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Scotland's Rural College

In-feed peracetic acid precursor nanoparticles improve reused litter exposed broilers performance

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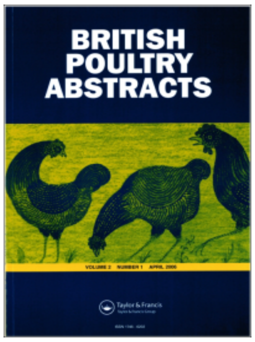

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2022 Abstracts

Oral communications and invited talks accepted for presentation at the WPSA UK Branch Meeting held on the 13th and 14th April 2022. These summaries have been edited for clarity and style by the WPSA UK Programme Committee but have not been fully peer-reviewed.

J. Edgar. What can mother hens teach us about welfare and sustainability in egg production?

S. Struthers, B. Andersson, M. Schmutz, H. A. Mccormack, P. W. Wilson, I. C. Dunn, V. Sandilands and J. J. Schoenebeck. What is the phenotypic variation and heritability of premaxillary and dentary bone shape in pure line White Leghorn laying hens?

S. Gilani, L. Marchal, A. Bello and Y. Dersjant-Li. Sustainable broiler productions without supplementation of inorganic phosphorus: a meta-analysis of four studies.

L Asher, K. A. Herborn, J. W. O'Sullivan, C Smith and H. E. Gray. Automating welfare assessment in poultry: What are the best options?

V. Sandilands, L. Baker, J. Donbavand and S. Brocklehurst. Do enrichments commonly provided to laying hens encourage appropriate behaviours?

V. Van Hoeck, G. Papadopoulos, A. Gonzalez Sanchez, A. Wealleans, F. Somers, D Morisset. New intrinsically thermostable xylanase improves performance, organ weights, and affects intestinal viscosity and pH of broilers.

H. Scott-Cook, C. Arthur, S. Rose, S. C. Mansbridge, R, Boffey, I. Kühn and V. Pirgozliev. The effects of *myo*-inositol and phytase supplementation on the tibia bone characteristics of 35 day old broiler chickens.

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M. Tuksa, I. Whiting, S. Mansbridge, A. Simic, P. Rose, M. Bedford and V. Pirgozliev. Does the rate of starch digestion predict the feeding value of wheat for broiler chicken?

L. Hinch, C. Arthur, S. Rose, S. C. Mansbridge, I. Kühn and V. Pirgozliev. The effect of dietary phytase and *myo*-inositol on the breast fillet meat quality of broilers chickens reared to 35 days of age.

A. Alkhtib, C. O. Sanni, E. Burton, and D. Scholey. Evaluating different bone processing methods used in assessing mineralisation in broilers.

S. Galgano, L. Conway, N. Dalby, A. Fellows and J. G. M. Houdijk. In-feed peracetic acid precursor nanoparticles improve reused litter exposed broilers performance.

A. Desbruslais, D. Gonzalez-Sanchez, M. Sonawanme, D. Morisset, and V. Van Hoeck. Chromium propionate improves performance and carcass traits in broilers.

J. G. M. Houdijk, M. Hussein, R. L. Walker and F. Khattak. Sensitivity of dry matter, ash and crude protein apparent ileal digestibility to starter feed form, grower and finisher inclusion of faba beans and stunning method in male broilers.

M. Tamiru, S. Edjigu, A. Alkhtib, E. Burton, S. Demeke, T. Tolemariam and G. P. J. Janssens. The effect of papaya seed and neem leaf meal on performance and health of laying hens.

A. Adebiyi. Processed animal protein as a feed ingredient for poultry – the feed industry's perspective.

C. Van Vuure. Processed animal protein as a feed ingredient for poultry – EU and renderers' perspectives.

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What can mother hens teach us about welfare and sustainability in egg production?

J. Edgar

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Maternal care has strong, beneficial effects on chick development. In a natural situation the mother hen directs chick behaviour and mediates their stress response. Despite the important of maternal care, it is not commercially viable to allow chicks to be reared by hens on farms and therefore almost all commercial chickens are reared without the benefits of maternal care. However, there is great underutilised potential to artificially simulate important features of maternal care. By motivating chick feeding, resting and reducing stress, these 'maternal simulations' have great potential to improve welfare, growth and feed conversion, and reduce behavioural problems and mortality. In this talk I will cover our background work on the importance of maternal care and outline studies aiming to artificially simulate maternal care in chickens.

What is the phenotypic variation and heritability of premaxillary and dentary bone shape in pure line White Leghorn laying hens?

S. Struthers[a,b], B. Andersson[c], M. Schmutz[c], H. A. McCormack[a], P. W. Wilson[a], I. C. Dunn[a], V. Sandilands[b] and J. J. Schoenebeck[a]

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Application

There is the potential to use the pre-existing variation in beak shape in laying hens to genetically select hens whose beak shapes are less apt to cause damage when engaging in severe feather pecking (SFP) behaviour.

Introduction

In laying hens, SFP is a commonly observed behaviour and results in pain and mortality. Beak treatment is used to reduce the damage inflicted by SFP; however, the use of alternative practices is increasing. Recently, it has been suggested that genetic selection for naturally shorter (blunter) beaks may help reduce SFP-related damage (Icken, Cavero, & Schmutz, 2017). However, to incorporate beak shape into selection indices, the range of phenotypes of both the external beak shape and the underlying bones must first be determined. The objectives of this work were to 1) determine the variation in premaxillary (within the top beak) and dentary (within the bottom beak) bone shape and 2) estimate the heritability of premaxillary bone shape and size in two populations of pure line White Leghorn laying hens.

Material and methods

This study approved by the Animal Welfare and Ethical Review Body at the Roslin Institute (University of Edinburgh). Two populations (Line A = 387; Line B = 432) of 40-week-old pure line White Leghorn laying hens were used in this study. Hens from both lines were housed in conventional cages in family groups. Lateral head radiographs were collected from the birds and the premaxillary and dentary bones in each radiograph were landmarked in ImageJ using 13 landmarks. The landmark coordinates were imported into R for geometric morphometric analyses using the package Geomorph. Procrustes superimposition was used to standardise all the landmarks in each radiograph by superimposing, re-scaling, and rotating them to a common orientation. The covariation of the transformed landmarks was analysed using principal components analysis and multivariate regression. The Procrustes superimposition also created an average bone shape by identifying the centre point (centroid) of all the landmarks in each radiograph. The centroid size was used as a proxy for relative bone size. Heritabilities and correlations between premaxillary bone principal components (PCs) and centroid size were estimated for each line using a bivariate model in ASReml.

Results

Three PCs explained 85% of the total premaxillary bone shape variation. Principal component 1 (PC1) described the curvature of the bone tip. The lines were partially separated by PC1 with Line B hens tending to have a more pronounced downwards curvature than Line A. PC2 described bone length and PC3 described a slight narrowing vs. widening of the caudal-most (towards the head) ventral margin (bottom edge) of the bone. Heritability estimates for PC1, PC2, PC3, and centroid size were 0.41, 0.54, 0.13, and 0.44 for Line A, respectively and 0.14, 0.22, 0.59 and 0.24 for Line B. For both lines, there were strong, positive genetic and environmental correlations between PC1 and centroid size. Both lines also had a moderate, negative environmental correlation between PC2 and centroid size. For the dentary bone, 2 PCs explained 81% of the total shape variation. PC1 described the bone length and width. Like the premaxillary bone, the lines were partially separated by PC1. PC2 described an upwards vs. downwards shift of the caudal end of the bone and a corresponding shift of the bone tip. Multivariate regression revealed that for both bones, the size of the bone was significantly associated with its shape ($P < 0.01$). There were also strong, positive relationships between the shapes of both bones (PC1 scores) and the sizes (centroid sizes).

Conclusion

The results of this study demonstrate significant phenotypic variation in the shape of both the premaxillary and dentary bone within two populations of pure line White Leghorn laying hens. Premaxillary bone shape heritability also varied between the two lines; however, there were similarities for the genetic and environmental correlations. Overall, the present study helps lay the foundation for investigating if the beak can be used as a tool to help mitigate damage caused by SFP.

Acknowledgments

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Reference

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Sustainable broiler productions without supplementation of inorganic phosphorus: a meta-analysis of four studies

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Application

Phosphorus reserves are limited but it is also an important nutrient for poultry health and welfare. This research focussed on inorganic phosphorus free diets (IPF) in broilers to save limited resources while keeping optimal growth and bone strength.

Introduction

Phytate is present in many ingredients and if phytate is degraded quickly and completely by phytase in the upper gastrointestinal tract, it can provide enough phosphorus for bones, growth and performance. Further it reduces the need of utilizing inorganic phosphorus in the diet, whose reserves are estimated to diminish before the end of this century. Phytase have been used since nineties, however, a recent phytase (novel consensus bacterial 6-phytase variant, PhyG) was tested to completely remove inorganic phosphorus supplementation from broilers' diets in all phases. Although this has positive environmental effect, it is important that birds have strong bones for bird's health and welfare as well as they grow optimally for maximizing profits. With this background four trials were conducted in The Netherlands (SFR), Spain (IRTA) and the USA (2 studies at TAMU (Marchal, Bello, Sobotik, Archer, & Dersjant-Li, 2020)) in broilers and the results of meta-analysis are shown here.

Material and methods

Ross 308 birds (n = 17,252 male/female or as hatched), 96 data points were utilized in this meta-analysis from four studies with 25–39 kg/m^2 density at finishing phase. In the meta-analysis all replicates were included to compare IPF+PhyG treatment with positive control (PC). Individual studies had 24–820 birds per pen with 8–10 replicates. Diets were mainly based on corn, wheat, soybean meal, rapeseed meal, sunflower meal, wheat bran, rice bran and oat hulls. Phytate-P level was > 0.33% in starter phase, > 0.31% in grower phase and > 0.26% in finisher phase. Xylanase enzyme (2000 Units/kg) was also included in the background in two studies (for both PC and IPF+PhyG treatments, where applied). Nutrient specs for PC were adequate with mono-calcium phosphate (MCP) as a phosphorus source. Other treatment did not include any MCP, but PhyG was added at 3000, 2000 and 1000 FTU/kg in starter, grower and finisher diet respectively. Body weight (BW), average daily feed intake (ADFI), average daily gain (ADG) and feed conversion ratio (FCR) (corrected for mortality or body weight separately) were measured for performance at day 35 (or day 37 in one study) and tibia ash content (DM basis) was measured for bone health at day 21. Data was analysed using one-way analysis of variance (ANOVA), with trial code as random effects (using JMP statistical program) and significance level was considered at $P < 0.05$.

Results

Meta-analyses of four studies showed that IPF+PhyG supplemented diets increased growth performance significantly and maintained tibia ash compared to PC. The final BW was significantly higher for IPF+PhyG (2.28 kg) compared to PC (2.23 kg). ADG was significantly higher (63.14 g/day) vs. PC (61.74 g/day). ADFI and mortality were not significantly different between groups. FCR was consistently reduced in treatment with IPF+PhyG ($P < 0.05$). BW corrected FCR was improved by 4 FCR points (1.451 for PhyG vs 1.491 for PC). Tibia ash for IPF+PhyG was comparable (50.5%) to PC (50.9%) ($P > 0.05$). These results indicate that birds can be raised without MCP with supplementation of a highly efficient phytase at proper dose levels with sufficient phytate P in each phase. MCP mining leads to approximately 570 g equivalent CO_2/kg. Considering European and global broiler feed production of ~ 55–335 million tons respectively, it can reduce the shipment of approximately 12,000–75,000 full load containers per year. Furthermore, based on above studies performance, it can potentially reduce 3% greenhouse gases emission per kg liveweight of broilers.

Conclusion

This meta-analysis of the four studies has demonstrated that broilers can be raised on diets without inorganic phosphorus or MCP when a highly efficient phytase is used. Results also show that birds fed without inorganic P, but supplemented with PhyG, improved bodyweight and reduced feed conversion ratio. This can help reduce greenhouse gases and reduce dependency on limited resources of inorganic phosphorus.

Acknowledgments

Thanks to Schothorst Feed Research (SFR), IRTA Animal Nutrition Centre Spain, and Texas A&M University (TAMU) for carrying out these studies.

Reference

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Automating welfare assessment in poultry: What are the best options?

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Application

Animal-based measures of welfare are an ethical requirement for poultry production systems, but current manual methods for welfare assessment are labour intensive, have potential to compromise biosecurity, and cover only a small proportion of a flock. Automated welfare assessment offers a solution to these issues and could also increase the transparency and authenticity of welfare assessment through the production chain.

Introduction

Over the past decade there has been a rapid increase in both commercial and academic research focused on automated poultry welfare assessment. Some of this research has focused on replacing existing methods with an automated like-for-like alternative, whereas other research has identified new welfare measures made possible using automated technology. There is also a stream of research (dominated by machine learning methods) which attempts to find signals of good or poor welfare in data, without specific *a priori* predictions about what those signals might be. Tuyttens (2021) highlighted some of the concerns with automated measures of welfare: that they could focus on the measurable not the meaningful; they may have poor performance or validation; and they could favour intensification over individualism.

Methods

Here I outline (provide a rough guide) the possibilities different automated measures of welfare offer. For a range of automated methods, I ask the questions: Is it measurable? Is it meaningful? Can it provide information about specific welfare problems? Can it provide information about overall welfare state? Does it measure welfare at an individual level? First, I consider monitoring poultry welfare using sound. Sound is easily measurable from a flock environment and in our own research we have found a single microphone is sufficient for monitoring chick distress calls in a large flock (Herborn et al., 2020). Specific poultry calls and the overall qualities of calls have both been linked with positive and negative welfare states. Sound analysis has also been developed to measure noises associated with certain behaviour, such as feeding. Vocalisations (and the absence of vocalisation) also show potential for detecting specific welfare problems including feather pecking and heat stress. However, further validation studies are required to ensure sound analysis is a valid welfare measure and sound analysis has limited potential to measure welfare at the individual level commercially. Second, I consider the use of imaging technologies and algorithms for processing images and videos of poultry for welfare benefit. Perhaps the best-known imaging method within poultry welfare is optical flow, which is one of a range of methods focused on movement or spacing of birds. Imaging methods focused on movement and spacing are useful for identifying specific welfare problems e.g. thermal discomfort, gait, smothering. Imaging can also include more detailed behaviour analysis, but unlike systems for larger animals, is unlikely to be able to track behaviour at an individual level over time. Image processing also has potential for measuring some physiological processes e.g. stress or feathering using thermal cameras. Historically, cameras have focused on overall flock views but could be placed nearer to hens to sample a number of birds at an individual level but would not be able to track changes in an individual over time. Finally, I consider wearable sensors which have primarily been considered as a research tool in poultry, rather than being feasible for commercial application due in part to the number of animals involved in poultry production systems. However, not all animals would need to be fitted with a wearable and there is commercial potential for longer term monitoring of sentinel individuals using wearables. Wearables have revealed much about the individual consistency and inter-individual differences in behaviour which would have been missed if studying poultry at a flock-level. Deviations from an individual's usually consistent pattern of behaviour could be a sensitive welfare measure from wearables. Wearables have potential therefore to monitor overall welfare and could help identify specific welfare problems associated with movement, or reduction in activity. Wearables are less practical for monitoring welfare than imaging or sound analysis.

Conclusion

Each of the three methods for automated welfare assessment (sound, imaging, wearables) has different advantages and disadvantages. With few exceptions, most methods still require further biologically-based validation studies. The true value in using automated collection of data is likely to arise from the quantity and longitudinal nature of data collected, compared to manual methods for scoring welfare. Longer-term monitoring allows for patterns and rhythms to be part of the welfare assessment. In the future, combinations of different automated welfare measures used in parallel is likely to provide the best chance of detecting a range of welfare problems.

Acknowledgments

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Do enrichments commonly provided to laying hens encourage appropriate behaviours?

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Application

Pecking enrichments are often provided to laying hens in loose-housed systems to encourage natural behaviour and to reduce/ prevent injurious pecking, however their utility is poorly understood. Are we providing the correct enrichments?

Introduction

Laying hens are motivated to show foraging behaviour as part of food-seeking, but if thwarted, can lead to injurious pecking (Schreiter et al., 2019). Loose-housed hens are typically given destructible enrichments to encourage appropriate pecking behaviour. However, of the common materials provided to hens for this purpose, it is unclear which are beneficial to them. This study observed the behaviour and feather cover of commercially-housed hens when given access to four different enrichments, to better understand if any of them were preferred by hens for appropriate behaviours.

Material and methods

Eight commercial free-range flocks (A-H) were recruited. Each housed 16,000 brown-strain hens with multi-tier structures. All sheds were split into four quarters. Per quarter, two commercially-endorsed enrichments (rope + another, four of each type) were provided. Other enrichment treatments were lucerne hay bales (B), pecking blocks (PB), scattered pelleted feed (PF, 4 kg/day) or more rope (R, control). Behaviour observations and feather scores (a proxy measure of feather pecking) were taken at ~34, 52, and 70 weeks of age, however due to COVID and AI, some data were missed, and feather scores were deemed unreliable so are not discussed further. Observations were relative to the scattering time of feed in the PF treatment (−1, 0, ≥ 1 h), and took place three times over 15 min in each quarter. Numbers of hens and their behaviours in 1-m areas around three locations (at the treatment enrichment ('Enrich'), at the control (ropes) enrichment ('ControlR'), and away from either enrichment ('Away')) were recorded. Data were analysed in Genstat 18 with fixed effects age, time, location, treatment (and their interactions), and random effects flock, shed quarter, location within shed quarter, plus interactions of these with temporal effects. We report analysis of total counts of birds in each location, and proportions of birds engaged in each behaviour, from GLMMs and LMMs.

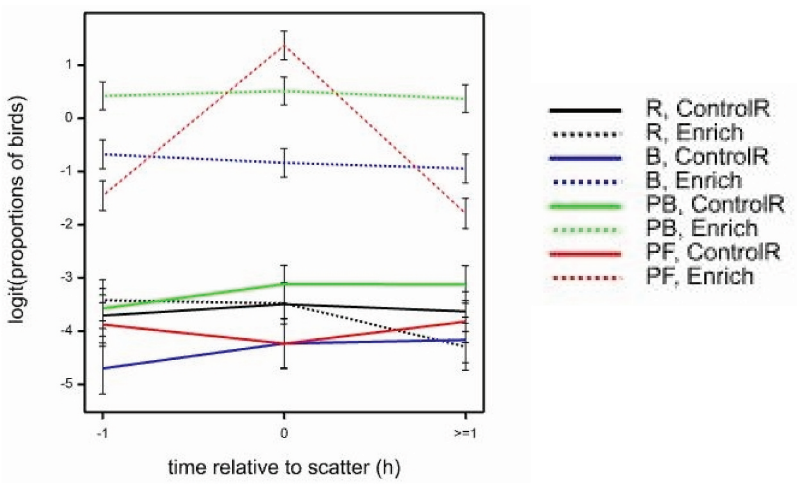

Figure 1. Mean ± SE logit(proportions of birds) observed interacting with enrichments over observation times according to enrichment and location, estimated from GLMM.

This work was approved by SRUC's ethical review committee (AU AE 36–2018).

Results

Fewest hens were seen in location ControlR and Away, and with enrichment R (X=6.8–8.7 hens), whereas up to twice the number of hens were seen in location Enrich with B, PB, and PF (X=10.8–17.2). Of the total birds observed, the mean proportion of birds interacting with enrichments in Enrich locations was higher for PF at scatter feeding time (0), then PB then B, and lowest for R (interaction time.location.treatment; $F_{6,621} = 8.44$ by GLMM, $P < 0.001$), however proportions were consistent across all three times with PB and B, whereas interaction with PF dropped at time −1 and ≥1 (Figure 1). Observations of birds in all treatments in the ControlR locations, plus R birds in the Enrich location, showed similarly low proportions of birds interacting with R, compared to B, PB and PF birds in Enrich locations.

Conclusion

Hens did not use ropes, but all other enrichments were used significantly more. This study investigated four commonly-used enrichments, but there may be other enrichments not studied here which hens would prefer. Ropes were much smaller in total volume than B or PB, so to be comparable they should be studied at a similar volume to these other enrichments.

Acknowledgments

This work was funded by Scottish Government and BFREPA. Thanks to commercial farms, and enrichment providers: J Wanstall & Sons (lucerne hay bales), ScotMin and Crystalyx (pecking blocks) and ForFarmers UK Ltd (layer pellets).

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Schreiter, R., Damme, K., Borell, E., Vogt, I., Klunker, M., & Freick, M. (2019). *Veterinary Medicine and Science*, *5*, 500–507.

New intrinsically thermostable xylanase improves performance, organ weights, and affects intestinal viscosity and pH of broilers

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Application

A newly developed xylanase has shown to positively impact the physicochemical properties of the intestinal tract. This suggests intestinal microbiome, gut health and nutrient digestion might be improved. Hence, the xylanase could become a key nutritional tool for the broiler industry, which is under increasing pressure to mitigate gut health disorders.

Introduction

Exogenous carbohydrases are commonly added to monogastric animal feed to degrade non-starch polysaccharides (NSP) for improving zootechnical performance and nutrient digestibility (Hahn-Didde & Purdum, 2014). In the current study, the effects of dietary supplementation of a new xylanase on intestinal parameters, growth and carcass traits of broilers were evaluated.

Material and methods

A total of 720 1-day-old broilers were randomly allotted to four wheat-based diets with different levels of xylanase (T1: control; T2: 30,000 U/g; T3: 45,000 U/g; T4: 90,000 U/g) and fed from 1 to 35 days of age (approved by Ethical Committee of Aristotle University of Thessaloniki: decision number 811/21-01-2020). The new intrinsically heat stable xylanase (Xygest™ HT; Kemin Animal Nutrition and Health, Herentals, Belgium) is a beta 1–4, endo-xylanase enzyme produced by *Thermopolyspora flexuosa* expressed in *Pichia pastoris*. Growth performance, organ weights, intestinal viscosity and pH were monitored. Statistical analyses were carried out using ANOVA and multiple comparisons between treatment means (Tukey's test) using SPSS 25.0 (Version 25.0. Armonk, NY: IBM Corp).

Results

The data (presented in Table 1) showed that xylanase supplementation significantly reduced intestinal viscosity, especially in the ileum. Duodenum pH was not affected by xylanase supplementation, while T3 treatment showed the lowest pH value in jejunum and ileum.

Xylanase supplementation also significantly reduced the feed conversion ratio (FCR) (data shown in Table 2) without affecting feed intake. T2 treatment exhibited a higher body weight gain compared the other treatments ($P < 0.05$). Live weight,

Table 1. Effects of different levels of enzyme supplementation on viscosity in jejunum and ileum of broilers (mean±SD).

	Treatments				
	T1	T2	T3	T4	P-value
Viscosity Jejunum	4.36 ± 1.92	3.38 ± 0.852	3.67 ± 1.285	2.85 ± 1.442	0.182
Viscosity Ileum	3.33 ± 0.679^{ab}	2.74 ± 0.809^{ab}	2.48 ± 0.217^{a}	2.86 ± 0.674^{ab}	0.015
pH duodenum	5.97 ± 0.079	5.93 ± 0.115	5.97 ± 0.052	5.99 ± 0.122	0.069
pH jejunum	6.71 ± 0.299^{a}	6.51 ± 0.285^{a}	5.77 ± 0.282^{b}	6.48 ± 0.385^{a}	<0.001

^{a,b}mean values not sharing the same superscript differ significantly between them ($P < 0.05$).

Table 2. Effects of different levels of xylanase enzyme supplementation on FCR of broilers (mean±SEM).

	Treatments				
	T1	T2	T3	T4	P-value
FCR 1–35	1.62 ± 0.03[a]	1.54 ± 0.03[b]	1.53 ± 0.03[b]	1.55 ± 0.03[b]	0.014

[a,b]Means within the same row with different superscripts are significantly different at p < 0.05.

carcass weight, legs and liver weight were significantly higher in T3 and T4 treatments compared to T1 (P < 0.05).

Conclusion

Dietary supplementation of the new xylanase resulted in lower intestinal viscosity and lower pH. Moreover, supplementation of the new xylanase at 30,000 U/kg in a wheat-based diet, resulted in a significant improvement of broiler performance and carcass traits.

Acknowledgments

This research was funded by Kemin Europa N.V., Research Project Code 99,821 (Aristotle University of Thessaloniki, Greece).

Reference

Hahn-Didde, D., & Purdum, S. E. (2014). *Journal of Applied Poultry Research*, *23*, 23–33.

The effects of *myo*-inositol and phytase supplementation on the tibia bone characteristics of 35 day old broiler chickens

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Application

The effects of *myo*-inositol (Ins) on bone strength and physiology are less well understood, which is critical in healthy broiler growth.

Introduction

The role of Ins in broiler chickens is not fully understood. Ins is an important biological compound, on its own or in combination with phosphorus. Phytase supplementation results in increased formation of free Ins in the digestive tract of broiler chickens, which may be a factor in improved growth performance. The importance of good bone growth with fast growing broiler strains is critical as any negative changes in the growth plates would negatively affect the gait and movement of broiler chickens. The aim of this study was to assess the tibial bone characteristics of broiler diets when fed phytase and Ins alone or in combination.

Material and methods

The study reported here was granted ethical approval by Harper Adams University Ethics Committee in accordance with the ARRIVE 2.0 guidelines. Three hundred and sixty male Ross 308 chicks were sourced from a local hatchery and allocated into 60 raised floor pens with 6 birds in each. Diets were fed in a 2 by 3 factorial arrangement from 0–35 days of age, treatments contained 0 or 4500 phytase (FTU/kg) and 0, 3.5 or 7 g/kg Ins. All diets contained 8% sunflower meal and the phytase was Quantum® Blue (ABVista, UK). Although such high phytase

Table 1. Tibia bone parameters of broilers fed the different dietary treatments at 35 days of age.

Treatment	Tibia weight (g)	Tibia length (mm)	Tibia width (mm)	*facies articularis inferior* (mm)	*facies articularis superior* (mm)	W/L	Ash (g)	Strength (N/mm²)
Phytase								
Yes	10.84	88.08	8.27	18.04	23.74	0.1207	2.197	388.2
No	10.04	86.38	7.95	17.92	23.41	0.1153	2.101	342.9
SEM	0.199	0.57	0.104	0.144	0.141	0.002	0.0534	8.86
CV	10.4	3.6	7.0	4.4	3.3	8.8	13.6	13.3
P value	0.006	0.039	0.037	0.537	0.104	0.006	0.210	<0.001
Ins								
0.0 g/kg	11.07[b]	88.68[b]	8.329[a]	18.15	23.76	0.1245[b]	2.302[b]	388.0[b]
3.5 g/kg	10.43[ab]	87.35[ab]	8.207[b]	18.11	23.72	0.1203[b]	2.134[ab]	357.9[ab]
7.0 g/kg	9.82[a]	85.67[a]	7.793[a]	17.68	23.24	0.1134[a]	2.012[a]	349.0[a]
SEM	0.235	0.674	0.122	0.172	0.170	0.002	0.0610	11.49
CV	10.0	3.5	6.7	4.4	3.2	8.6	12.7	14.1
P value	0.002	0.010	0.008	0.116	0.063	0.004	0.005	0.050

[a,b,c]different superscript letters denote differences (P < 0.05).

concentrations are not used in practical dietary formulations, in this study we aimed to hydrolyse the majority of the phytate in diets. On day 35, two birds from each pen were dispatched, the left legs removed and frozen (−20°C) until further analysis. Tibia bones were then removed, weighed, and measured using digital callipers. Bone strength was analysed using a TA. HD*plus*C texture analyser set up with a 500 kg load cell and 3 point bend test fixture. Bones were then ashed using a muffle furnace overnight at 550°C. Data was analysed by ANOVA and differences were reported as significant at $P < 0.05$.

Results

Phytase supplementation improved tibia weight, length, width, W/L and strength compared to the un-supplemented phytase (standard P) diets (Table 1). In addition, Ins supplementation reduced the tibia weight, length, width, W/L, ash and strength.

Conclusion

Dietary Ins addition resulted in a significant reduction in bone strength ($P < 0.05$) which is in accordance with Lee, Nagalakshmi, Raju, Rao, and Bedford (2017). This may be due to P being used to phosphorylate Ins rather than being used for bone growth, further work is required to understand this.

Acknowledgments

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The distribution of gastrin, cholecystokinin and their receptors expression suggests a role of cholecystokinin in the chicken crop

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Application

Understanding the biology of food intake is critical to optimise poultry growth and tackle issues such as the broiler breeder paradox. Feedback between the gastro-intestinal tract and the crop may offer a control mechanism.

Introduction

Food intake is controlled by a balance of central signals to increase or decrease consumption with peripheral signals from the gut and organs involved in food processing. Cholecystokinin (CCK) is preferentially bound by CCK receptor A (CCKAR) and this defines body weight (Dunn et al., 2013). CCK/gastrin family expression and the novel distribution of their receptors expression was measured to understand the peptides target organs and how expression of the genes responds to changes in food intake. The functional consequences of expression in a novel target organ for CCK, the crop, were elucidated.

Materials and methods

Gastrin, CCK, CCKAR and CCKBR mRNA expression in chicken tissues was measured by qPCR in four 42-day-old broiler hens (Ross 308). Tissues were the basal hypothalamus, breast muscle, liver, pancreas, crop, proventriculus, gizzard, antrum, antro-duodenal boundary, duodenum, proximal jejunum, mid-jejunum, jejuno-ileal boundary, mid-ileum, distal ileum, caecum and rectum. The effect of food intake was assessed in food restricted broiler breeders at 12 weeks of age with a control group, a group released from restriction for 2.5 days or receiving ispaghula husk ($n = 24$) for 2.5 days (Caughey et al., 2018). ANOVA using a general linear model was used to fit the main effects. Contraction of the crop in response to CCK or depolarising K^+ was measured using a custom-made organ bath filled with Kreb's solution. Use of animals was approved by the Roslin Animal Welfare and Ethical Review Body under the Animals (Scientific Procedures) Act 1986, licence 70/7909.

Results

CCK was abundantly expressed in the hypothalamus of the brain followed by the jejunal and ileal GIT regions. Gastrin was confined to the antrum and was significantly higher when broiler breeders were released from feed restriction ($P = 0.007$). CCKBR was most abundant in the hypothalamus and the proventriculus and CCKAR was most abundant in the pancreas and crop. CCK expression in the pancreas increased after removal of food restriction ($P = 0.011$). Crop contractions as a % of a maximal K^+ induced response was 58 ± 11% in response to 1×10^{-6} M CCK and formed a dose response curve down to 1×10^{-8} M.

Conclusion

The high level of expression in the crop was unexpected. The potential role of CCKAR in mediating crop emptying in response to CCK was supported by the observation of *in-vitro* contraction of the crop after CCK administration. The elevation of gastrin expression in response to ad-libitum feeding was in line with its trophic role in the proventriculus. The higher expression of CCK in the pancreas after removal of feed restriction is consistent with the pancreas being a major source of satiety signals. The results should inform new hypotheses on the genes role in growth in poultry and may strengthen the role of the crop in poultry growth (Rodrigues & Choct, 2018).

Acknowledgements

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Effect of pelleting process on particle size of commercial poultry feeds

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Application

Determination of particle size of different forms of poultry feed can lead to a better understanding of how particle size is influenced by the pelleting process.

Introduction

Particle size reduction increases interaction with digestive enzymes because of increased surface area (Nir, Melcoin, & Picard, 1990). However, a potential negative effect of reduced particle size is inadequate gizzard development (Ferket, 2000). Inferior development of digestive organs especially the gizzard has been reported when poultry were fed pelleted diets (Amerah, Lentle, & Ravindran, 2007). Little is known about how pelleting process affects particle size of poultry feeds. The aim of this study was to assess the effect of pelleting on particle size of poultry feeds when they have ingredients of the same size and inclusion level.

Materials and methods

A total 14 of commercial feed samples per category of feed form were provided by AB Agri in mash and pellet form. All samples were of same commercial standard formulation and grinding size with respect to their feed forms but from different batches. Each mash sample was further divided into two equal parts; one for dry and other for wet sieving. All pellet samples were wet sieved. For wet sieving, 50 g of mash or pellet was soaked into 1 L of water for 1 hour before sieving. All samples (50 g) were sieved using the Retsch® auto shaker stacked with set of sieves (4 mm, 2 mm, 1 mm, 0.5 mm 0.25 mm, 0.125 mm, 0.063 mm) to measure particle size as geometric mean diameter (GMD). The GMD, geometric standard deviation (GSD), and minimum and maximum particle size were calculated with the following formulae:

Average diameter of the two sieves $(d_i) = (d_u \times d_o)^{1/2}$,
Geometric mean diameter (GMD in µm)
$$= \log^{-1} [\Sigma (W_i \log d_i) \div \Sigma W_i]$$
Geometric standard deviation (GSD)
$$= \log^{-1} [\{\Sigma W_i (\log d_i - \log d_{gw})^2 \div \Sigma W_i\}]^{1/2}$$
Minimum particle size = GMD ÷ GSD,
Maximum particle size = GMD × GSD

Where d_i is the diameter of i^{th} sieve in the stack, d_u is diameter through which particles pass (sieve proceeding i^{th}), d_o is diameter through which particles do not pass (i^{th} sieve), W_i is the weight of the sample on each sieve, and d_{gw} is GMD. Data were analysed by one-way ANOVA to determine the effect of feed form and sieving method on GMD and GSD using IBM SPSS-26 software. Means were compared using the LSD method.

Table 1. Effect of feed form and sieving method on geometric mean diameter (µm) and geometric standard deviation.

Source	GMD (SE)	GSD (SE)	Min GMD (SE)	Max GMD (SE)
Mash-DS	637.9(35.52)[a]	2.266(0.036)[c]	280.6(8.230)[a]	1455(78.75)
Mash-WS	711.1(34.39)[a]	2.686(0.081)[b]	267.7(17.74)[a]	1922(149.0)
Pellet-WS	507.3(43.50)[b]	2.962(0.097)[a]	192.3(9.020)[b]	1750(166.4)
P-value	0.003	<0.001	<0.001	0.063

Means within the same column with no common superscripts differ significantly ($P \leq 0.05$). GMD: Geometric mean diameter (µm); GSD: Geometric standard deviation; DS: Dry sieving; WS: Wet sieving; SE: Standard error of mean.

Results

A significant decrease ($P < 0.05$) in GMD of wet-sieved pellet compared to dry or wet-sieved mash was observed. The particle size GSD increased significantly ($P < 0.05$) with wet-sieved mash or pellet. The minimum GMD of wet-sieved pellet decreased ($P < 0.05$) compared with dry or wet-sieved mash (Table 1).

Conclusion

Average and minimum particle size of wet-sieved pellet were significantly reduced by 20.47 and 31.47% respectively, compared to dry-sieved mash, due to pelleting process. Whether such a reduction is consistent over different diet formulations and the implications of this observation in animal health and performance is yet to be determined.

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The response of male and female broiler chicken antioxidant status to xylanase and a fermentable xylo-oligosaccharide supplementation

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Application

Antioxidants are known for their biological activities, which are Considered to benefit animal health.

Introduction

Although feeding xylanase to broilers has shown potential to improve their hepatic antioxidant status through increasing the content of carotenoids (Pirgozliev et al., 2015), there is a lack of information on the possible effect of combining fermentable xylo-oligosaccharide (XOS) or supplementing XOS alone. Sex has a significant impact on broiler growth and blood biochemistry, therefore the study was conducted to investigate the effect of xylanase and a fermentable xylo-oligosaccharide supplementation on males and female broilers.

Material and methods

The experiment was conducted at the National Institute of Poultry Husbandry (UK) and was approved by Harper Adams University's Research Ethics Committee. A 35-day study was conducted on 960 male and 960 female Ross 308 broiler chicks, reared in 96 pens and fed ab libitum. Experimental maize-soybean meal based diets were split into two phases; starter (0–21d) and finisher (22–35d). The basal diets were split into four batches, one of them was used as a control, and each of the others was supplemented either with xylanase (16,000 BXU/kg XT), xylo-oligosaccharides (XOS) or with a stimbiotic combination of xylanase and xylo-oligosaccharides (STBIO, 16,000 BXU/kg XT) produced by AB Vista, UK. At 35d one bird from each pen was randomly chosen and sacrificed. The liver without the gallbladder was then freeze dried and further analysed for the antioxidant content by using the HPLC as previously described by Karadas et al. (2014).The data were analysed in GenStat (20th edition) by ANOVA with 2 × 4 factorial design including two sexes and 4 dietary treatments (Table 1).

Results

The supplements did not influence hepatic antioxidants status, furthermore, the sex of the birds impacted levels of lutein, zeaxanthin, β-cryptoxanthin, Q10 and sum of individual carotenoids ($P < 0.05$).

Conclusion

Diet did not have an impact on antioxidant status of the birds, however, the male broilers had higher hepatic antioxidant concentrations compared to females.

Acknowledgments

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Table 1. The effect of dietary treatments on hepatic antioxidants status of 35d old broilers fed a maize-based diet.

	Lutein	Zeaxanthin	β-cryptoxanthin	β-carotene	Coenzyme Q_{10}	Sum of individual total carotenoids
Sex						
F	0.182	0.176	0.0107	0.369	307.1	0.738
M	0.319	0.338	0.0273	0.350	341.2	1.035
SEM	0.0406	0.0430	0.00471	0.0212		0.0902
Treatments						
Control	0.268	0.275	0.0188	0.327	321.2	0.889
Xylanase	0.243	0.247	0.0198	0.395	315.0	0.904
XOS	0.268	0.277	0.0170	0.335	321.9	0.897
STBIO	0.223	0.229	0.0203	0.383	338.4	0.855
SEM	0.0573	0.0609	0.00667	0.0300		0.1276
Probabilities						
Sex	0.019	0.010	0.015	0.289	0.018	0.022
Treatment	0.932	0.932	0.986	0.533	0.683	0.993
Sex x Treatment	0.660	0.709	0.325	0.440	0.869	0.849

SEM, standard error of the mean.

Interactive effects of breed and faba bean feeding on broiler performance

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Application

Home grown faba beans may be used to reduce reliance on imported soya bean meal to a greater extent in slower growing breeds.

Introduction

A quadratic response to faba bean (FB) inclusion to reduce reliance on soya bean meal (SBM) in grower and finisher rations on Ross308 broiler performance was previously shown, with optimal performance deducted to be around 15% FB inclusion (Houdijk & Walker, 2020). With a lower pressure on selection for growth performance, slower growing breeds may attain greater levels of FB. Here, we tested this hypothesis by assessing the effects of FB inclusion on growth performance and carcass parameters in both Ross308 and the slower growing Hubbard JA787 broiler chickens.

Material and methods

A total of 1152 Ross308 and Hubbard JA787 day-old male broilers were placed in 96 pens (12 birds per breed) with 0, 10, 15, 20, 25 and 30% FB as grower/finisher feeding treatments (n = 8 pens; randomised block design). Diets were wheat-SBM based, with FB exchanged against SBM on a digestible lysine basis, formulated to meet average Ross308 and Hubbard JA787 requirements, using pure amino acids as required and small wheat and oil variations to maintain same energy levels. Birds were fed *ad libitum* a common starter crumb (d0 to 14), grower pellet (d14 to 28) and finisher pellet (d28 to end: d35 for Ross308 and d42 for Hubbard JA787). Bird weights (BW), feed intake and mortality corrected feed conversion ratio (FCR) were determined on a weekly basis; data reported here is for the common d0 to d35 phase. Two randomly selected birds per pen were processed at trial end to obtain carcass and relative breast weights. Data were analysed via a 2 × 6 factorial ANOVA for breed, FB level and interaction effects, combined with three orthogonal contrasts to assess effects of FB *per se* (i.e. 0 vs 10, 15, 20, 25 and 30% FB combined) and linear and quadratic effects of FB inclusion. SRUC's ethical review approved this study (POU AE 14–2021).

Results

Whilst the breeds differed for each parameter reported (Table 1), there were no clear interactions with FB level overall. The latter quadratically affected day 35 BW, which was similar across breeds up to 25% FB but reduced over the last FB increment. FB fed birds performed at elevated FCR, which stepwise increased after 15% and 20% FB for Ross308 and Hubbard JA787, respectively. Whilst FB feeding did not strongly impact on carcass yield, the largest relative breast yield was observed at 15% FB, which was more pronounced for Ross308 than for Hubbard JA787 (breed × quadratic FB: $P = 0.037$).

Conclusion

Whilst FB up to 15% in grower and finisher rations can partly replace SBM without elevating FCR for Ross 308, this may be up to 20% for Hubbard JA787. Though further stepwise modelling other than regression used here may be required to better analyse the purported relationships here observed, this novel data can contribute to debating the wider benefits of slower growing breeds. In addition, variation between effects on live weight compared to those on carcass weight and breast yield suggest that evaluation of FB as an alternative nutritional strategy based on gross performance only may miss impact on key meat production traits.

Acknowledgments

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Table 1. Day 35 weight, FCR, carcass and breast yields for Ross308 and Hubbard JA787 broilers fed up to 30% faba beans.

	d35 BW (g)		FCR d0-d35		Carcass (g)		Breast (g/kg carcass)	
FB (%) Breed	Ross308	JA787	Ross308	JA787	Ross308	JA787	Ross308	JA787
0	2757	1799	1.342	1.501	2076	1769	250	221
10	2723	1810	1.350	1.524	2183	1916	244	214
15	2790	1816	1.353	1.527	2152	1853	270	222
20	2713	1845	1.371	1.515	2129	1873	262	213
25	2771	1783	1.371	1.561	2132	1776	253	216
30	2695	1757	1.376	1.550	2102	1822	236	210
P-values s.e.d.	37		0.012		76		9	
Breed	0.001		0.001		0.001		0.001	
FB	0.101		0.001		0.242		0.020	
FB *per se*	0.709		0.001		0.091		0.775	
Linear	0.068		0.001		0.069		0.114	
Quadratic	0.029		0.707		0.655		0.003	
Breed × FB	0.221		0.138		0.952		0.314	

Ammonia emissions from broiler production under modern systems

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Application

Ammonia emissions are 29% less than current UK standard values and adoption of new emission values will enable accurate ammonia emission modelling and provide information for planning decisions.

Introduction

The detrimental effect of ammonia gas pollution has been well documented in terms of the reduction in biodiversity in sensitive sites, reduced carbon sequestration ability and as a source of nitrous oxide which is a potent greenhouse gas (Wang et al., 2019). Agricultural production is a major contributor to ammonia emissions and a number of legislative regulations are in force to reduce emissions within agriculture (e.g. IPPC, 2008). The UK Ammonia Inventory (2019) lists the ammonia emissions from all livestock production including broiler production and the current value calculates to be 34 g bird/place/year. This figure is based on historic data and it was hypothesised that it would no longer be applicable to modern systems. It is important that ammonia emissions are accurately quantified in order to ensure effective modelling to mitigate the adverse effects of ammonia and to ensure informed decisions on planning applications that are close to sensitive sites. The aim of this study was to measure ammonia emissions from broiler production with a view to establishing an up-to-date emission factor.

Materials and methods

Ammonia emissions were measured from two broiler units with two identical broiler houses to enable measurement of ammonia from four houses with indirect heating systems. The study followed the principles of the Verification of Environmental Technologies for Agricultural Production (VERA) Test Protocol for Livestock Housing and Management 2.0. Ammonia production was assessed for over one year's production which encompassed six continuous measurement periods of a minimum of 24 hr. Ammonia concentrations in each house were recorded by a Solus Ammonia Analyser using tuneable diode laser absorption spectroscopy. Sampling lines were placed according to VERA specifications on four fan outlets and on two inlets in each house and the analyser connected at least 24 hr prior to the sampling period to allow for equilibration. Ammonia emissions were measured every 15 minutes in sequential order from each fan and inlet. The sampling schedule allowed for representation across the production cycle for over a year and captured ammonia emissions from birds at different ages across six crops per site and house. Weather data was obtained from weather stations close to each site and internal temperature recorded. Ammonia measurements were converted to g/bird place/year and the average across sites and houses taken as the ammonia emission. Site and house differences were tested for using ANOVA. Regression analysis was conducted to test for the relationship between age of bird and temperature on ammonia emissions.

Table 1. Ammonia (NH_3) emissions (g/bird place/year) from each site (S) and house (H).

	S1	S2	SEM	Prob.	H1	H2	H3	H4	SEM	Prob.
NH_3 g/bird place/year	27.0	21.3	3.30	0.387	26.1	27.9	17.3	24.9	3.30	0.713

Results

The overall average value for ammonia emissions was calculated to be 24.1 g bird place/year. There were no significant differences in emissions between site and house (Table 1). There was a positive (R^2 = 0.67) and significant ($P < 0.001$) relationship between ammonia emission and the age of the bird. There was no significant relationship (R^2 = 0.04, P = 0.336) between the ammonia emission and ambient temperature.

Conclusion

Ammonia emissions were 29% lower than the value of 34 g/bird place/year in the current UK Ammonia Inventory (2019). This can be attributed to advancements in genetics, improved nitrogen efficiency and feed efficiency and also modern production systems which increase dry matter content of litter and thus decrease ammonia production. As this work was conducted in units representative of UK production and followed internationally recognised methodology, it is applicable to broiler production across the UK and will support changes to the current standards.

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Does the rate of starch digestion predict the feeding value of wheat for broiler chicken?

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Application

The rate of starch digestion is unlikely to predict the feeding value of wheat for young broilers.

Introduction

Among the nutrients in poultry diets, starch is the most important source of energy (Svihus, 2014). Wheat is the main cereal supplying starch in poultry feed in the UK. Dietary apparent metabolisable energy corrected for nitrogen (AMEn) is often used to predict feeding value in poultry diets. However, information on the correlation between the rate of starch digestion (RSD) and AMEn in wheat is scarce. Thus, the aim of the study was to investigate the effect of two wheat-based diets with similar starch and crude protein (CP) contents on the relationship between dietary AMEn and RSD. Growth performance variables, including feed intake (FI), weight gain (WG), and feed conversion ratio (FCR), were also measured.

Material and methods

One hundred and ninety-eight, 7 days old male Ross 308 broiler chickens were used in the experiment which was approved by the Harper Adams University Research Ethics Committee. At 6 d old, birds were individually weighed and assigned to 32 raised floor pens with six birds of approximately the same weights in each pen. Birds were fed 2 diets based on 2 wheat cultivar samples: Bennington and Siskin (Table 1), which were coarsely ground and mixed with balancer based on soya bean meal in the ratio 63:37. The balancer was very low on starch with 393 g/kg CP and 12.07 MJ/kg ME. After mixing diets were cold pelleted (50°C). Each diet was fed *ad libitum* to 16 pens following randomisation. On day 28, all birds and feed were weighed to calculate FI, WG and FCR. Immediately after weighing, all birds were euthanised and digesta from proximal and distal parts of the jejunum and ileum were collected into plastic containers, freeze-dried, milled, and analysed for gross energy, starch and titanium dioxide used as an indigestible marker. Values of RSD were calculated using an exponential, non-linear model $DS = DST \times (1\text{-}e^{-kds \times t})$ by relating mean retention time (MRT) and the starch digestibility values in each part of the intestine using Sigma Plot (Sinstat Software Inc.). Data were analysed by ANOVA and differences where $P < 0.05$ were taken as significant.

Results

The diet based on cultivar Bennington had higher AMEn ($P < 0.05$) and birds fed the diet had an improved FI ($P < 0.001$), WG ($P < 0.001$), and FCR ($P < 0.05$) compared to those fed Siskin. However, there was no difference in the values of RSD ($P > 0.05$).

Conclusion

Despite superior available energy and growth performance variables, the diet based on Bennington did not produce higher RSD compared with the diet based on Siskin. The results from this study suggest that broiler performance may not be described by the RSD of the wheat samples and other factors may be responsible. However, only two wheat samples were used in the experiment therefore more research is needed to support the results.

Acknowledgments

Harper Adams University and AB Vista, UK are acknowledged for providing funding for this project.

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Table 1. The impact of experimental diets with similar chemical composition on the performance variables, available energy (AMEn) and rate of starch digestion (RSD).

Wheat	Starch (g/kg)	Protein (g/kg)	Dry matter (g/kg)	BW (g) day 7	BW (g) day 28	FI (g/b/d DM)	WG (g/b/d)	FCR	AMEn (MJ/kg) DM	RSD
Bennington	569	98.5	880	139.5	1118	61.84	46.57	1.329	12.89	0.046
Siskin	564	112	883	138.6	999	55.85	40.97	1.365	12.53	0.043
SEM				0.38	18.2	1.372	0.863	0.0114	0.1141	0.0013
P-value				0.095	<0.001	<0.001	<0.001	0.037	0.039	0.189

The effect of dietary phytase and *myo*-inositol on the breast fillet meat quality of broilers chickens reared to 35 days of age

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Application

The effects of free *myo*-inositol (Ins) supplementation and Ins generated from phytase on the texture and colour of meat, which is critical to the profitability of chicken meat.

Introduction

Currently in the broiler industry there is an emphasis on increasing meat quality, in particularly appearance and texture. Phytase supplementation in broiler diets is now routine, primally releasing otherwise stored phosphorus from phytate. Once all six phosphorus groups have been removed, the molecule left is Ins. The positive effects of improved P digestibility are well understood, however the biological role Ins may have in a broiler chicken is less well known. Therefore, there is warrant investigating the possible effects that Ins may have on meat quality. The aim of the present study is to assess the impacts of Ins and phytase supplementation on breast meat quality of broiler chickens.

Material and methods

The experiment reported here is in accordance with the ARRIVE 2.0 guidelines and was approved by Harper Adams University Research Ethics Committee. A total of 360 Ross 308 chicks were obtained from a local hatchery and reared in 60 raised floor pens (6 birds in each). Diets were used in a 2 by 3 factorial experiment, whereby P source, either from formulated recommended P or phytase supplementation (4500 FTU/kg, Quantum® Blue, ABVista, UK) with 1.5 g/kg less formulated P will be compared with three inclusion levels of Ins at 0 g/kg, 3.5 g/kg and 7 g/kg. All diets contained 8% sunflower meal and were cold pelleted before feeding *ad lib*. At the end of the study (day 35), one bird from each pen was randomly selected and dispatched. The breast meat was removed and analysed for; colour (L*(lightness), a*(redness) and b* (yellowness)) using a Chroma meter CR-400 in 3 different locations on each chicken breast, pH using a Jenway 550 pH meter, 24-hour drip loss and texture. Data was analysed using ANOVA in GenaStat® (20th edition), differences were reported as significant at $P < 0.05$.

Results

Phytase improved the body weight at day 35 ($P = 0.004$), however there was no significant of Ins dosage on body weight ($P > 0.05$) (Table 1). The yellowness (b*) of breast was decreased, with increasing Ins dosage ($P = 0.013$). There was no significant difference in pH, drip loss, texture (Shear force and shear energy), L* or a* ($P > 0.05$).

Conclusion

Breast meat quality was not affected by phytase supplementation, but body weight was improved, which is an important factor in the profitability. Ins decreased b* (relative yellowness) at the highest dosage of 7 g/kg, which is important as colour is the most important physical characteristic of meat for the consumer (Batkowska, Brodocki, Zięba, Horbańczuk, & Łukaszewicz, 2015).

Acknowledgments

The authors would gratefully thank the poultry technicians (Rich James and Conor Westbrook) and Robert Boffey at the Regional Food Academy, Harper Adams University.

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Table 1. The effect of phytase and *Ins* supplementation of breast meat fillet quality of broiler chickens reared to 35 days.

Treatment	Body weight of bird at day 35 (g)	pH (24hrs post slaughter)	24-hour drip loss (%)	L*	a*	b*	Shear force (N)	Shear energy (N.mm)
P source								
Phytase (−1.5 g/kg av P)	2364	5.91	0.94	54.42	3.63	3.46	2.96	18.59
No Phytase (standard P)	2212	5.87	1.00	54.79	3.77	3.09	2.88	19.38
SEM	35.5	0.014	0.053	0.383	0.167	0.167	0.065	0.431
CV	8.5	1.3	30.1	3.8	24.7	28.0	12.3	12.4
P value	0.004	0.091	0.366	0.500	0.551	0.130	0.406	0.200
Ins dosage								
0 g/kg Ins	2372	5.88	0.98	54.54	3.57	3.678[b]	2.90	18.50
3.5 g/kg Ins	2276	5.90	0.97	54.77	3.86	3.315[ab]	2.95	19.32
7 g/kg Ins	2218	5.89	0.97	54.52	3.66	2.833[a]	2.91	19.15
SEM	44.9	0.018	0.066	0.475	0.204	0.195	0.081	0.534
CV	8.8	1.4	30.5	3.9	24.7	26.7	12.4	12.6
P value	0.057	0.832	0.993	0.916	0.584	0.013	0.886	0.525

[a]different superscript letters denote differences ($P < 0.05$).

Evaluating different bone processing methods used in assessing mineralisation in broilers

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Application

The method of analysing broiler bone ash as recommended by the current study would improve the accuracy of ash determination and decrease bias in skeletal evaluation and phosphorus availability in broilers.

Introduction

Lameness in broilers is a major issue in the poultry industry affecting negatively both welfare and growth performance. Bone ash content has been widely used to evaluate the skeletal status of poultry and it is the preferred criterion for estimating phosphorus availability due to its simplicity. Variations in bone processing methods may affect ash content results and make no sense of comparing bone ash content from different broiler studies. Especially that many of the studies which included bone ash determination did not report bone processing during ash determination in enough details. Therefore, the main goal of this study is to identify the effect of processing method (fat extraction, including cartilage caps, autoclaving prior to fat extraction, fat extraction time) on ash content of broiler tibia.

Table 1. The effect of increasing fat extraction time on fat extraction efficiency.

Extraction time (hour)	Cumulative fat extracted (%)	Additional fat extracted (%)
1	5.72 f	5.72a
2	9.39e	3.89b
3	11.6d	2.41c
4	12.9c	1.5d
5	13.5abc	0.72e
6	13.9ab	0.45ef
7	14.2a	0.35 f
8	14.5a	0.35 f
SEM	0.243	0.131
P- value	<0.001	<0.001

Means within a column with the same letter are not significantly different (P > 0.05)

Material and methods

All experimental procedures involving animals were approved by the University's College of Arts and Science ethical review committee. A total of 288 day-old male broiler chicks were fed on 6 diets differed in phosphorus level (8 pens/treatment) for 42 days. Tibias of 2 birds/pen were used to determine the effect of fat extraction and cartilage caps exclusion on ash content. 264 day-old male chicks were reared in 33 pens and fed a standard broiler diet for 35 days. Tibias of one bird/pen were used to examine the effect of duration of extraction on fat extraction efficiency and the effect of autoclaving on bone ash content. ANOVA models were used to calculate the predicted ash content of tibia, residuals then prediction error (PE). R was used to analyse the data.

Results

Autoclaving did not significantly affect tibia ash content. Fat extraction significantly decreased the PE of tibia ash determination (Table 1). Fat extracted from tibias were significantly increasing up to 6 hours only. Cartilage inclusion did not significantly alter bone ash determination PE.

Conclusion

Autoclaving to ease flesh removal followed by a 6 hours fat extraction is recommended before bone ashing for ash determination. That would decrease the bias in skeletal status evaluation and estimation of phosphorus availability in poultry.

Acknowledgments

We gratefully acknowledge the poultry integrator based in the UK Midlands that supplied all the birds.

In-feed peracetic acid precursor nanoparticles improve reused litter exposed broilers performance

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Application

In-feed peracetic acid (PAA) from sodium percarbonate (SP) and tetraacetylethylenediamine (TAED) nanoparticle precursors improves body weight (BW), BW gain (BWG) and mortality-corrected feed conversion ratio (mFCR), likely by modulating gut microbiota through non-antibiotic, biocide mechanisms.

Introduction

Misuse of antimicrobials in livestock has led to rising antimicrobial (AM) resistance, urging the need of AM alternatives (Koch, Hungate, & Price, 2017). We demonstrated that in-water provision of the well-known biocide PAA (Kitis, 2004) improved performance and reduced crop bacterial load in 7 to 14 days old broilers (Galgano et al., 2021). Here, these findings are extended by testing in-feed controlled release precursor derived PAA provision impacts on performance from day-old onwards.

Material and methods

Study design and protocol were approved by SRUC Animal Welfare and Review Body (POU AE 16–2021). A total of 375 Ross 308 male day-old chickens were housed in 75 pens (5 birds per pen) in 4 rooms following a randomised block design for five treatments (A to E, n = 15 pens). PAA was administered for 28 days at 0ppm (C), 30ppm (D) and 80ppm (E) via mixing precursor-nanoparticles (Aga Nanotech Ltd) with feed (or empty nanoparticles for 0ppm), with broilers challenged by placing at day-old on re-used litter from a previous 42-day broiler study. Treatments A and B were diet-only controls placed on clean bedding and challenged, respectively. Feed and treatments were offered fresh daily. Bird-level body weight was measured weekly. This trial was informed by a previous 21-day pilot study, with 45 pens, 5 birds per pen, three treatments (i.e. 0ppm, low and high PAA levels), administered daily during the last week. Statistical analysis was performed via linear mixed model (LMM, i.e. treatment and time as fixed effect and room/pen/bird as random effect). P-values were estimated via t-tests using Satterthwaite approximations to degrees of freedom.

Results

Both 30ppm and 80ppm (days 7, 14, 21) and 30ppm (day 28) increased BW ($P < 0.05$). 0ppm increased BW (days 7 to 21, $P < 0.05$) over diet only controls at a lower magnitude than 30 and 80ppm. Birds on clean litter had lower BW (days 21 and 28, $P < 0.05$) and BWG (day 0 to 14, $P < 0.05$) than diet-only challenge. Treatment-independent mortality was 8 birds, PAA at 0, 30 and 80ppm reduced mFCR longitudinally ($P < 0.05$), yet with positive treatment-time interactions between 0 and 30ppm and the intervals; day 0 to 21 and day 0 to 28. After a reduction (day 0 to 7), clean litter birds had a significantly greater mFCR compared to diet-only challenged control (Fig 1). 80ppm significantly reduced mFCR between day 0 to 14 and day 0 to 28. Linearly scaled normalised BWG fold-change from the pilot study was also improved ($P < 0.05$) on high PAA, which concurred with reduced colonic pH ($P < 0.05$).

Conclusion

PAA administered in-feed via precursor-nanoparticles improved BW, BWG and mFCR at both 30 and 80ppm. Interestingly, 0ppm was also associated with some of the positive performance effects, albeit not to the extent of the rest of the treatments, possibly due to an increased interest towards the nanoparticles. Birds housed on clean litter had lower performance than challenged birds. Colonic pH was reduced in pilot study with similar effect on performance. Pending future work on microbiota analysis will elucidate the microbiological mechanisms underlying these observations.

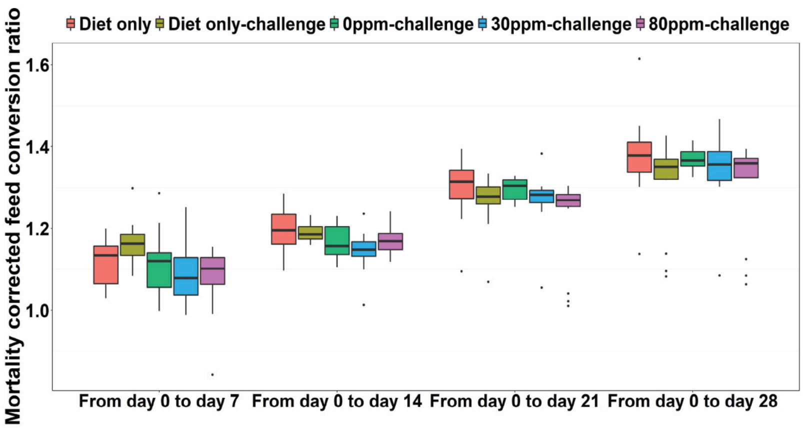

Figure 1. Longitudinal mortality corrected FCR.

Acknowledgments

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Chromium propionate improves performance and carcass traits in broilers

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Application

Supplementation of chromium propionate in broilers can significantly enhance growth performance and carcass traits.

Introduction

Poultry may have a dietary requirement for bio-available chromium (Cr) that exceeds typical provision in traditional broiler diets (NRC, 1997). Dietary Cr may also help birds to cope with a variety of stressors, including heat stress, through antioxidant, insulinotropic, and other physiological regulatory mechanisms (Han et al., 2021; Lu, Zhao, Dong, Liao, & Zhang, 2019). This study was designed to elucidate the effects of dietary supplementation of organic Cr from Cr propionate, at different doses.

Materials and methods

1080 male Ross 308 broilers were assigned at day 0 to 3 dietary treatments, with 30 birds/replicate and 12 replicates/treatment. Birds were fed a standard corn/soy diet, supplemented with 0, 200 or 400 µg/kg of Cr propionate (KemTRACE™ Cr, Kemin Industries). Diets were formulated to meet the complete nutritional need of the birds and fed in three phases (starter 0–14, grower 15–28 and finisher 29–35. All groups were provided with *ad libitum* feed and water. Growth performance and feed intake were measured weekly by pen. Carcass parameters were measured on day 35 for one bird from each pen. The bird was assessed for carcass yield, breast meat yield, and abdominal fat pad weight post-mortem. Data were analysed using ANOVA (JMP 15) and Tukey's HSD; significant difference determined at $p < 0.05$. Study was conducted in compliance with the EFSA FEEDAP guidance. The experiment was approved by the Scientific Research Council of the University of Jordan.

Results

Supplementation of both 200 and 400 µg/kg Cr propionate to the diet formula resulted in significantly increased final body weight gain (BWG), reduced cumulative feed intake and feed conversion rate (FCR) compared to the control (Table 1). At d35, 200 µg/kg of Cr propionate was able to significantly increase BWG and decrease FCR compared to the unsupplemented control, while 400 µg/kg, further significantly increased BWG and decreased FCR compared to 200 µg/kg, demonstrating a clear dose response to increasing dietary Cr supplementation.

Carcass evaluation demonstrated that 400 µg/kg Cr propionate resulted in significantly increased carcass weights, dressing percentages, breast meat yields and reduced abdominal fat deposition (Table 2). Unlike for performance data, supplementation with 400 µg/kg had no further significant benefit compared to supplementation with 200 µg/kg, though numerical differences were observed.

Conclusion

Cr propionate resulted in significantly improved growth performance and carcass traits, demonstrating the value of chromium in supporting a sustainable broiler production.

Table 1. Performance results for broilers supplemented with 0, 200 0 r 400 µg/kg Cr propionate.

Treatment	Body weight (g)				Feed Intake (g)				FCR			
Time Point (days)	0	14	28	35	0–14	15–28	29–35	0–35	0–14	15–28	29–35	0–35
0 µg/kg	42.1	488.2	1575.4^{c}	2281.5^{c}	548.4	1605.6^{a}	1178.8	3332.7^{a}	1.23	1.48^{a}	1.67^{a}	1.49^{a}
200 µg/kg	42.2	490.6	1618.0^{b}	2345.7^{b}	538.8	1555.1^{b}	1169.0	3262.9^{b}	1.20	1.38^{b}	1.61^{a}	1.42^{b}
400 µg/kg	42.1	491.7	1675.4^{a}	2443.1^{a}	538.5	1528.9^{b}	1160.4	3227.8^{b}	1.20	1.29^{c}	1.51^{b}	1.34^{c}
Pooled SEM	0.128	4.84	7.98	13.32	4.79	11.67	8.45	13.16	0.02	0.02	0.02	0.01
p-value	0.05	0.8735	<0.0001	<0.0001	0.2671	0.0002	0.3186	<0.001	0.3643	<0.0001	<0.001	<0.0001

Table 2. Carcass traits for broilers supplemented with 0, 200 0 r 400 µg/kg Cr propionate.

Parameter	Carcass Weight (g)	Dressing %	Breast Meat Yield (g)	Abdominal fat %
0 µg/kg	1571^{b}	70.28^{b}	413.47^{b}	0.97^{a}
200 µg/kg	1658^{a}	71.37^{b}	498.04^{a}	0.42^{b}
400 µg/kg	1757^{a}	72.04^{a}	540.87^{a}	0.36^{b}
Pooled SEM	37.22	0.19	15.16	0.054
p-value	0.0003	<0.0001	<0.0001	<0.0001

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Sensitivity of dry matter, ash and crude protein apparent ileal digestibility to starter feed form, grower and finisher inclusion of faba beans and stunning method in male broilers

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Application

Faba bean inclusion in grower/finisher rations may improve their nutritional value as protein and mineral digestibility increases. Sensitivity of the latter to stunning method warrants careful consideration of sampling strategies in mineral availability studies.

Introduction

We previously reported that faba beans (FB) can safely be included at 15% in nutritionally balanced grower and finisher diets to reduce reliance on soya bean meal (SBM), in the presence of performance benefits of starter crumbs over coarse meal throughout, with some evidence of compensatory growth following low performance on meals during the starter phase (Houdijk & Walker, 2022). Here, we present digestibility data derived from these studies, where in addition to starter feed form and grower/finisher FB inclusion, we examined the effect of stunning method as different methods are being used prior to digesta collection.

Material and methods

A total of 448 Ross308 day-old male broilers were reared under one of four feeding treatments (n = 8 pens; 14 birds/pen). Two starter treatments (meal vs crumbs) were factorially combined with two pelleted grower/finisher treatments (with 0 or 15% FB). All rations were wheat-SBM based, with FB exchanged against SBM based on digestible lysine levels, using pure amino acids as required and variations in wheat and oil to maintain similar energy levels. At trial end (d37), ileal digesta was collected to determine apparent digestibility of dry matter, ash and crude protein from three birds per pen either after electrical stunning followed by exsanguination or cervical dislocation. Data were analysed via a 2 × 2 × 2 split-plot ANOVA, with pen as main plot for the feeding treatments and stunning method as sub-plot for the latter and possible interactions with feeding treatment. SRUC Animal Welfare and Ethical Review Body approved this experiment (POU AE 01–2020).

Table 1. Apparent ileal digestibility of dry matter, ash and crude protein in broilers fed grower-finisher rations with 0 or 15% faba beans and sampled after electrical stunning followed by exsanguination or cervical dislocation.

	Apparent ileal digestibility (%)		
Treatments	Dry matter	Ash	Crude protein
Faba bean level (%)			
0	77.9	55.3	84.5
15	78.6	59.2	86.4
s.e.d.	0.61	1.56	0.76
P-value	0.240	0.020	0.021
Stunning method			
Electrical stunning + exsanguination	77.7	52.1	85.4
Cervical dislocation	78.9	62.4	85.6
s.e.d.	0.71	1.87	0.67
P-value	0.101	0.001	0.754

Results

Feeding treatments and stunning method did not interact (P > 0.20) on the parameters measured. Starter treatment did not affect dry matter or ash digestibility (data not shown) though feeding starter as meal tended to increase crude protein digestibility over feeding starter as crumb (86.2 vs 84.7%; s.e.d. 0.67%; P = 0.070). Table 1 shows that the inclusion of 15% FB in the grower and finisher ration did not affect dry matter digestibility but increased digestibility of ash and crude protein. In addition, whilst stunning method did not affect dry matter and crude protein digestibility, ash digestibility was greater following cervical dislocation compared to electrical stunning.

Conclusion

Faba bean inclusion increased ash and protein digestibility, suggesting an improved nutritional value of the ration as a whole. The absence of interactions between feeding and stunning treatment assists using historic digestibility data derived through different stunning methods. However, the smaller apparent ileal digestibility of ash following electrical stunning compared to cervical dislocation suggests that electric stunning may result in enhanced endogenous mineral losses, including possible loss of calcium. The possible carry over effect of starter feed form on digestibility may have arisen from compensatory effects following performance limiting starter meal feeding (Houdijk & Walker, 2022).

Acknowledgments

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The effect of papaya seed and neem leaf meal on performance and health of laying hens

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Application

Commercial poultry industry could integrate a 3% level consisting of equal proportion of neem leaf meal and papaya leaf meal to basal ration to improve performance and health of laying hens.

Introduction

Small-scale poultry rearing in developing countries has been challenged by ever-increasing price of commercial additives. As papaya seed (Devi & Kumar, 2017) and neem leaf meal are cheap, readily available and contain functional active ingredients such as nimbin, nimbidin, nimbolide, limonoids, quercetin, ß-sitosterol, ferulic acid, caffeic acid, p-coumaric acid, kaempferol-3-glucoside, p-hydroxybenzoic acid and quercetin-3-galactoside regulating genetic pathways and disease resistant, this study aimed to unravel the modulatory effect of papaya seed meal, neem leaf meal and their equal mixture on the performance and health of laying hens.

Material and methods

Approved by the ethical committee of Jimma University. A total of 192 twenty-two-week-old Lowman Brown layers were randomly distributed equally into 4 treatments (6 pens/treatment with 8 birds/pen): Control, 3% NLM, 3% PSM and 1.5% NLM+ 1.5% PSM inclusion in the diets. Standard layers commercial mash type feeds were formulated to meet the nutrient requirement and the control diet was supplemented with experimental diets at the level of 3%. Feed intake, egg production and egg storage quality of each pen were recorded on two weeks interval. The trial lasted for 8 weeks in addition to one week adaptation. At the end of the experiment, two birds per replicate were blood sampled from punctured brachial vein and analysed for serum chemistry and haematological indices of layering hens. All data was analysed using the one-way analysis of variance by using Statistical Analysis System (SAS, 2012).

Results

The result revealed that supplementation of a mixture of papaya seed meal (1.5%) and neem leaf meal (1.5%) improved production performance, hormonal profile and general health of laying hens (Table 1).

Conclusion

Inclusion of equal proportion of papaya seed meal and neem leaf meal at 3% dosage improved egg production and health of laying hens.

Reference

Devi, P. S., & Kumar, N. S. (2017). *Journal of Pharmacognosy and Photochemistry*, 6(1),424–429.

Table 1. Egg production and blood constituents of Lowman brown layers fed diets with supplementation of dried neem leaf meal (NLM) and papaya seed meal (PSM).

	Neem leaf meal and Papaya seed meal dosages (g /kg diet)				
Production performance	0%	3% NLM	3% PSM	1.5% NLM+1.5%PSM	SEM
Feed intake (g/bird)	94.5^{d}	106.1^{c}	110.4^{b}	111.3^{a}	0.024
Egg production (%)	76.1^{c}	86^{b}	86.4^{b}	88.3^{a}	0.193
Feed conversion ratio (g egg/g feed)	1.93^{b}	1.89^{a}	1.92^{b}	1.84^{c}	0.004
Blood parameters					
Low density lipoprotein (mg/dl)	122^{d}	113^{c}	114^{a}	90 ^{b}	0.288
High density lipoprotein (mg/dl)	0.611^{c}	0.461^{d}	0.683^{a}	0.723^{b}	0.003
Alanine amino transferase (IU/L)	296^{a}	288^{ab}	292^{a}	258^{b}	10.6
Aspartate amino transferase (IU/L)	146^{b}	146^{b}	145^{a}	145^{a}	0.174
Uric acid (mmol/L)	6.15^{d}	6.72^{c}	5.93^{b}	5.19^{a}	0.05
Creatinine(mmol/L)	75.9^{b}	75.8^{b}	76.4^{a}	76a^{b}	0.144
Alkaline phosphatase (IU/l)	6921^{d}	6870^{c}	6797^{b}	6826^{a}	7.61
Thyroxine (ng/ml)	15.2^{c}	17.1^{b}	17^{b}	18^{a}	0.092
Thryiiodothyronine(ng/ml)	0.122^{d}	0.14^{c}	0.161^{b}	0.152^{a}	0.001
Luteinizing hormone(ng/ml)	0.461^{d}	0.611^{c}	0.723^{b}	0.683^{a}	0.003
Progesterone(ng/ml)	7.61^{d}	6.09^{c}	5.33^{b}	5.19^{a}	0.028

Means in a row with different superscript are significantly different ($p < 0.05$) SEM, standard error of the mean.

Processed animal protein as a feed ingredient for poultry – the feed industry's perspective

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Application

Processed animal protein (PAP) is a highly digestible source of protein, energy and phosphorus and a potential alternative to soyabean in poultry diet. Whilst, PAP is not currently authorized in the UK, there are considerations that need to be addressed if re-approved in the future.

Introduction

After a ban lasting more than 20 years, the EU re-authorised the use of porcine PAP in poultry diets in 2021. Notably, the ban on the use of PAP in ruminants and on species-to-species recycling remains in force in the EU. Many in the UK still recall the impact of the BSE crisis in 1994, and so there is need to carefully assess the potential benefits and risks if the UK were to consider similar legislative amendments that re-approves PAP in poultry and pig diets.

It is noteworthy that the processing of PAPs have improved significantly in the last few years and there are better control measures. For example, PAP can only be made from Category 3 by-products, from traceable healthy animals which at the point of slaughter are fit for human consumption. In addition, the sourcing, processing and transport of PAP need to be done under veterinary control. A lot of technical improvements have also been made to ensure consistency in product and nutritional quality.

The amino acid profile and nutrient digestibility in PAP make them a valuable feed ingredient for many poultry species. PAP can partially replace soyabean meal in diets for laying hens (Krimpen, Veldkamp, Binnendijk, & de Veer, 2010) and in broilers (Krimpen, Bikker, & van Harn, 2019). Therefore the use of PAP may reduce reliance on imported soyabean whilst also contributing positively to efficient resource use and minimizing nutrient wastage.

There are many practical considerations that need to be addressed if the UK feed industry were to consider the use of PAP in poultry diets. These factors include, but are not limited to: 1. food safety risk and consumer acceptance, 2. PAP availability in the UK and how it compares as an opportunity to other protein sources, 3. ability to adhere to regulatory rules and quality control procedures, and 4. the need for investment in the supply chain.

References

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Processed animal protein as a feed ingredient for poultry – EU and renderers' perspectives

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Part of the European Green Deal is the Farm-to-Fork strategy. One of the pillars of this Farm-to-Fork strategy is the circular economy. To realize future proof poultry production we need to use circular feed ingredients. Less imports from 3rd countries, more local resources.

One of the options for the supply of the proteins in the feed can be the processed animal proteins: PAPs. They are nutritious, natural, sustainable and local. By their high nutritional value they can supply essential amino acids, digestible phosphorus and they deliver energy due to the fats still present in the PAPs. Chickens are in nature omnivorous animals. So, it is natural for them to consume animal proteins. Further they can help to improve the welfare of chickens by a nice plumage, healthy feet and stronger bones.

They are sustainable because they are produced out of co-products from the meat production. This results in a low carbon footprint compared with protein sources from 3rd countries, like for example standard soybean meal. Especially when the LULUC = land-use-land-change factor is taken into account.

They are always local, because they are produced out of co-products from the local meat industry. So, they can help in the desire from the European consumers to consume more local. In fact the whole supply chain, from the farmer, the processor (we), the poultry feed producer till the poultry meat consumer, can take advantage of this new circular poultry feed ingredient!

To produce those PAPs the whole supply chain needs to be certified by the competent authorities. This is necessary to guarantee that this supply chain is completely dedicated to only one single type of species. For poultry feeds this means that we can only source by-products from porcine meat producers to produce this valuable PAP.

A safe, healthy, natural and local new protein source for poultry feeds in Europe.