

2021



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The Poultry Innovation Partnership (PIP) is a collaboration of the Poultry Industry, Government of Alberta and University of Alberta to foster a healthy Canadian poultry enterprise. Excellence in research and innovation, knowledge management, technology transfer and mentoring tomorrow's poultry professionals are the Centre's hallmark.

Together, PIP partners collaborate to create an environment where research, extension and tech transfer can flourish and grow far beyond the reach of a single

entity. This research showcase highlights the cutting-edge research published in 2021 by Poultry Innovation Partnership scientists.

The University of Alberta and the poultry industry have a long history of collaborating on leading edge research. Each partner brings diverse knowledge, skills, resources and perspectives in exploring solutions to systems-level issues such as achieving high standards for animal care, respect for the environment and genetic resources, economic efficiency and poultry by-product utilization. The Showcase covers the entire spectrum of research from discovery to farm-ready application.

'This Research Showcase highlights what is possible when academia, industry and farmers work together to explore and develop solutions within the unique Western Canadian context.'

Dr. Valerie Carney, Poultry Innovation Partnership Lead

Contents

[Advancing the Canadian Poultry Enterprise 2](#)

[Feeding different cultivars and quality levels of faba bean to broiler chickens 4](#)

[Feeding, feed-seeking behavior, and reproductive performance of broiler breeders under conditions of relaxed feed restriction 5](#)

[A supervised machine learning method to detect anomalous real-time broiler breeder body weight data recorded by a precision feeding system 6](#)

[A protected complex of biofactors and antioxidants improved growth performance and modulated the immunometabolic phenotype of broiler chickens undergoing early life stress 7](#)

[Feather keratin derived sorbents for the treatment of wastewater produced during energy generation processes 8](#)

[Broiler growth and efficiency in response to relaxed maternal feed restriction 9](#)

[Ileal digestibility of energy and amino acids in three faba bean cultivars \(*Vicia faba* L.\) planted and harvested early or late in broiler chickens 10](#)

[Improving a nonlinear Gompertz growth model using bird-specific random coefficients in two heritage chicken lines 11](#)

[Intergenerational effects of maternal growth strategies in broiler breeders 12](#)

[Timing of growth affected broiler breeder feeding motivation and reproductive traits 13](#)

[The use of disinfectant in barn cleaning alters microbial composition and increases carriage of *Campylobacter jejuni* in broiler chickens 14](#)

[Purification and identification of novel ACE inhibitory and ACE2 upregulating peptides from spent hen muscle proteins 15](#)

[Amylase enhances production of low molecular weight collagen peptides from the skin of spent hen, bovine, porcine, and tilapia 16](#)

[Egg white ovomucin hydrolysate inhibits intestinal integrity damage in LPS-treated Caco-2 cells 17](#)

[Spent Hen Muscle Protein-Derived RAS Regulating Peptides Show Antioxidant Activity in Vascular Cells 18](#)

[Using an artificial neural network to predict the probability of oviposition events of precision-fed broiler breeder hens 19](#)

[Impact of Adding Polysaccharides on the Stability of Egg Yolk/Fish Oil Emulsions under Accelerated Shelf-Life Conditions 20](#)

FEEDING DIFFERENT CULTIVARS AND QUALITY LEVELS OF FABA BEAN TO BROILER CHICKENS

M.N. Smit, L. He, E. Beltranema

KEYWORDS: broiler chicken, cultivar, faba bean, frost damage, growth performance, quality

ABOUT

Faba bean has a growth cycle longer than field pea making it susceptible to frost. Damaged beans would not make human food export quality but instead would be diverted to animal feeding. A concern of both pulse growers and poultry producers is how frost damage around harvest time affects the nutritional quality of faba bean for broiler chickens. The objective of this study was to compare feeding three faba bean cultivars differing in antinutritional factors content and bean quality level (high [#1 certified seed] vs. low [#2 feed grade, frost damaged and immature beans]) on growth performance, carcass traits, and yield of saleable cuts of broiler chickens.

APPROACH

To investigate, 2 zero-tannin cultivars (Snowbird, Snowdrop) and 1 low vicine and convicine cultivar (Fabelle) sourced from seed growers were spring planted 3 weeks later than recommended (mid-May) and harvested late October to purposely increase frost damage. Parent, certified seed (high quality) and harvested frost damaged beans (low quality) of the 3 cultivars were fed to 740 chickens housed in 64 floor pens in a 2 x 3 factorial plus control (9 pens of 11 or 12 birds per treatment). Starter (d 0 to 11), grower (d 12 to 24) and finisher (d 25 to 40) diets included 15, 30, and 45% faba bean in partial (starter, grower) or total replacement of soybean meal (SBM; control). Harvested Snowbird, Snowdrop, Fabelle averaged 52, 62, 17% blackened hull and 35, 43, 51% immature beans, respectively.

ANALYSIS OF RESULTS

Broilers fed low-quality Snowdrop consumed 10 grams per day (g/d) more finisher and 6 g/d more feed overall than those fed low-quality Snowbird or Fabelle; broilers fed parent seed were intermediate. Feeding low-quality Fabelle resulted in best overall G:F (0.646) versus high-quality Snowbird (0.611), high-quality Fabelle (0.624), or low-quality Snowdrop (0.624). Average daily weight gain (ADG) and bird body weight (BW) at the end of each growth phase were not affected by cultivar or quality level. Controls fed SBM only grew 2.75 g/d faster overall and were 113.5 g heavier at the end of the trial than broilers fed faba bean ($P < 0.05$). Controls fed SBM only had 0.024 g/g better overall G:F than broilers fed faba bean ($P < 0.05$). Feeding low-quality beans or high-quality seed had no effect on antemortem BW, chilled carcass weight (WT), dressing percentage or yield of saleable cuts except that broilers fed Snowbird or Snowdrop had 0.8%-unit larger thighs than those fed Fabelle. Controls fed SBM only were 110 g heavier at slaughter, had 72 g heavier chilled carcass WT, and 0.5%-unit greater dressing percentage than broilers fed faba bean ($P < 0.05$).

APPLICATION

The results of this experiment indicate that feeding frost damaged and/or immature, low-quality faba bean, to the extent observed in this trial, did not negatively affect growth performance or carcass attributes of broiler chickens compared to feeding parent, certified seed quality of these faba bean cultivars (Snowbird, Snowdrop, and Fabelle). This allows faba beans that are not in perfect condition to be fed to broilers without any negative consequences.



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FEEDING, FEED-SEEKING BEHAVIOR, AND REPRODUCTIVE PERFORMANCE OF BROILER BREEDERS UNDER CONDITIONS OF RELAXED FEED RESTRICTION

N.M. Zukiwsky, M. Afrouziyeh, F.E. Robinson, M.J. Zuidhof

KEYWORDS: precision livestock feeding, body weight, hunger, unrestricted feed intake, sexual maturity

ABOUT

Broiler breeders are feed restricted to control BW throughout their life cycle. Feed restriction leads to poor bird welfare. However, unrestricted feed intake can lead to health issues related to rapid growth and obesity, which is also considered to be a welfare issue. The objective of this study was to implement a variety of BW trajectories using a precision feeding system (PF) to evaluate the effect of varying degrees of relaxed feed restriction on feeding, feed-seeking behavior and reproductive performance of broiler breeders.

APPROACH

Ross 708 female broiler breeders (n = 36) were fed using a precision feeding system from 2 to 42 wk of age. Ten BW trajectories were created from a multiphasic Gompertz growth model that increased growth from 0 to 22.5% in the prepubertal and pubertal phases of growth, in 2.5% increments. Six unrestricted birds were not limited to a maximum BW. All birds had access to 2 PF stations 24 h per day and ad libitum access to water throughout the experiment. Station visit frequency, average daily feed intake (ADFI), the number of meals, and meal size were derived from records in the PF system database. A single RFID-equipped nest box (8 nesting sites) and trap nest box (10 nesting sites) were introduced to the chamber at 14 wk of age so that pullets could familiarize themselves with the nests before the onset of lay. Each RFID nesting site was equipped with an RFID reader which identified a hen with each egg that was laid. Eggs were collected, weighed, and assigned to individual hens daily.

ANALYSIS OF RESULTS

Body weight increased as trajectory-specific BW targets increased from 6 to 28 wk of age. Differences of BW between BW trajectories decreased during the laying period, which was a result of individual bird variation within BW trajectories. Station visit frequency decreased per kilogram increase in BW for all birds during rearing and lay, and within feed-restricted birds during lay only. The number of meals and ADFI increased with age, which reflected nutrient intake to support maintenance, growth, and reproductive requirements. Mean egg weight (EW) of all birds increased by 0.72 g per kilogram increase in BW from 22 to 41 wk of age. From 22 to 29 wk of age, mean EW of feed-restricted birds increased by 2.78 g per kilogram increase in BW. For every kilogram increase in BW, age at first egg comparing all birds decreased by 10.83 d. Two unrestricted birds came into lay before photostimulation. In contrast with the hypotheses, BW increased up to 22.5% above the recommended target did not reduce feeding and feed-seeking behavior, or negatively impact reproductive performance.

APPLICATION

BW increased up to 22.5% above the recommended target did not reduce feeding and feed seeking behavior, or negatively impact reproductive performance. Thus, there is potential to increase broiler breeder BW targets and reduce the degree of feed restriction without reducing reproductive performance. The BW results of the present study indicated that optimal BW trajectories may strongly depend on the individual broiler breeder.

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A SUPERVISED MACHINE LEARNING METHOD TO DETECT ANOMALOUS REAL-TIME BROILER BREEDER BODY WEIGHT DATA RECORDED BY A PRECISION FEEDING SYSTEM

J. You, E. Lou, M. Afrouziyeh, N.M. Zukiwsky, M.J. Zuidhof

KEYWORDS: outlier detection, machine learning, model selection, imbalanced classification

ABOUT

A precision feeding (PF) system is an intelligent computer-controlled feeding system that can be used to feed individual broilers, breeders, or layers automatically based on measuring real-time body weight (BW). Vast amounts of real-time BW data can be obtained every day when birds visit a PF station. However, anomalous observations in real-time BW observations occur and they should be removed. Manually cleaning the anomalies is accurate, but it is time-consuming and labor-intensive. The objective of this study is to report a supervised machine learning method to detect anomalies in real-time BW recorded by the PF system.

APPROACH

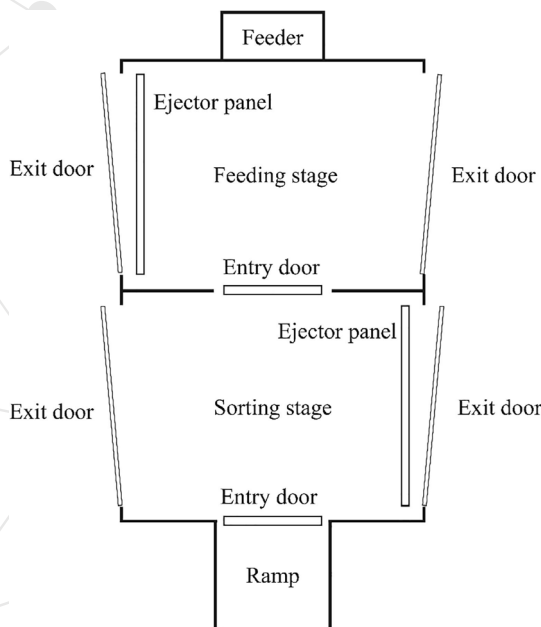
The data were obtained from a flock of Ross 708 broiler breeders ($n = 95$) raised in 2 environmentally controlled chambers. Each chamber had two PF stations that were used to feed birds and record data automatically. The breeders were fed with the PF stations from day 15 to the end of the trial (day 306). To manually label anomalous real-time BW of broiler breeders, 5 breeders from day 15 to day 306 were randomly selected from the flock and their real-time BW data were checked. If the real-time BW value of an observation deviated a lot from that of other observations in one day and the deviation could not be explained by the feeding activities of a bird, the observation was defined as an anomaly or an anomalous observation. Python 3.7.0 was used to facilitate all the data analysis work including data preprocessing, feature engineering, algorithm selection, and comparison with other common anomaly detection methods.

ANALYSIS OF RESULTS

Were evaluated 4 machine learning algorithms including k-nearest neighbor (KNN), random forest classifier (RF), support vector machine (SVM), and artificial neural network (ANN). KNN had the highest precision (0.9746) and SVM had the highest recall (0.9917). RF produced the highest F1 score (0.9712) and area under the precision-recall curve (0.9948). Compared with 4 other common anomaly detection methods including Z-scores, interquartile range (IQR), density-based spatial clustering of applications with noise (DBSCAN), and local outlier factor (LOF), RF had a higher average F1 score (0.9448), which indicated that RF was a more effective anomaly detection algorithm for this type of data. RF detected almost all anomalous observations without identifying many normal observations as anomalies.

APPLICATION

The current study was the first to propose a supervised machine learning method to detect anomalies in real-time BW data of broiler breeders collected by a PF system. Real-time BW data of 5 randomly selected broiler breeders were used in the current study. To detect the anomalous observations over the period of trial (from day 15 to day 306), 12 variables considering statistical distribution of data and features regarding the feeding activity recorded by the PF system for each day were created and then machine learning algorithms were used to identify anomalies from normal observations. RF was selected as the best algorithm among 4 different machine learning algorithms because it had the highest F1 score (0.9712) and AUCPR (0.9948). Comparing with common anomaly detection methods (Z-scores, IQR, DBSCAN, and LOF) that just checked data distribution, the RF method in the current study had a higher average F1 score (0.9448). The current study provided an effective solution to clean anomalous observations of real-time BW of broiler breeders fed by the PF system.



Section view of a precision feeding station.

J. You et al., *Computers and Electronics in Agriculture* 185 (2021)

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A PROTECTED COMPLEX OF BIOFACTORS AND ANTIOXIDANTS IMPROVED GROWTH PERFORMANCE AND MODULATED THE IMMUNOMETABOLIC PHENOTYPE OF BROILER CHICKENS UNDERGOING EARLY LIFE STRESS

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KEYWORDS: antioxidants, broiler chickens, early life stress, immune system, infectious bronchitis

ABOUT

Acute change in environmental temperature may have negative impacts on the performance of broiler flocks. Additionally, cold stress may increase the susceptibility to respiratory diseases such as avian infectious bronchitis (IB). The supplementation of biofactors combined with antioxidants may help the animal to cope with early life stressors and improve growth performance. The objective of this study was to evaluate the dietary supplementation of Protected Biofactors and Antioxidants (P(BF+AOx)) on the growth performance, antioxidant activity, expression of immune-related genes, and immunometabolic phenotype of the jejunum and liver of broiler chickens submitted to early life stress.

APPROACH

The treatments were a nutritionally complete basal diet supplemented or not with P(BF+AOx) from 1 to 14 d of age. A total of 720 one-day old male Ross 308 chickens were placed into pens of 30 birds (12 replicates/treatment). The P(BF+AOx) is a complex of vitamins and fermentation extract (vitamin A, vitamin D3, vitamin E, menadi-one, thiamine, riboflavin, niacin, pantothenic acid, vitamin B6, biotin, folic acid, vitamin B12, L-tryptophan, and fermentation extract of dried *Bacillus subtilis*, *Aspergillus niger* and *A. oryzae*) microencapsulated in a matrix of triglycerides from hydrogenated vegetable oil. Birds were double-vaccinated against infectious bronchitis (IB) at the hatchery and submitted, on d 3, to an acute reduction on environmental temperature (from 32° C to 20°C) for 48 h. Feed intake (FI), body weight gain (BWG), and feed conversion ratio (FCR) were calculated weekly. On d 7 and 15, samples were collected for expression of immune-related genes and kinome array analysis, and serum to evaluate the antioxidant status.

ANALYSIS OF RESULTS

From d 1 to 21 and d 1 to 28, the dietary supplementation of P(BF+AOx) significantly increased BWG ($P < 0.05$) by 3.6 and 3.8%, and improved FCR ($P < 0.05$) by 1.2 and 1.8%, respectively. From d 1 to 35, dietary supplementation enhanced BWG ($P = 0.03$) by 4%. Serum glutathione reductase activity on d 15 was higher in birds fed diets supplemented with P(BF+AOx) compared to the control diet-fed birds ($P = 0.04$). Dietary supplementation reduced the expression of IL-1 β ($P = 0.03$) in the lungs on d 7. On d 15, dietary supplementation increased the expression of IL-6 ($P = 0.02$) and IL-10 ($P = 0.03$) in the liver. It was observed that, via decreased phosphorylation, catalase was activated in the jejunum and liver, and the phosphorylation of immunoregulatory or proinflammatory proteins was decreased. Other important cellular signaling pathways were also changed in the liver and jejunum due to the supplementation.

APPLICATION

The supplementation of P(BF+AOx) improved the growth performance of broiler chickens undergoing early life stress. Further analyses demonstrated that this novel feed additive was beneficial in modulating the immune and antioxidant defense systems of the birds. Overall, the kinome data functionally agreed with the gene expression and antioxidant results and indicates a general anti-inflammatory and antioxidant response in birds supplemented with P(BF+AOx).



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FEATHER KERATIN DERIVED SORBENTS FOR THE TREATMENT OF WASTEWATER PRODUCED DURING ENERGY GENERATION PROCESSES

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KEYWORDS: energy generation, water pollution, keratin biopolymers, characterization, water purification

ABOUT

Separation of heavy metals from wastewaters is achieved through physical, chemical and biological methods. However, these methods have several drawbacks, such as chemical precipitation producing large volumes of sludge with higher metal concentrations. Chicken feathers being an abundant waste by-product of the poultry industry has gained attention because of its potential for wastewater treatment. This study includes (i) modification and detailed structural characterization of developed keratin biopolymers (KBP) and (ii) their screening for sorption of targeted multiple metals from energy industry simulated wastewater.

APPROACH

Eight keratin derived biopolymers were developed to sequester the toxic trace elements from synthetic wastewater. Chemical modifications of biopolymers affect their physical and chemical characteristics, hence, enhance the sorption of contaminants from wastewaters. KBP-I (processed chicken feathers), KBP-II (acid modified), KBP-III & KBP-IV (modified with ionic liquids), KBP-V (amine modified), KBP-VI & KBP-VII (POSS modified) and KBP-VIII (sodium sulfite modified) were characterized for their surface morphology, structural integrity, functional group changes, crystallinity behavior, surface area, and pore size distribution using different analytical techniques. Developed biopolymers were then tested against synthetic wastewater spiked with nine transition and redox sensitive elements (100 µg L⁻¹ each).

ANALYSIS OF RESULTS

Based on initial screening, all the eight biopolymers performed well where KBP-I removed 87–93% of As and Cd, KBP-IV showed adsorption capacity of 80–85% of Cu and W, KBP-V represented 60–90% efficiency for the removal of Co, Ni and Zn and KBP-VI demonstrated removal efficiency of 95% for CrVI metal. The developed keratin biopolymers show prospects to effectively treat the metals contaminated wastewater.

APPLICATION

This work highlights the role of keratin derived biopolymers as an emerging area towards remediation of heavy metal water pollution. The proposed methodology has illustrated the ability of keratin feathers (before and after modifications) as effective adsorbents to sequester the transition and redox sensitive heavy metals from energy simulated wastewater. The characterization studies of keratin derived biopolymers provide an additional insight about surface functionality that also reflect the adsorption analysis. All of the developed biopolymers have shown better metal adsorption capabilities owing to their larger accessibility of functional groups present on surface. On an optimistic approach, keratin derived polymers open diverse possibilities in detoxifying pollutants from energy related wastewaters and also make them potential candidate for the scale-up treatment of multi-metal contaminated industrial wastewaters. The utilization of these keratin biopolymers provide multiple benefits, including economical and eco-friendly filtration system for wastewater treatment and diversion of feather waste generated by poultry processing plants leading to social, economic and environmental benefits.



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BROILER GROWTH AND EFFICIENCY IN RESPONSE TO RELAXED MATERNAL FEED RESTRICTION

N.M. Zukiwsky, M. Afrouziyeh, F.E. Robinson, M.J. Zuidhof

KEYWORDS: precision livestock farming, intergenerational, maternal body weight, maternal age, offspring performance

ABOUT

In combination with recent genetic change, some precision-fed broiler breeders with an optimum body weight (BW) above the current recommended standard might not be receiving a sufficient amount of nutrients to support high rates of egg production. Thus, there may be a need to increase nutrient intake for precision-fed broiler breeders. It is known that maternal nutrition, BW, and age can influence offspring growth. Therefore, the main objective of this study was to evaluate offspring growth performance in response to relaxed maternal feed restriction, implemented through various maternal BW trajectories. A second objective was to investigate the effects of maternal age and broiler sex on offspring growth performance.

APPROACH

Ten BW trajectories were applied to precision-fed Ross 708 female broiler breeders ($n = 30$) from 2 to 42 wk of age. Trajectories varied in prepubertal and pubertal growth phases from 2.5 to 22.5% above the recommended BW target. Additional unrestricted breeders ($n = 6$) were not limited to a maximum BW (fed ad libitum). Two 35 d experiments were conducted with precision-fed broilers from these breeders at 35 and 42 wk of age. Broiler chicks from 35 wk old ($n = 105$) and 42 wk old ($n = 112$) breeders were feather-sexed and randomly assigned to 1 of 4 environmental chambers that contained 3 PF stations and ad libitum access to water. Two analyses (full and restricted analysis scopes) were performed to evaluate broiler BW, feed conversion ratio (FCR) and carcass traits with maternal BW at photostimulation (22 wk of age) as a continuous effect, and maternal age and sex as discrete effects. The full scope included broilers from all hens (feed restricted and unrestricted). The restricted scope excluded broilers from unrestricted hens.

ANALYSIS OF RESULTS

For every kilogram increase in maternal weight, cumulative FCR increased by 0.235 and 0.471 g:g for broilers from all and feed restricted hens, respectively. Proportional gut weight of broilers from feed restricted hens decreased by 0.8244% per kilogram increase in maternal BW. Males were heavier than females on day 28 and 35, and broilers from 42-wk-old breeders were heavier than broilers from 35-wk-old breeders on day 0 and 35. Males from all hens were more feed efficient (1.318 g:g) than females (1.335 g:g) from day 29 to 35. Females from all and feed restricted hens had a greater proportional fat pad and breast muscle weight than males, and proportional breast muscle yield of broilers from 42-wk-old breeders was on average 1.04 times greater than that of broilers from 35-wk-old breeders. Maternal BW did not affect offspring BW, reduced cumulative FCR, and reduced gut weight in the restricted analysis scope.

APPLICATION

Increased maternal BW up to 22.5% above the recommended BW and unrestricted growth had little impact on broiler growth performance. This suggests that increasing female broiler breeder BW targets to lower the severity of feed restriction would reduce gut weight and increase feed efficiency in broiler offspring.

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ILEAL DIGESTIBILITY OF ENERGY AND AMINO ACIDS IN THREE FABIA BEAN CULTIVARS (*VICIA FABIA* L.) PLANTED AND HARVESTED EARLY OR LATE IN BROILER CHICKENS

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KEYWORDS: broiler chicken, fabia bean cultivar, frost damage, ileal digestibility, immature beans

ABOUT

Locally grown fabia bean represent an opportunity to poultry producers in temperate regions to reduce feed cost by replacing higher priced ingredients like imported corn grain and soybean meal. Sub-optimal growing conditions can also result in a high percentage of immature beans at harvest time. Little is known about the effect of feeding frost damaged and immature beans on digestibility of gross energy (GE), crude protein (CP), and amino acids (AA) for broiler chickens, yet pulse growers phase this harvest challenge almost every year. Therefore, the objective of this study was to compare the effect of feeding diets including different fabia bean cultivars planted and harvested either EARLY (mostly ripen grain, no frost damage) or LATE (high proportion of immature beans, blackened hulls) on digestibility of GE, CP, and AA in broiler chickens.

APPROACH

To investigate, half of the seed of 2 zero-tannin cultivars (Snowbird and Snowdrop) and 1 low vicine and convicine cultivar (Fabelle) were planted at a single site either in early May and harvested in late September (EARLY) or planted in late May and harvested in late October (LATE). Diets of the 3 EARLY or LATE cultivars (95% inclusion) were fed to 756 broiler chickens (Ross 708) from d 15. Chickens were housed in 56 floor pens (13–14 birds/pen) in a 3 by 2 factorial arrangement (7 pens/diet). A nitrogen-free diet to correct for endogenous amino acid (AA) losses was fed to broilers in 14 pens from d 20. Ileal digesta was collected after euthanizing birds on day 23 or 24.

ANALYSIS OF RESULTS

Planting and harvesting LATE vs. EARLY increased the proportion of immature beans from 5 to 64% for Snowbird, 7 to 79% for Snowdrop, and 22 to 80% for Fabelle. Planting and harvesting LATE vs. EARLY increased the proportion of frost-damaged beans from 20 to 83% for Snowbird, 36 to 88% for Snowdrop, and 5 to 29% for Fabelle. Planting and harvesting LATE vs. EARLY increased ($P < 0.001$) apparent ileal digestibility (AID) of gross energy (GE) by 45% and standardized ileal digestibility (SID) of CP by 13%. Planting and harvesting LATE vs. EARLY increased ($P < 0.001$) SID of AA by 11% except Cys. Snowbird and Snowdrop had greater ($P < 0.05$) SID of AA by 4.5% except Thr and Trp compared with Fabelle. Fabelle had 13% greater ($P < 0.001$) SID of Trp compared with Snowbird or Snowdrop. Results indicate that planting and harvesting LATE vs. EARLY increased GE, CP, and AA digestibility possibly by frost interrupting bean ripening on the field. Hull tannin content may have reduced the AA digestibility of Fabelle compared with Snowbird or Snowdrop.

APPLICATION

Compared with planting and harvesting fabia beans at the recommended time for the region (early May), delaying planting and harvesting by 2 to 3 wk resulted in beans with greater proportions of frost-damaged (blackened) hull and immature grain (green and soft) cotyledons. Late planted and harvested fabia bean had both lower condensed tannin and vicine and convicine content than early planted and harvested fabia bean. Contrary to that expected, the results of this digestibility trial indicate that LATE vs. EARLY planting and harvesting fabia bean increased GE, CP, and AA digestibility possibly by frost interrupting bean ripening on the field. Tannin content may have reduced the AA digestibility of Fabelle compared with Snowbird or Snowdrop fabia bean cultivars.



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IMPROVING A NONLINEAR GOMPERTZ GROWTH MODEL USING BIRD-SPECIFIC RANDOM COEFFICIENTS IN TWO HERITAGE CHICKEN LINES

M. Afrouzیه, R.P. Kwakkel, M.J. Zuidhof

KEYWORDS: Gompertz, growth model, heritage, multiple random coefficient, nonlinear mixed model

ABOUT

Growth models describe body weight (BW) changes over time, allowing information from longitudinal measurements to be combined into a few parameters with biological interpretation. Nonlinear mixed models (NLMM) allow for the inclusion of random factors. Random factors can account for a relatively large subset of the total variance explained by bird-specific measurement correlation. The objectives of the current study were 1) to evaluate different nonlinear mixed models with and without inclusion of random coefficients to account for knowable individual sources of variation using birds from 2 heritage chicken lines: New Hampshire (NH) and Brown Leghorn (BL); 2) to obtain estimated values for random coefficients of growth parameters including growth rate and mature BW; 3) to investigate the effect of minor feed restriction on production efficiency.

APPROACH

A total of 32 birds (16 mixed sex birds from each strain) were raised to 17 wk of age. After 12 wk, half were continued on ad libitum (AL) feed intake, and half were pair-fed, using a precision feeding system; they were given 95% of the AL intake of a paired bird closest in BW. Residual feed intake (RFI) of birds, as an indicator of production efficiency, was increased in pair-fed BL birds as a result of minor feed restriction. Growth data of the birds were fit to a mixed Gompertz model with a variety of different bird-specific random coefficients. The model had the form: $BW = W_m \times \exp(-\exp(-b(t - t_{inf}))$; where W_m was the mature BW, b was the rate of maturing, t was age (d), t_{inf} was the inflection point (d). This fixed-effects model was compared with NLMM using model evaluation criteria to evaluate relative model suitability. Random coefficients, $W_{mu} \sim N(0, W_m)$ and $b_u \sim N(0, b)$, were tested separately and together and their differences, for strains, sex, and feeding treatments, were reported as different where $P \leq 0.05$.

ANALYSIS OF RESULTS

Inclusion of random effects accounted for bird-specific variation in W_m and b resulted in reduced bias (systemic error) in prediction of individual BW through increasing the homogeneity of residual variation. Residual feed intake (RFI) of birds, as an indicator of production efficiency, was increased in pair-fed Brown Leghorn birds (BL) as a result of minor feed restriction. The RFI was decreased with age for all groups, that is, the birds became more efficient as age advanced. Growth data of the birds were fit to a mixed Gompertz model with a variety of different bird-specific random coefficients. The model with both random coefficients was determined to be the most parsimonious model, based on an assessment of serial correlation of the residuals. NLMM coefficients allow stochastic prediction of the mean age and its variation that birds need to achieve a certain BW, allowing for unique new decision support modeling applications; these could be used in stochastic modeling to evaluate the economic impact of management decisions.

APPLICATION

In this study, a nonlinear mixed-effects growth model was developed for growth data of NH and BL birds. The growth model with 2 random parameters for W_m and b was found to be the most parsimonious model based on fit statistics, and further analysis showed that it reduced autocorrelation bias in longitudinal growth data. The mixed-effects model provided an estimation of random coefficients for growth parameters of different subsets of the population. Mature BW (W_m) and rate of maturing (b) could be used in genetic selection programs. These random coefficients could be used as a tool in different scenarios of poultry production system such as stochastic prediction of BW of individuals at any age to better match nutrient supply to nutrient requirements, and to predict and evaluate the economic impact of management decisions on designing target growth curves, breeding programs, and nutritional management decisions.



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INTERGENERATIONAL EFFECTS OF MATERNAL GROWTH STRATEGIES IN BROILER BREEDERS

M. Afrouziyeh, N.M. Zukiwsky, M.J. Zuidhof

KEYWORDS: broiler breeder, carcass, feed restriction, intergenerational, multi-phasic growth

ABOUT

Controlling body weight in broiler breeder farms is achieved through feed restriction. The degree of feed restriction depends on the target growth curve. It is valuable to investigate the intergenerational impact of lesser growth restriction and earlier pubertal growth. Most of the research pertaining to consequences of maternal effects in chickens have focused on nutrient composition of the diet; however, there is little data on effects of alterations of the maternal prepubertal BW gain (MW) and pubertal inflection (MI) on progeny performance in the literature. The objective of the current study was to investigate the effect of a reduced degree of maternal prepubertal phase growth restriction and earlier maternal pubertal phase growth on offspring growth and development.

APPROACH

In a randomized controlled trial, a total of 40 female broiler breeders were randomly assigned to 10 unique growth trajectories with 2 levels of maternal BW gain (MW) in prepubertal phase and 5 levels of maternal pubertal growth inflection (MI) for each level of the MW. Growth parameters (MW and MI) were estimated by fitting a 3-phase Gompertz model to the breeder-recommended BW target (Standard MW; SMW), or 10% higher (HMW). Maternal pubertal inflection was advanced by 0, 5, 10, 15, or 20% in both SMW and HMW groups. Maternal growth trajectories were implemented from 0 to 42 wk of age using a precision feeding (PF) system. The current study consisted of two cohorts that varied in maternal age (MA) of 35 and 42 wk. The broiler chicks were fed to 35 d of age, also with the PF system. Analysis of covariance was conducted on all dependent variables (body weight, feed conversion ratio, carcass traits) with maternal age (MA), MW, and offspring sex as categorical variables and MI as a continuous predictor variable.

ANALYSIS OF RESULTS

Chicks from 42 wk old hens had higher 0 (hatch), 14, 21, and 28 d BW, liver, and heart weight, and lower FCR from 7 to 35 d of age than those from the 35 wk old hens. Compared to SMW hens, HMW hens produced female offspring with lower FCR, and male offspring with heavier gut weight. Advancing MI increased hatch BW in both sexes and 35 d BW in male broilers. For every week that the MI was advanced, hatch BW increased by 0.26 g in females and 0.39 g in males; however, 21 and 35 d BW decreased by 6.85 and 17.29 g/wk in females and increased by 10.53 and 25.94 g/wk in males, respectively. Overall, a lesser degree of growth restriction during prepubertal and earlier pubertal growth increased male offspring growth.

APPLICATION

To investigate the effects of maternal growth patterns downstream in the broiler supply chain, the current experiment focused on relaxed maternal growth restriction during the prepubertal growth phase and earlier pubertal growth in breeders on their offspring growth and carcass traits. To our knowledge, this is the first investigation of the maternal effects of strategically designed growth trajectories based on advancing the timing of the pubertal growth phase in breeders. Overall, the current results indicate that increasing maternal prepubertal phase BW gain by 10% and advancing maternal pubertal phase inflection from 22 to 18 wk of age can increase male broiler growth rate and some carcass components weight in offspring chicks.



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TIMING OF GROWTH AFFECTED BROILER BREEDER FEEDING MOTIVATION AND REPRODUCTIVE TRAITS

M. Afrouzیه, N.M. Zukiwsky, M.J. Zuidhof

KEYWORDS: broiler breeder, feed restriction, Gompertz model, hunger

ABOUT

Broiler breeders are subjected to feed restriction programs to control excessive growth. Over the years, the gap between growth potential of broilers and broiler breeder target BW is increasing, which has resulted in increased feed restriction intensity. Leading up to the onset of lay, breeders should have adequate fleshing (body condition) with optimum levels of protein mass and fat tissue available. The objective of the current study is to evaluate the effect of increased BW gain during prepubertal growth phase and earlier pubertal growth phase on hunger, reproductive performance, body frame size, and body fat in broiler breeder pullets and hens.

APPROACH

To investigate the effect of growth pattern on feeding motivation and reproductive performance, 10 unique growth trajectories were designed with 2 levels of the amount of early growth and 5 levels of timing of growth around puberty. A 3-phase Gompertz model that described growth in phase 1 (prepubertal), phase 2 (pubertal), and phase 3 (postpubertal) was used to design the growth trajectories. Second growth phase inflection point (I2) was advanced by 0, 5, 10, 15, or 20% of the coefficient estimated from the recommended breeder target BW. The growth trajectories were designed with 2 discrete levels of total gain in the prepubertal phase (g1); g1 was either the prepubertal phase gain coefficient, estimated from the breeder-recommended BW (Standard g1) target, or 10% higher (High g1). Forty female Ross 708 broiler breeder pullets were randomly assigned to the growth trajectories using a precision feeding (PF) system. Analysis of covariance was conducted on dependent variables in ten 4-wk periods with g1 and periods as discrete fixed effects, I2 as a continuous fixed effect, and age as a random effect. Differences were reported at $P \leq 0.05$.

ANALYSIS OF RESULTS

For every week of earlier I2 (second growth phase inflection point), body weight at photostimulation (BWPS) increased by 126 g; BW at first egg (BWFE) increased by 94 g; 24 wk shank length increased by 0.038 and 1.495 mm in the Standard g1 (prepubertal phase gain coefficient, estimated from the breeder-recommended BW) and High g1 (10% higher) treatments; 24 wk body fat increased by 0.38%; pullets came to lay earlier by 0.49 d; egg weight (EW) increased by 0.27 g; egg production and egg mass (EM) increased by 0.33 egg/hen/d and 0.916 g/d in the High g1 treatment but decreased by 0.27 egg/hen/d and 0.29 g/d in the Standard g1 treatment, respectively. Increasing g1 reduced feeding motivation index by 1.6 and 0.8 visits/meal during rearing and laying phase, respectively. Earlier pubertal growth showed prominent effects on the reproductive performance.

APPLICATION

The results of the current study indicated that the strategy of earlier pubertal growth could reduce hunger in broiler breeders during rearing and laying phase. Furthermore, it allowed female broiler breeders to achieve a sufficient foundation and appropriate fat level, which advanced sexual maturation. Relaxed feed restriction during prepubertal phase and earlier pubertal growth showed prominent effects on egg production, egg mass, and egg weight as proxies for reproductive output.

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THE USE OF DISINFECTANT IN BARN CLEANING ALTERS MICROBIAL COMPOSITION AND INCREASES CARRIAGE OF CAMPYLOBACTER JEJUNI IN BROILER CHICKENS

Y. Fan, A.J. Forgie, T. Ju, C. Marcolla, T. Inglis, L.M. McMullen, B.P. Willing, D.R. Korver

KEYWORDS: broiler chicken, barn disinfection, gut microbiota, pathogen

ABOUT

To maintain food safety and flock health in broiler chicken production, biosecurity approaches to keep chicken barns free of pathogens are important. Canadian broiler chicken producers must deep clean their barns with chemical disinfectants at least once annually (full disinfection; FD) and may wash with water (water-wash; WW) throughout the year. However, many producers use FD after each flock, assuming a greater efficacy of more stringent cleaning protocols, although little information is known regarding how these two cleaning practices affect pathogen population and gut microbiota. The objective of this study was to evaluate the effects of barn cleaning method on the commercial broiler intestinal microbiota, occurrence of select pathogens and abundance as well as short-chain fatty acids (SCFA) profile in 30-day-old broiler ceca.

APPROACH

Two cleaning methods were evaluated for full disinfection (FD), chicken manure, used litter, and organic matter were completely removed from the chicken house after depopulation followed by a two-step disinfection. For water wash (WW), manure and used litter were removed, followed by low-pressure water rinse with the water temperature set at 35°C of the facility surfaces, air dried, and placement of fresh wood shavings. The current study was performed on 28 production flocks, and the FD and WW treatments were each applied on 14 production flocks. For each flock, 14,000 Ross 308 broiler chicks were placed at 1 day of age and confined to half of the house, then allowed access to the entire house at 7 days of age. All chickens were fed ad libitum and reared from 1 day of age through processing at about 32-35 days of age. At day 30, five birds from each flock were selected for sampling and cecal contents were collected for detection of cecal *Campylobacter* and *Salmonella* by enrichment and DNA extraction.

ANALYSIS OF RESULTS

Chicken 32-day body weight and mortality were not affected by the cleaning methods. No difference in 30-day mortality was observed between the two barn cleaning treatments suggesting that the cleaning method had a minimal impact on the flock performance. FD resulted in increased *Campylobacter* occurrence in the 30-day-old chicken ceca. Therefore, the WW rearing environment reduced the occurrence of *Campylobacter* colonization in the 30-day-old chicken ceca. The barn cleaning method did not affect the total bacterial load in the chicken ceca.

APPLICATION

The results revealed that barn cleaning methods had little impact on the 30-day body weight and mortality rate of broiler chickens. In addition, the FD treatment had a subtle but significant effect on the broiler cecal microbiota with increased abundances of *C. jejuni* and decreased SCFA concentrations, which would support the adoption of WW as a standard practice. Thus, compared to FD, WW can be beneficial to broiler chicken production by inhibiting zoonotic pathogen colonization in the chicken gut with reduced cost and labor of cleaning. Further studies examining other barn disinfection practices and testing for other pathogens are warranted to identify the best practices to minimize pathogen load and maintain animal performance



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PURIFICATION AND IDENTIFICATION OF NOVEL ACE INHIBITORY AND ACE2 UPREGULATING PEPTIDES FROM SPENT HEN MUSCLE PROTEINS

H. Fan, J. Wu

KEYWORDS: spent hen, muscle proteins, purification, identification, bioactive peptides

ABOUT

Hypertension, afflicting more than 20% of adults worldwide, is a major risk factor for cardiovascular diseases. Spent hens, a major egg industry byproduct, can be used as the starting material for preparing antihypertensive peptides. Therefore, the objectives of this study were to identify both ACE inhibitory (ACEi) peptides and ACE2 upregulating (ACE2u) peptides in spent hens (SPH-T) and to determine gastrointestinal stability of these peptides. In addition, structure-activity relationships and molecular interactions between ACE and ACEi peptides were also explored.

APPROACH

Spent hen carcasses were purchased from a local supermarket. Spent hen muscle proteins were extracted according to a pH-shift method with slight modifications. The protein extract (~93% protein) was dissolved in ddH₂O (5%, w/w), pre-heated at 90 °C for 10 min for protein denaturation, prior to a 3 h of hydrolysis by thermoase PC10F (4% enzyme/substrate, E/S, w/w protein in a jacket beaker, connected with a Titrande (Metrohm, Herisan, Switzerland) and a circulating water bath (Brinkman, Mississauga, ON, Canada) for pH and temperature control, respectively. After the hydrolysis, the slurry was heated at 95 °C for 10 min to inactivate the enzyme. After centrifuged at 10,000 g for 15 min (4 °C), the supernatant was collected, freeze-dried, and kept at -20 °C for further analysis.

ANALYSIS OF RESULTS

Our recent study indicated that SPH-T had both high ACEi and ACE2u activities. Five potent ACEi peptides and four ACE2u peptides were identified from SPH-T using the conventional activity-guided fractionation method. The structural requirements of the identified ACEi peptides corresponded well with the structure-activity relationship reported in literature; the molecular docking study confirmed that these peptides formed H-bonds with ACE. A lack of sufficient number of ACE2u peptides makes it impossible to draw any structure-activity relationship, which relies heavily on a continuous discovery of new peptides.

APPLICATION

Our study supports the potential use of spent hens as antihypertensive functional food ingredients and nutraceuticals. However, the in vivo efficacy of the identified ACEi and ACE2u peptides are yet to be determined in order to confirm their antihypertensive effect. Biotransformation of spent hens into high-valued health-beneficial compounds will contribute to a more sustainably growing egg industry, which also shed light on valorization of other under-utilized protein-rich agricultural byproducts.



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AMYLASE ENHANCES PRODUCTION OF LOW MOLECULAR WEIGHT COLLAGEN PEPTIDES FROM THE SKIN OF SPENT HEN, BOVINE, PORCINE, AND TILAPIA

H. Hong, H. Fan, B.C. Roy, J. Wu

KEYWORDS: amylase, porcine, bovine, spent hen, tilapia, collagen, low molecular weight peptides

ABOUT

Low molecular weight (LMW) collagen peptides show skin and bone health benefits for human. However, the production of LMW collagen peptides from land vertebrate sources remains challenging due to the presence of advanced glycation end products (AGEs) cross-links. The objective of this study was to investigate the effect of alpha-amylase pre-treatment on proteolytic production of LMW collagen peptides by papain using spent hen, bovine, porcine, and tilapia skin collagens (HSC, BSC, PSC, and TSC, respectively).

APPROACH

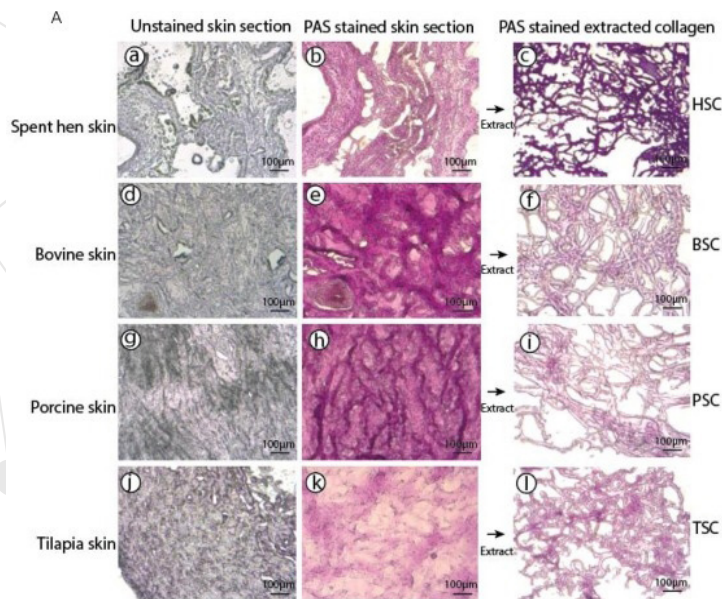
Frozen spent hen (about 17 months) (n = 10), fresh tilapia skin (about 6 months old), porcine skin (about 6 months old) fresh bovine hides were obtained and taken to laboratory where histological analysis of skin was carried out. The standard AOAC methods were used to determine the proximate composition (including carbohydrate content) of the skin collagen samples. Total nitrogen, protein, fat, ash and moisture content were also measured. Skin samples were sliced and grounded. Fifty grams of skin sample were then incubated with alpha-amylase (2% enzyme/substrate [E/S], w/w protein basis) in 500 mL 50 mM sodium phosphate buffer (pH 5.4) at 20 °C for 6 h under continual stirring for extraction of collagen. After alpha-amylase pre-treatment, the skin collagens were further hydrolyzed by papain to produce LMW peptides.

ANALYSIS OF RESULTS

There were significant differences of glycoprotein (collagen) morphology among HSC, BSC, PSC, and TSC. The carbohydrate content of HSC, BSC, PSC, and TSC and was found to be $18.88 \pm 0.66\%$, $4.48 \pm 2.73\%$, $3.55 \pm 2.00\%$, and $2.69 \pm 0.48\%$, respectively. HSC showed comparatively lower MW polypeptides than BSC, PSC, and TSC. This might be due to the breakdown of collagen polypeptides during the extraction process of HSC. Glycopeptides were only observed in HSC and HP (horseradish peroxidase, positive control). Glycopeptides noticed in HSC were less than 10 kDa. However, no glycopeptides were observed in amylase pretreated HSC (HSC-Amylase-Papain). This indicates that amylase cleaved the AGE cross-links of collagen molecules, suggesting its efficiency in producing low MW peptides by papain hydrolysis. Glycopeptides were not detected in BSC, PSC, and TSC. In the current investigation, alpha-amylase pre-treatment considerably enhanced the production of LMW peptides (<2 kDa) from HSC, BSC, PSC, and TSC. Compared to those without alpha-amylase pre-treatment, alpha-amylase enhanced the production of LMW peptides (<2 kDa) by papain from HSC (from 33.79 to 67.66%), PSC (86.03–90.85%), BSC (6.60–28.78%), and TSC (89.92–90.27%).

APPLICATION

The current study, for the first time, reported the production of LMW peptides from skins of spent hen, bovine, porcine, and tilapia by employing alpha-amylase pre-treatment before papain hydrolysis. The results indicated that pre-treatment with alpha-amylase significantly enhanced the production of LMW peptides from spent hen, bovine, porcine, and tilapia skin collagens. It is suggested that alpha-amylase cleaved the glycosidic bonds of AGEs cross-links and thereby enhanced the production of LMW collagen peptides. The LMW peptides obtained in this study could be developed as functional ingredients in food and pharmaceutical products. Prior to that, however, bioactivities of these LMW peptides are warranted to be investigated in animal models.



Glycoprotein visualized by Schiff reagents of spent hen, bovine, porcine, and tilapia skins. Hong et al., Food Chemistry 352 (2021)

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EGG WHITE OVOMUCIN HYDROLYSATE INHIBITS INTESTINAL INTEGRITY DAMAGE IN LPS-TREATED CACO-2 CELLS

X. Bao, J. Wu

KEYWORDS: ovomucin hydrolysate, inflammation, tight junction, MAPK

ABOUT

Disruption of the intestinal barrier is closely associated with intestinal inflammation and disease development. Ovomucin is a bioactive protein in chicken egg white, and its hydrolysate has been revealed to prevent the adhesion of pathogen to intestinal epithelial cells. However, the effect of ovomucin hydrolysate on intestinal barrier integrity and associated anti-inflammation mechanism has not been demonstrated. The objectives of this study were to investigate the beneficial effects of ovomucin-protex 26L hydrolysate on intestinal barrier integrity and its anti-inflammatory activity in differentiated Caco-2 cells challenged with LPS (Lipopolysaccharide).

APPROACH

Fresh eggs from White Leghorns were collected and fresh egg white was mixed with 3 times volume of Milli-Q water, and stirred constantly for 2 h before the pH was adjusted to 5.0. Then the slurry was placed at 4°C for 24 h, followed by centrifugation at 15,344g for 10 min at 4°C and lyophilization. The ovomucin hydrolysate was prepared by the enzyme Protex 26L (*Aspergillus niger* origin, Genencor Division of Danisco) for 4 h at 50°C and pH 3.0 in a 1% (ovomucin/Milli-Q water, w/v) slurry. The enzyme was added at the ratio of 2% (enzyme/substrate, w/w). The process was conducted using a Titrande (842, Metrohm, Switzerland). The suspension was heated in a water bath at 95°C for 15 min, and was centrifuged at 15,344g for 20 min at 4°C after cooled down to room temperature on ice. Finally, the supernatant was obtained, lyophilized, and stored at -20°C for future use. Caco-2 cells were cultured in DMEM with 10% FBS, 1% NEAA, and 1% penicillin – streptomycin solution in a humidified incubator under 5% CO₂ atmosphere at 37°C. Ovomucin hydrolysate was diluted in medium to the final concentration of 0.1, 0.5, and 1.0 mg/mL and incubated with differentiated Caco-2 cells for 24 h. Then samples were collected for different analysis.

ANALYSIS OF RESULTS

Ovomucin-protex 26L hydrolysate inhibited endotoxic activity of LPS in a concentration-dependent manner. Ovomucin-protex 26L hydrolysate significantly increased transepithelial electronic resistance (TEER) values, decreased the paracellular FITC-dextran flux permeability, and recovered the expression of occludin and ZO-1 in LPS-stimulated Caco-2 cells. Meanwhile, ovomucin-protex 26L hydrolysate significantly inhibited the LPS-induced activation of NF-κB and MAPK pathways.

APPLICATION

In conclusion, this study revealed that ovomucin-protex 26L hydrolysate showed LPS-neutralizing activity and reduced the TJ (tight junction) permeability, and that it mitigated inflammatory response induced by LPS likely via inhibiting the activation of the NF-κB and MAPK signaling pathways in Caco-2 cells. These data indicate the possible application of ovomucin hydrolysate as an intervention strategy to prevent inflammation in pathogenic infection. Further experiments in animal models of pathogenic infection are necessary to advance our understanding of the activities of ovomucin hydrolysates and support the potential application.

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SPENT HEN MUSCLE PROTEIN-DERIVED RAS REGULATING PEPTIDES SHOW ANTIOXIDANT ACTIVITY IN VASCULAR CELLS

H. Fan, K.S. Bhullar, J. Wu

KEYWORDS: chicken, laying hen, muscle protein, ACE, ACE2, oxidative stress, antioxidant peptides

ABOUT

Spent hens are egg-laying hens reaching the end of their egg-laying cycles, being a major byproduct of the egg industry. Recent studies have been focusing on finding new value-added uses for spent hens. We have previously identified four bioactive peptides from spent hen muscle proteins, including three angiotensin-converting enzyme (ACE) inhibitory (ACEi) peptides (VRP, LKY, and VRY), and one ACE2 upregulating (ACE2u) peptide (VHPKESF (V-F)). The current study aims to explore the antioxidant effects of these bioactive peptides from spent hen muscle proteins, as well as the underlying mechanisms underlying their antioxidant actions.

APPROACH

Peptides, including VRP, LKY, VRY, and V-F (purity > 98%) were synthesized by Genscript Corp (Piscataway, NJ, USA). Triton-X-100, dithiothreitol (DTT), and Ang II were obtained from Sigma (St Louis, MO, USA). The cytotoxicity of peptides against VSMCs and ECs followed an alamarBlue assay. After reaching 80% of confluency on a 96-well plate, cells were treated with 100 μ M of peptides for 24 h in growth media, after which the media were replaced with 200 μ L of 10% alamarBlue solution (in growth medium, v/v) for 4 h avoiding light. Then, 150 μ L of the solution was transferred into an opaque 96-well plate for fluorescence signal detection, with an emission wavelength at 590 nm and excitation wavelength at 560 nm. A control without any treatment was added. Both cells were grown in DMEM containing 10% FBS and 1% penicillin-streptomycin at 37 °C in with 5% CO₂ and 100% humidity; ECs were supplemented with NEAAs (1%). The growth media were changed every three days for both cells. Superoxide detection, lipid peroxidation assay, and western blotting were performed.

ANALYSIS OF RESULTS

In the current study, we further assessed their antioxidant and cytoprotective activities in two vascular cell lines—vascular smooth muscle A7r5 cells (VSMCs) and endothelial EA.hy926 cells (ECs)—upon stimulation by tumor necrosis factor alpha (TNF α) and angiotensin (Ang) II, respectively. The results from our study revealed that all four peptides attenuated oxidative stress in both cells. None of the investigated peptides altered the expression of TNF α receptors in ECs; however, VRY and V-F downregulated Ang II type 1 receptor (AT1R), while V-F upregulated the Mas receptor (MasR) in VSMCs. Further, we found that the antioxidant effects of VRP, LKY, and VRY were likely through acting as direct radical scavengers, while that of V-F was at least partially ascribed to increased endogenous antioxidant enzymes (GPx4 and SOD2) in both cells. Besides, as an ACE2u peptide, V-F exerted antioxidant effect in a MasR-dependent manner, indicating a possible involvement of the upregulated ACE2-MasR axis underlying its antioxidant action.

APPLICATION

The antioxidant effects of four previously identified, spent hen-derived peptides, including three ACEi peptides (VRP, LKY, and VRY) and one ACE2u peptide (V-F), were studied in two vascular cells, ECs and VSMCs, in vitro. All the four peptides reduced oxidative stress in both ECs and VSMCs, initiated by TNF α or Ang II stimulation, respectively. None of these peptides altered the expression of TNF α receptors (TNF-R1 and TNF-R2) in ECs, while VRY and V-F downregulated AT1R and meanwhile V-F upregulated MasR in VSMCs. In addition, we found that V-F exerted its antioxidant effect partially dependent on MasR in VSMCs, which might involve upregulating ACE2 and counteracting the ROS produced from the binding of Ang II with AT1R. Further analysis on the expression of endogenous antioxidant enzymes demonstrated that only V-F upregulated GPx4 and SOD2. The antioxidant activities of VRP, LKY, VRY, and V-F in vascular cells indicated their multifunctional properties, in addition to their ACEi or ACE2u activity, which supports their potential use as functional food ingredients against hypertension.



HYPERTENSION

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USING AN ARTIFICIAL NEURAL NETWORK TO PREDICT THE PROBABILITY OF OVIPOSITION EVENTS OF PRECISION-FED BROILER BREEDER HENS

J. You, E. Lou, M. Afrouziyeh, N.M. Zukiwsky, M.J. Zuidhof

KEYWORDS: oviposition, probability, feature, neural network, artificial intelligence

ABOUT

Identifying daily oviposition events for individual broiler breeders is important for bird management. Identifying non-laying birds in a flock that might be caused by improper nutrition or diseases can guide diet changes or disease treatments for these individuals. The day and time of oviposition events of individual birds in a free-run flock can be hard to predict. Based on a precision feeding (PF) system that can record the feeding activity of individual birds, a recent study reported a machine learning model to predict daily egg-laying events of broiler breeders. The objective of the current study was to improve the previous approach in 2 aspects: 1) To apply the model on the current day; 2) To output more informative results. To accomplish this, an artificial neural network (ANN) model was built to predict the probability of oviposition events occurring.

APPROACH

In this study, data were obtained from a flock of broiler breeders (n = 95) raised in 2 environmentally controlled chambers. Each chamber was equipped with 2 PF stations. After photo-stimulation at 22 wk of age, the egg production of individual hens was recorded on a daily basis. If a hen laid an egg in 1 day, it was considered as an egg-laying event; if a hen did not lay an egg in 1 day, it was considered as a no-egg-laying event. A traditional trap nest box with 8 nesting sites was placed in each pen, and it was checked every hour from 07:30 to 17:30 every day. During the study, 706 egg-laying events occurred in the RFID nest box, while the remaining egg-laying events occurred in the trap nest box. The total number of no-egg-laying events was 3,559. Python 3.7.0 was used to facilitate data pre-processing, feature engineering, and model construction. The ANN model was evaluated by the receiver operating characteristic (ROC) curve and the area under the ROC curve (AUC).

ANALYSIS OF RESULTS

AUC was 0.9409, which meant a 94.09% chance to correctly distinguish an egg-laying event from a no-egg-laying event. The ANN model could predict oviposition events on the current day, and the output was a probability that could be informative to indicate the likelihood of an oviposition event for an individual breeder. In situations where total egg production was known for a group, the ANN model could predict the probability of daily oviposition events occurring of all individual birds and then rank them to choose those most likely to have laid an egg.

APPLICATION

The AUC value of the ANN model was 0.9409, indicating the ANN model had an outstanding classification performance. A possible application scenario of using the ANN model was to identify the breeders that have laid an egg in the pen. The ANN model could be used to predict oviposition events before the end of each day, and the prediction outputs were informative probabilities that indicated the likelihood of oviposition by individual hens within each day. In situations where the total egg production for a flock of breeders in one day was known, the probability of daily oviposition events occurring of all individual birds could be predicted and then ranked to choose those most likely to have laid an egg.

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IMPACT OF ADDING POLYSACCHARIDES ON THE STABILITY OF EGG YOLK/FISH OIL EMULSIONS UNDER ACCELERATED SHELF-LIFE CONDITIONS

S.Y.G. Toledo, J. Wu

KEYWORDS: egg yolk, gum guar, gum arabic, high-pressure homogenization, oxidation, EPA, DHA

ABOUT

Emulsions have great potential for use as the delivery systems of lipophilic bioactive compounds, mainly for applications in food and pharmaceutical products. The effectiveness of these delivery systems can be assessed by the degree of protection they offer to the encapsulated compounds, or core material, from environmental stresses, such as those encountered during food processing and later in the gastrointestinal tract. The objective of this study was to assess the effect of adding gum guar or gum arabic on the stability and cytotoxicity of egg yolk/fish oil emulsions. The performances of two processing conditions, simple and high-pressure homogenization, were also evaluated.

APPROACH

Eggs were collected and egg yolks were manually separated from the whites and rolled on Whatman no. 1 paper to eliminate the albumen residues. After puncturing the vitelline membrane, the egg yolk content was collected in a container placed in an ice bath and used to form the monolayer emulsions. Fish oil from Alaska Pollock (*Gadus chalcogrammus*) with a high content of eicosapentaenoic (EPA) and docosahexaenoic (DHA) fatty acids as triglycerides or ethyl esters was obtained. The moisture content of the freshly extracted egg yolk was determined using a convection oven set a 105–110 °C for 5 h. The 1% w/w polysaccharide solutions were prepared by stirring gum guar or gum arabic in cool Milli-Q water at 400 rpm until complete dissolution. Egg yolk/polysaccharide emulsions were produced using simple or high-pressure homogenization, stored for up to 10 days at 45 °C, and characterized for their particle size and distribution, viscosity, encapsulation efficiency, oxidative stability, and cytotoxicity.

ANALYSIS OF RESULTS

Emulsions containing gum guar and/or triglycerides had the highest viscosity. There was no significant difference in the encapsulation efficiency of emulsions regardless of the polysaccharide used. However, emulsions containing gum arabic displayed a bridging flocculation effect, resulting in less stability over time compared to those using gum guar. Emulsions produced using high-pressure homogenization displayed a narrower size distribution and higher stability. The formation of peroxides and propanal was lower in emulsions containing gum guar and was attributed to the surface oil. No significant toxicity toward Caco-2 cells was found from the emulsions over time. On the other hand, after 10 days of storage, nonencapsulated fish oil reduced the cell viability to about 80%. The results showed that gum guar can increase the particle stability of egg yolk/fish oil emulsions and decrease the oxidation rate of omega-3 fatty acids.

APPLICATION

In this study, egg yolk was used as the primary emulsifier of fish oil triglycerides or ethyl esters. Gum guar or gum arabic was further added to the primary emulsion to act as a secondary layer. Simple or combined simple/high-pressure homogenization were the two homogenization processes tested. The resulting emulsions were developed to protect highly sensitive lipophilic bioactive compounds, namely, EPA and DHA, from environmental stresses. The effectiveness of the emulsions was given by their stability and their ability to prevent oxidation/degradation of EPA and DHA over 10 days of storage at 45 °C. The encapsulation efficiency of an emulsion and its ability to prevent the core material release during processing and storage will impact its oxidative stability, which is of crucial importance in an oil-in-water emulsion system. Further studies are needed to evaluate the mechanisms with which these polysaccharides exert these beneficial properties.



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