in agricultural production. They are needed to understand when and how quickly animals gain weight, to be able to optimize this weight gain for desired production purposes. However, a limited number of studies are available investigating growth models in turkeys. Multiphasic models allow for multiple sets of coefficients and multiple inflection points, therefore are able to describe several overlapping growth spurts. Thus far, only two studies have been found investigating multiphasic growth in turkeys. Hence, the aim of the current study was to 1) compare sex and line differences in turkeys in the parameter estimates of mono- and di-phasic Gompertz growth models, and 2) evaluate mono and diphasic mixed Gompertz growth models to determine the variation in parameter estimates in a group of female line turkey toms. The models were assessed based on parameter estimates and their ability to identify multiple growth phases. These models can evaluate differences in growth curve shape between genetic lines and sexes and demonstrate variation in growth curve parameter estimates within genetic lines and sex in turkeys.

APPROACH

Two datasets were provided by Hendrix Genetics. The first dataset included male and female BW data from a male line and a female line of Large White turkeys. Data included 913 weekly observations from hatch to 20 wk of age. The data also consisted of 68 observations on hens between 28 and 32 wk of age and 75 observations on toms around 24 wk of age. The second dataset included individual BW data from 68 turkey toms of a different genetic female line from 5 to 24 wk of age. Birds were wing banded for individual identification with a radio frequency identification (RFID) wing band. All birds were ad libitum fed a standard North American commercial turkey diet and water was provided ad libitum during the entire growth period. A modified Gompertz growth model was used to describe BW as a function of age. Genetic line and sex differences

in model fit were evaluated based on the monophasic version of the model to allow for comparison with previous literature. Monophasic and diphasic versions were evaluated within genetic line and sex for goodness of fit. Based on the analysis of the fit of monophasic and diphasic models within the dataset with individually collected BW data, three nonlinear mixed models were defined.

ANALYSIS OF RESULTS

Growth curve shapes were different between male line toms, male line hens, female line toms, and female line hens ($P < 0.001$). However, inflection points were similar between male and female line toms and between male and female line hens (14.06 vs. 13.72 wk and 11.22 and 10.71 wk, respectively), while mature BW differed between lines by 6.49 and 3.81 kg for toms and hens, respectively. The normalized growth rate constant (growth rate constant corrected for mature weight) was around the same magnitude between male and female line toms (0.0031 vs. 0.0038, respectively), but slightly lower in male line hens compared to female line hens (0.0072 vs. 0.0091, respectively). Diphasic Gompertz models described growth better in all line \times sex combinations compared to the monophasic models ($P < 0.001$) and mixed diphasic Gompertz models showed improved fit over mixed monophasic Gompertz models. The correlation structure of the random components identified that individuals with a higher mature weight had a later inflection point and lower growth rate coefficients.

APPLICATION

The current study identifies differences in growth curves in modern male and female line turkey toms and hens. Diphasic Gompertz models described male line toms, female line toms, and female line hens better compared to monophasic functions. Mixed multiphasic Gompertz models showed variation between individuals in estimates of mature BW and inflection point of each phase. The models described here could form a basis for new trait development based on individual BW curves for improved breeding practices and provide tools for studies evaluating the effect of dietary or environmental factors on growth trajectories in turkeys.



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IS RELAXING BROILER BREEDER GROWTH RESTRICTION COST-EFFECTIVE?

M. Afrouziyeh, M.J. Zuidhof, V.L. Carney

KEYWORDS: broiler breeder, growth trajectory, partial budget, progeny

ABOUT

Broiler breeders have high growth potential, which needs to be passed onto their broiler offspring, yet, breeders need to produce fertile eggs. Broiler breeders are feed restricted to control excessive growth. There is a growing body of evidence that the intensity of feed restriction has increased in broiler breeders over the past decades, raising welfare concerns. The economic projections of various relaxed growth restrictions should be considered in designing strategic growth trajectories. One of the important questions associated with relaxing growth restriction in broiler breeder pullets is how the resulting performance in hatching egg production will compensate for the concomitant increase in feed intake and cost. This research evaluated the economic projection of various relaxed growth trajectories for hatching egg producers and supply chain sectors.

APPROACH

Ross 708 pullets (n=40) were placed in a pen containing 2 precision feeding (PF) stations from hatch to 43 wk of age. The pullets were randomly assigned to 10 growth trajectories. The birds in the High g1 groups were raised heavier by 10% than their Standard g1 counterparts during the prepubertal phase. The pubertal phase inflection point coefficient (I2) was advanced by 0, 5, 10, 15, and 20% creating inflection points at 22.29, 21.16, 20.05, 18.94, and 17.82 wk of age, respectively. The growth trajectories were: Scenario 1 (Ross 708 target) = Standard g1, I2-0%; Scenario 2 = Standard g1, I2-5%; Scenario 3 = Standard g1, I2-10%; Scenario 4 = Standard g1, I2-15%; Scenario 5 = Standard g1, I2-20%; Scenario 6 = High g1, I2-0%; Scenario 7 = High g1, I2-5%; Scenario 8 = High g1, I2-10%; Scenario 9 = High g1, I2-15%; Scenario 10 = High g1, I2-20%. Two progeny trials varied in maternal age (MA = 35 and 42 wk) were conducted to evaluate the intergenerational effects of two degrees of maternal prepubertal BW gain (MW) and five earlier maternal pubertal growth inflection points (MI) on offspring growth and development. An average of 12 chicks per maternal treatment, were placed in 4 controlled pens and individually fed commercial diets via PF stations until 35 days. Individual BW and feed intake were recorded by the PF system. The economic projections of switching

broiler breeder target growth from the breeder-recommended target growth to 9 alternative growth scenarios were investigated using a partial budget analysis in Canadian dollars. In the partial budget analysis for the broiler sector, differential chick cost estimated in the broiler breeder partial budget, broiler 35 d live BW, and cumulative feed consumption were included in the broiler margin calculation.

ANALYSIS OF RESULTS

The partial budget for the hatching egg sector predicted that increasing prepubertal BW gain by 10% along with advancing the pubertal growth inflection by 15 or 20% resulted in a greater margin over feed and pullet cost compared to the breeder-recommended growth trajectory (scenarios 9 and 10 vs. scenario 1). If a hatching egg producer switched from the breeder-recommended BW target scenario to scenario 9, the model-predicted margin over pullet and feed cost until 42 wk of age would increase by \$0.52/hen; the increase in profitability would be \$1.97/hen for scenario 10. For every week of earlier pubertal growth, ADFI decreased by 1.3 g/d/wk for the Standard g1 hens and increased by 1.2 g/d/wk for the High g1 birds, egg production increased by 0.33 egg/hen for the High g1 treatment and decreased by 0.27 egg/hen and for the Standard g1 treatment; egg mass increased by 0.916 g/d for the High g1 treatment and decreased by 0.29 g/d for the Standard g1 treatment. 35 d BW of broilers from 42-wk old hens were greater than that of broilers from 35-wk old hens (1,955 vs. 1,903 g, respectively), which increased revenue for the 42-wk old hens' offspring cohort compared to that of the 35-wk old hens. Furthermore, FCR of chicks from older breeders was lower than that of the ones of younger mothers. In the partial budget analysis for the broiler sector, the margin over feed and chick cost estimated for maternal scenario 1 from 35-wk old hens was used as a reference to compare the margin of other maternal growth scenarios. All maternal growth scenarios increased margin over feed and chick cost compared to that of the breeder-recommended maternal growth scenario (scenario 1), except for scenario 6 from 35-wk old hens.

APPLICATION

Increasing prepubertal BW gain by 10% and advancing the pubertal growth phase by 20% (scenario 10) could increase margin over feed and chick cost for the hatching egg producers by CDN\$1.97/hen. For broiler chicken supply chain as a whole, the highest differential margin over feed and chick cost was for maternal growth scenario 10 from 42-wk old hens. The latter margin over feed and chick cost was greater than that of breeder-recommended maternal growth (from 35-wk old hens) by \$0.1053/kg live chicken under the current economic situation.



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PRELIMINARY ASSESSMENT OF THE IMPACT OF DIETARY YEAST PRODUCTS ON EGG PRODUCTION AND CECAL MICROBIAL PROFILES OF LAYING HENS

D.R. Korver

KEYWORDS: yeast product, laying hen, cecal microbiota, egg production, eggshell quality

ABOUT

Yeast fermentation products are commercially available for inclusion in poultry diets. Due to the various yeast species and strains used, fermentation conditions, processing methods, and bioactive compound concentrations generated, many different forms of yeast by-products exist. Numerous studies have examined the impact of various gut health-targeted additives such as prebiotics, probiotics and postbiotics on laying hens, but much less is known about current commercial yeast products on egg production or the GIT microbiota in laying hens. The objective of this study was to conduct an initial comparison of commercial yeast products with different expected modes of action in laying hen diets on egg production parameters and the corresponding impact on the cecal microbiota.

APPROACH

A short-term feeding study was carried out to test commercial yeast products: Citristim (an inactivated whole cell yeast (*Pichia guilliermondii*) postbiotic) at 0.5 kg/tonne, Maxi-Gen Plus (processed yeast containing nucleotides, β 1,3-glucans and mannans) at 1.0 kg/tonne, Hilyses (hydrolyzed product derived from *Saccharomyces cerevisiae*, consisting of peptides, free amino acids, nucleotides, β -glucans and mannanoligosaccharides) at 2.5 kg/tonne, and ImmunoWall (20% mannanoligosaccharide [MOS] and 35% β -1-3 glucans from *S. cerevisiae*) at 0.5 kg/tonne. Dietary inclusion level of each yeast product was chosen based on supplier recommendations specific to each product. Single-comb White Leghorn laying hens were moved to individual cages ($n = 7$ per treatment; starting at 40 wk of age) and randomly assigned to one of 5 experimental treatment groups. Hens were fed a standard wheat-based, commercial-type diet containing either no yeast product (control) or 1 of the 4 products. Initial and final (46 wk of age) body weights, overall

feed intake, initial and final egg weights, initial and final shell quality (shell weight and shell thickness) and total egg production from 40 to 46 wk of age were determined for each hen.

ANALYSIS OF RESULTS

Initial and final hen body weights, change in body weight, feed intake during the experiment, egg production, and egg weights were not affected by dietary treatment. The lack of a treatment effect suggests that, at least in the short term, there were no negative effects of any of the products on hen productivity. Although initial shell weight and shell thickness were similar among the treatment groups, hens fed Hilyses had lower shell weight and thickness at the end of the experiment ($P = 0.004$ and 0.026 , respectively). Given the short duration of the trial, the small number of hens in the experiment, and the small numbers of eggs sampled, this could be an experimental artifact and may not reflect an actual decrease in shell quality.

APPLICATION

The objective of this study was to conduct an initial comparison of commercial yeast products in layer hen diets on egg production parameters and the corresponding impact on the cecal microbiota. However, the commercial yeast products tested in this short trial had little effect on egg production and shell quality, and only moderately impacted the composition of mature layer hen cecal microbiota.



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AN EGG WHITE-DERIVED PEPTIDE ENHANCES SYSTEMIC INSULIN SENSITIVITY AND MODULATES MARKERS OF NON-ALCOHOLIC FATTY LIVER DISEASE IN OBESE, INSULIN RESISTANT MICE

J. Wu

KEYWORDS: bioactive peptides; egg; metabolic syndrome; non-alcoholic fatty liver disease; type 2 diabetes

ABOUT

Non-alcoholic fatty liver disease (NAFLD) affects 25% of the global population and is strongly associated with obesity, type 2 diabetes (T2D)/insulin resistance (IR), and dyslipidemia. All of these conditions are a public health concern and beget socioeconomic problems. Lifestyle interventions (diet and physical activity) improve NAFLD, but currently no pharmacological treatment is approved for NAFLD. Natural health products and functional foods include potential candidates to aid in the management of metabolic conditions. Food-derived bioactive peptides have effects beyond their nutritive value and can modulate physiological processes promoting health benefits. There are many food sources of bioactive peptides, including the egg. We aimed to identify specific effects of Peptide 2 diet supplementation on manifestations of the metabolic syndrome including systemic IR, WAT response to insulin and NAFLD markers, compared with the thiazolidinedione rosiglitazone.

APPROACH

Protocol 1: Male Sprague Dawley (SD) rats (n = 48) were fed with high fat diet (HFD) for 6 wks. Then, half of the animals received HFD+4% EWH with the remainder serving as HFD controls for another 6 wks. At the end of week 12, half of the animals received an intraperitoneal injection of insulin (2 IU/kg of body weight (BW)) to stimulate insulin signaling prior to euthanization using CO₂. Protocol 2: Male C57BL/6 mice (5 wks old) were housed 4/cage with ad libitum access to food and water. Mice received a low fat diet (LFD, 10% kcal fat) or a high fat diet (HFD, 45% kcal fat) for 6 wks. After that, the HFD animals were divided into 3 groups: HFD only,

HFD + Peptide 2 (PEP2) and HFD + rosiglitazone (ROSI) and continued receiving their respective diets for another 8 wks. LFD animals continued receiving LFD for another 8 wks. After a total of 14 wks, mice either received an intraperitoneal injection of insulin (1.5 IU/kg BW) prior to euthanasia or were directly euthanized using CO₂, while some mice underwent hyperinsulinemic-euglycemic clamp prior to euthanasia by ketamine. Peptide 2 was administered at 45 mg/Kg BW/day daily mixed in the diet. Mice were weighed weekly. Blood was collected for further analysis. Tissues were collected for histological analysis.

ANALYSIS OF RESULTS

The analysis revealed that 4% EHW treated animals had reduced p-HSL in rWAT after intraperitoneal injection of insulin ($p < 0.05$) despite no change in phosphorylation on PKA. Total PKA abundance was reduced by 4% EWH treatment. Plasma and WAT adiponectin and resistin concentrations were not different between groups. Peptide 2 supplementation did not influence final BW or BW gain in comparison to HFD. Body composition analysis revealed that only the LFD animals had a lower fat mass % and higher lean mass % than HFD. In vivo tests confirmed that at week 14 HFD animals were glucose intolerant compared to LFD animals, and that the ROSI group had improved glucose tolerance compared to HFD group. Improvement in insulin sensitivity after PEP2 and ROSI treatment was confirmed during the insulin tolerance test.

APPLICATION

In conclusion, this study shows for the first time that egg-white derived Peptide 2 diet supplementation improves IR in HFD-induced obese and IR mice, while at the same time preventing further exacerbation of HFD-induced NAFLD features independently of BW. On the other hand, rosiglitazone-treated mice, despite having improved IR, exhibited worse hepatic steatosis if administered together with HFD. Therefore, compared to rosiglitazone, Peptide 2 promotes more beneficial effects on the combined outcomes of insulin resistance, WAT dysfunction and hepatic steatosis.



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CHEMICALLY CROSS-LINKED KERATIN AND NANOCHITOSAN BASED SORBENTS FOR HEAVY METALS REMEDIATION

A. Ullah

KEYWORDS: Keratin biopolymer, Chicken feathers, Nanochitosan, Sustainable, Heavy metals, Industrial wastewater

ABOUT

Access to clean drinking water is one of the most significant challenges and is becoming extremely scarce and polluted. Most of the industrial wastewater is discharged into freshwater bodies without adequate treatment, severely polluting the water resources. Various conventional methods have been used to remediate industrial effluents before releasing them into the environment. However, most techniques are not viable in areas with limited resources because of the high cost. Hence, there is an urgent need to develop green, sustainable, and economical alternatives with excellent removal efficiency for industrial wastewater treatment. Keratin has a unique, diverse chemical structure and offers exciting opportunities for modification with advanced biosorption properties. Keratin can be extracted from low-cost biomass sources such as hairs, nails, claws, hooves, wool, horns, and feathers. As a poultry industry by-product, feathers pose severe ecological and commercial issues. Globally, 8–9 million tonnes of chicken feathers are produced yearly. Keratin biopolymer from chicken feathers (keratin >90 %) is one of the viable options for the biosorption of heavy metal ions due to its natural abundance, easy availability and environment-friendly nature. The main objective of this research is to develop an alternative way to use chicken feathers keratin to produce affordable, renewable and sustainable keratin-nanochitosan based biosorbents for industrial wastewater treatment.

APPROACH

Nanochitosan was synthesized by an adapted Calvo et al. method. Chicken feathers (CF) were washed and process to obtain chicken feathers keratin (CFK). Nanochitosan particles (1, 3, and 5 %) on the weight basis of keratin were dispersed using a sonicator for 30 min in 50 ml of distilled water. The keratin-nanochitosan mixture was processed and dried. The dried biosorbents were ground and sieved through 80 µm brass mesh to obtain powdered biosorbents for further structural analysis and biosorption studies. Biosorption studies were conducted with ICP-MS (Perkin Elmer's Elan 6000) to

assess the removal efficiencies of the developed biosorbents and compare them with the neat keratin. The biosorption performance of each sample was investigated with simulated laboratory synthetic wastewater.

ANALYSIS OF RESULTS

The chemical modification of keratin biopolymer with bio-derived nanoparticles can be feasible and sustainable to increase its surface affinity for metal sorption in large-scale applications such as water remediation. The nano-chitosan has polar functional groups such as the hydroxyl group, which can interact with the keratin's side chains, enhancing the polar and charged side chains on the keratin surfaces and making them more effective for metal removal. It was observed that biosorption of the keratin-nanochitosan derived biosorbents increases with the increase in nanochitosan content. Keratin-nanochitosan derived biosorbents clearly show substantial differences in the surface morphology in contrast with the neat keratin surface. The neat chicken feathers keratin has a fibrous, smooth, homogeneous surface and long shafts. However, the incorporation of nanochitosan turned the keratin surface into a coarse or rough surface. As a result, more sorption sites on the keratin protein matrix were exposed, resulting in greater biosorption towards heavy metal ions. The CFK modified with nanochitosan gave a better biosorption capacity for all metals oxy- anions and cations than neat CFK.

APPLICATION

This study demonstrated excellent sorption of heavy metal ions by chicken feathers keratin-nanochitosan derived biosorbents. As a renewable carbon resource, chicken feathers keratin is a promising biosorbent for large-scale remediation of industrial wastewater containing multiple heavy metal cations and anions. In future, optimization of the biosorbent concentration, actual wastewater treatment and biodegradation of the developed biosorbents will be studied to broaden the impact of this research study.



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REMOVAL OF DIVALENT CATIONS AND OXYANIONS BY KERA-TIN-DERIVED SORBENTS: INFLUENCE OF PROCESS PARAMETERS AND MECHANISTIC STUDIES

A. Ullah

KEYWORDS: Synthetic wastewater, Feather keratin

ABOUT

Currently, water pollution is a significant threat to human health and the environment around the globe. Industrial wastewater most commonly contains heavy metals (Ni, Zn, Cd, Hg, Pb, As, Cu, Cr, Co, Fe, Mn) along with other metals (Ca, Sb, Ag, B, Mo) which are considered to be hazardous, non-biodegradable, carcinogenic, and have a high affinity to assemble in the food chain and human body. So, it is essential to remove heavy metals from water resources, even if detected in trace amounts, to secure a healthy environment. Keratin proteins are one of the sustainable and renewable biomass resources that have the potential to be utilized as an adsorption material for the heavy metals remediation. Chicken feathers (CFs) are by-products produced in large quantities by the poultry industry and they contain >90 % of keratin protein. By modification with chemical agents, the adsorption capacity of the CF keratin can be improved. In our previous study, we reported the influence of chemical modification of CFs keratin with eight different chemical agents. Herein, we studied three out of the eight available KBPs (KBP-I, KBP-IV, KBP-V) adsorbents based on preliminary screening of their adsorption performances. So, the main objective is to investigate the processing parameters, i.e., temperature, contact time and pH, adsorption equilibria and mechanistic behavior related to the adsorption of divalent cations and oxyanions.

APPROACH

Chicken/keratin feathers (KBP-I) were washed, dried, ground and processed to prepare KBP-IV, KBP-V, and KBP-VII. The KBP-IV was prepared by the chemical modification of processed CFs using the ionic liquid [1-butyl-3-methylimidazolium bromide (BMIM)Br]. The KBP-V was prepared from processed CFs by a method already reported by Zahara et al., 2021. The KBP-VII was modified using the

mercaptopropylisobutyl- polyhedral oligomeric silsesquioxanes (POSS). Removal of metal ions were tested under the influence of process parameters (temperature, contact time, and pH of the aqueous solution). Then, the adsorption mechanisms involved in the removal of divalent cations and oxyanions from synthetic wastewater by KBP-IV and KBP-V was investigated.

ANALYSIS OF RESULTS

The KBPs provide an optimization of the adsorption parameters (temperature, contact time, and pH) based on their better metal adsorption abilities owing to the larger accessibility of functional groups present on the surfaces. The incubations of KBP-I, KBP-IV, and KBP-V at 30 °C and 45 °C with MMSW, elaborated that 30 °C is the optimized temperature for the removal of divalent cations and oxyanions using the KBP-I and KBP-IV. However, KBP-V adsorbed divalent cations effectively at 45 °C. For divalent cations and oxyanions adsorption, the fastest equilibrium was achieved within 15–60 min by KBP-I, KBP-IV, and KBP-V. No significant differences were observed for inorganics removal from MMSW at two initial solution pHs (5.5 and 8.5). However, the divalent cations and oxyanions removal from single metal synthetic wastewater at two pHs (5.5 and 8.5) concluded that KBP-V adsorbed divalent cations at pH 8.5 and KBP-IV removed oxyanions at pH 5.5 effectively. The results of the XPS analysis demonstrated that adsorption mechanisms (complexation/chelation, electrostatic attraction, or chemical reduction) are involved in the removal of divalent cations and oxyanions by KBPs from synthetic wastewater. The adsorption behavior for (Cd²⁺, Ni²⁺, Cr^{VI}) by using KBP-I, KBP-IV, KBP-V was best described by the Langmuir model, and for As^{III} by KBP-I was best described by the Freundlich model. The maximum adsorption capacities were found to be 2.4 mg g⁻¹ for Cd²⁺, 2.8 mg g⁻¹ for Cr^{VI}, and 2.2 mg g⁻¹ for Ni²⁺ which were comparable with the values reported in the literature for other forms of materials.

APPLICATION

The high performance of KBPs towards the inorganic removal (Ba²⁺ and Sr²⁺) from field-collected wastewater (OSPW) indicated that developed KBPs display great potential to be utilized as an alternative, cheap and effective material for large-scale industrial wastewater remediation to save the eco-environment.

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CECAL MICROBIOTA DEVELOPMENT AND PHYSIOLOGICAL RESPONSES OF BROILERS FOLLOWING EARLY LIFE MICROBIAL INOCULATION USING DIFFERENT DELIVERY METHODS AND MICROBIAL SOURCES

C.S.Marcolla, B.P. Willing

KEYWORDS: broiler, ceca, commensal, early-life, gut microbiota, microbial inoculation, microbiota, next-generation probiotics

ABOUT

Intensive poultry production systems rely on several practices to minimize exposure to potential pathogens that could lead to increased mortality, disease outbreaks, and the contamination of food products. On broiler breeder farms, eggs are collected soon after being laid to lower the chance of the fecal contamination of eggshells. Eggs are incubated in sanitized hatcheries, and chicks are born in an environment that is depleted of chicken commensal microbes, compared to an environment in which a hen is present. This study aimed to investigate the cecal microbiota of broilers after early life exposure to bacteria that were harvested from different sources using three inoculation strategies. Our objectives were (i) to evaluate whether microbial cultures can mimic the composition of cecal contents and promote similar effects on the microbiota community when introduced to chicks; (ii) to identify bacteria that can consistently colonize and persist in the chicken gut environment after a single exposure, despite the composition of the inoculum being introduced; (iii) to evaluate the effectiveness of delivery routes (oral gavage, spraying the inoculum into the bedding, and cohousing); and (iv) to test whether the cecal microbiota obtained from extensively or intensively raised chickens is more capable to colonize the ceca of modern broilers.

APPROACH

1-day-old broilers (Ross 708) were distributed in sterile environment containing autoclaved aspen shavings. Chicks were fed a commercial, laboratory-grade, antibiotic-free, corn-soybean meal-based diet. Chicks were inoculated with microbiota from cecal samples that were obtained from chickens of different genetic lines and ages. In the first trial, 90 one-day-old chicks were assigned to: cecal contents (from a 40-week-old Lohmann white chicken) delivered via oral gavage (ceca_gavage) or spraying into bedding (ceca_spray); microbial culture derived from cecal contents delivered via oral gavage (culture_gavage) or spraying into bedding (culture_spray). The control group received sterile LCY supplemented with 30% glycerol and 0.05% L-cysteine via oral gavage. In the cohousing experiment, 6 one-day-old chicks were used. In each isolator, one bird was selected as the “seeder” bird, and the other was called the “cage mate”. The seeder bird received cecal contents that were obtained

from a healthy backyard chicken (eA) by oral gavage, whereas its cage mate remained untreated. Control chicks were inoculated with sterile LCY via oral gavage. For the competition experiment, 81 chicks received cecal contents from either intensively (donor birds iA and iB) or extensively (donor birds eA and eB) raised chickens, or from a mixture containing cecal contents from intensively and extensively raised chickens via oral gavage. For all experiments, the birds were weighed weekly, and samples were collected at the end of the experiment.

ANALYSIS OF RESULTS

The inocula of cecal contents and microbial cultures derived from cecal contents are both effective in increasing alpha diversity, changing the microbial community composition, and favoring the predominance of Bacteroidetes. Comparisons between the gavage and spray treatments indicated that both can be used as effective delivery routes, provided that a sufficient volume of spray is applied. We compared the microbiota of chicks that were exposed to ceca_gavage and culture_gavage treatments (exposed) to the microbiota of control chicks (control) and broilers of same age that were reared in two intensive commercial farms. Firmicutes dominated the microbiota of the control and commercial birds, whereas the microbiota of the exposed birds were dominated by Bacteroidetes. The results indicated that, although they were reared in conditions that would be deemed extremely hygienic, the control birds in the present study harbor microbiota similar to those of birds in commercial settings. The cohousing experiment was performed to test whether the microbiota of one chick (the seeder) could be effectively transmitted to another chick (the cage mate). The inoculation caused significant shifts in the cecal microbial community structures between the birds that were exposed to the inoculum and the control birds ($P = 0.006$, $R^2 = 0.45$). A competitive colonization study was conducted to evaluate the colonization ability of bacteria unique to extensive or intensive systems. All of the alpha diversity indices that were measured were higher in the birds that received inocula from extensively raised chickens (eA and eB), compared to the control birds. The microbiota of the control birds were dominated by Firmicutes and Proteobacteria, whereas the inoculated birds showed a predominance of Bacteroidetes, which was consistent with the observed results in the inoculation strategy and cohousing experiments.

APPLICATION

Inoculated birds present a lower relative abundance of Enterobacteriaceae, which can negatively impact chicken health and cause foodborne illnesses. These results indicated that microbiota transfer can potentially promote pathogen exclusion and affect bird physiology.

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