

Book of Abstracts

‘EGGMEAT 2017’

XVIIth European
Symposium on the
Quality of Eggs and
Egg Products

XXIIIth European
Symposium on the
Quality of Poultry Meat.



EGGMEAT 2017
3-5th September, Edinburgh, Scotland

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The symposia is organised by the Eggmeat 2017 committee under the auspices of the UK branch of the World' Poultry Science Association (WPSA) and the European Federation of the WPSA.

The EGGMEAT 2017 symposium is a joint activity of working groups 4 and 5 of the European Federation of the WPSA. This symposium forms part of the WPSA's mission to support education, organisation and research in the poultry sector. An industry that provides a large proportion of the world's food.



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Introduction

It is our great pleasure to welcome you to Edinburgh for the 17th European Symposium on the Quality of Eggs and Egg Products and the 23rd European Symposium on the Quality of Poultry Meat. This meeting is being held under the auspices of the UK branch of the WPSA.

The poultry industry relies on science and its application. These meetings are important in making sure we educate future scientists and keep advancing to meet the biggest challenges the world faces in terms of sustainable food supply. We have worked hard to provide a stimulating programme across the topical issues we see facing the industry, but ultimately, it is the delegates that make the meeting a success.

The meetings of the working groups have a long history. In the case of the meat WG5 starting in 1973 and for egg WG4 since 1991. A full history can be read under the working group section of the WPSA web site <http://www.wpsa.com/index.php> or on the conference web site.

We have tried some new ideas in the format of this meeting and as always it will be good to get feedback on what did and did not work. This is important to help the meeting evolve to continue to meet the needs of industry and egg and meat science.

Have a good conference,

Ian Dunn and Maureen Bain (Co-Chairpersons)



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*Plen =plenary, A=Invited speaker, CS=Contributed speaker, SO=short oral, P=poster

PLENARY SESSION 1

PLEN_I_P_1

NUTRITION AND METABOLISM IN POULTRY: ROLE OF LIPIDS IN EARLY LIFE

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Fertilized egg provides physical environment and serves as a reservoir of nutrients that are needed for sustaining the growth, development and maturation of the hatchling. For a viable healthy chick, all the necessary nutrients must be deposited into the egg by the breeder hen. Currently, little consideration is given to the breeder hen dietary fat composition and what effect it may have on immune, or inflammatory responses or other metabolic disorders/pathologies in progeny chickens. Transgenerational effects of certain nutrients such as lipids and essential fatty acids are gaining increased attention in the field of human and animal medicine as a new tool to improve immune health and animal performance during perinatal life. During incubation, egg lipids are the major source of energy and are the only source of polyunsaturated fatty acids that are needed for embryonic structural membrane synthesis. In addition, certain polyunsaturated n-3 fatty acids (e.g. eicosapentaenoic acid, (20:5n-3), docosahexaenoic acid (22:6n-3)) are needed for cellular signaling purposes, maturation and development of central nervous system, immune health, and inflammatory responses. The current industry practice of feeding hens diets high in n-6 fatty acids limits the n-3 fatty acid content in the serum, egg and the hatchling. The metabolites produced from n-6 fatty acid such as arachidonic acid (20:4n-6) is more pro-inflammatory than those produced from n-3 fatty acids. Early access to n-3 fatty acids are important because much of the immune system development occurs in early life in modern day fast-growing broiler chickens. The hypothesis tested is that early exposure to n-3 fatty acids during pre-hatch period through hatching egg will have long term positive impacts on tissue n-3 and n-6 polyunsaturated fatty acid composition, immune and inflammatory responses in the progeny broiler birds during the post-hatch period. Hatching egg n-3 fatty acid enrichment was achieved through hen diet manipulation or *in ovo* method. At post-hatch, chicks were fed diets varying in n-3 and n-6 fatty acids simulating a commercial diet. Immune or inflammatory responses and tissue fatty acid composition was assessed at different stages post-hatch. Overall, early access to n-3 fatty acids through hatching egg led to the following changes in the progeny chicks during perinatal life. 1) Increase in the retention of n-3 fatty acids in thrombocytes, peripheral blood mononuclear cells, brain, cardiac, hepatic, gastro intestinal, and immune tissues. 2) Decrease in tissue and immune cell arachidonic acid content. 3) Decrease in the production of proinflammatory eicosanoids (e.g. prostaglandin E2, leukotriene B4) by cardiac and immune cells. 4) Decrease in the production of inflammatory cytokine (interleukin-6) in liver and serum. 5) Decrease in cell mediated immune response. The plasticity and responsiveness to *in ovo* n-3 fatty acid nutrition varied among immune cells, tissues and different sections of the gastrointestinal tract. The positive impacts associated with *in ovo* nutrition persisted anywhere from seven up to 35 days post-hatch in progeny chickens. Considering the decreased age to market of modern-day commercial broiler chickens, 21-day pre-hatch period, constitute over >35% of the broiler chicken life span. Therefore, "feeding the embryo" or early nutrition through *in ovo* method

offers a powerful and holistic tool to promote the health of the hatchlings in a natural and sustainable way. Exploring the biological mechanisms associated with *in ovo* nutrition will expand our knowledge on the importance of maternal diet, and can lead to dietary strategies that will ameliorate hatchability loss, early chick mortality and culls, and will improve perinatal chick immune health and productivity.

Keywords: hatching egg, embryo, n-3 fatty acids, eicosanoids, in ovo nutrition

PLEN_I_P_2

DOES IMPROVED ANIMAL WELFARE RESULT IN BETTER PRODUCT QUALITY?

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Because of the increasing demand for raw cuts and processed products, there is a trend to producing very heavy broilers. Breeds that are used for such kinds of production have been intensively selected for growth rate and breast meat yield, and birds are reared for a longer period than standard broilers. In the same time, poultry meat industry has faced numerous quality issues related to these practices. The most known are the myodegenerative defects Wooden Breast and White Striping, whose increasing incidence seriously penalizes the competitiveness of the poultry industry but also its image among consumers. Even if the etiologic origin of these defects are not yet well established, there are several evidences of developmental and metabolic disturbances that affect muscle integrity and may lead to the appearance of such meat defects. This includes hypoxia, altered glucose utilization, increased oxidative stress, protein catabolism, cellular repair and regeneration process, and in some case abnormal accumulation of intracellular calcium. All these changes have direct incidence on muscle composition and structure but also may affect animal robustness and welfare. Indeed, it has been shown that increasing slaughter age simultaneously affect bird welfare and breast meat quality in a modern heavy broiler line. Changes were particularly marked between 42 and 49 d of age, a period during which hypertrophy of muscle fibres was maximal and major changes in behaviour occurred, especially for walking ability, locomotion, and panting. Hypertrophy of the fibres, obtained by either selection, improved nutrition or longer rearing, leads to cellular glycogen depletion, which is the main energy reserve of the breast glycolytic muscle. Up to a certain level, this decrease induces an improvement in the technological and sensorial characteristics of the meat since it increases its ultimate pH. However, recent evidences have shown that a significant muscle glycogen depletion, obtained by selection, can negatively affect broiler activity (measured through the gait score) and probably be involved in the occurrence of new degenerative muscle defects. Indeed, recent observations showed that broilers selected for a high breast meat pHu, which corresponds to a low level of muscle glycogen, rather used energy produced from amino acid catabolism and lipid oxidation rather than carbohydrate, leading to an adaptive response to oxidative stress and regeneration process in muscle. This underlines the likely role of a decrease in muscle energy status in several metabolic and cellular processes that are also involved in the establishment of emerging defects, white striping and wooden breast. Moreover, the broiler line selected for high breast meat pH shows higher mortality rate in suboptimal conditions and their muscles are more affected by the white striping by comparison to the corresponding line selected for low meat pH. In a general way, selection for growth and high breast yield as well as increasing weight of animals at slaughter led to an increase in the lipid content of the breast meat, which penalizes its nutritional quality and in some case its appearance (white striping). The occurrence of

white striping and wooden breast defects is also concomitant with decreased muscle protein content. Altogether, these trends negatively affect the recognized dietary value of chicken fillet, and thus its interest for some consumers. In addition, there are questions about the conditions of production of poultry and respect for animal welfare. For all these reasons, there is currently a renewed interest in alternative production systems based on the use of less efficient strains. These systems respond to a number of societal and economic issues, whether linked to meat product quality or animal welfare. From a nutritional point of view, meat from slow- or intermediate-growing genotypes appeared healthier, with less fat and higher content of proteins and omega 3 fatty acid than modern fast-growing genotypes, and might better fit with the consumer's expectations. They are also little or not affected by emerging muscle degenerative defects, and the breeding methods from which they originate are generally more respectful of animal welfare (access to the open air, lower stocking density, less musculoskeletal problems, etc.). Access to the grass can also improve carcass composition and the nutritional quality of meat that is enriched in omega 3 fatty acid and several bioactive compounds like carotenoids, tocopherols, and flavonoids. These systems have existed in France for many years and now account for 40% of household consumption in this country. They begin to develop in other European countries. However, high production cost compared to standard systems may be an obstacle to their development on the sectors of cutting and processing, which are now predominant in most developed countries. Therefore, a compromise between techno-economic performance, animal welfare and product quality must be reached, which requires a better understanding of the genetic and physiological mechanisms that control these traits and their interactions to allow optimal co-adaptation of the animal and its type of farming while maintaining competitive production systems. The objective of this review is to present the knowledge about the biological mechanisms involved in the development of the quality of poultry meat and understand how selection and production practices can promote robust and well-being animal as well as the quality of poultry meat.

Keywords: broiler, meat defects, welfare, genotype, production system

EGG SESSION I

EGG_I_A_1

TECHNOLOGICAL ADVANCES IN EGG PRODUCT PROCESSING WITH REFERENCE TO ALLERGENICITY

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Egg is a widely used ingredient in many food products all around the world. It is indeed a major source of high quality proteins and essential nutrients and provides many desirable functional attributes such as foaming, emulsifying, gelling, colouring, and flavouring. However, hen's egg is also one of the most frequent allergenic foods, particularly in childhood, affecting 1.6 to 3.2 % of young children in Europe. Egg products represent 15 to 50% of egg consumption in Europe depending on the country. For microbiological safety reasons, thermal treatments are applied to egg products. Liquid egg products are thus pasteurized for 2 to 6 min between 56°C (for egg white) and 68°C (for whole egg and yolk), whereas egg white powders are dry-heated up to several weeks between 60 and 80°C. The effects of these treatments on egg functional properties have been widely studied; this is not the case for egg protein digestibility or allergenicity. The aim of our study was thus to investigate the effect of a wide range of pasteurization rates (on liquid whole egg) or dry heating rates (on egg white powder) on the *in vitro* digestibility, antigenicity and allergenicity of egg proteins. Liquid whole egg was pasteurized from 2 to 6 min between 60°C and 66°C, and egg white powder was dry heated from 1 to 10 days between 60°C and 90°C. *In vitro* digestion of samples was performed using a model that mimics successive gastric and duodenal stages of digestion in the adult human. The degree of hydrolysis was quantified by OPA method at the end of each stage, and the SDS PAGE pattern was followed throughout the *in vitro* digestion. Ovomucoïd, ovotransferrin and lysozyme antigenicity was tested by inhibition ELISA with specific monoclonal antibodies. Liquid whole egg allergenicity was investigated in 54 egg-allergic children by skin prick testing and IgE-binding pattern to egg proteins was determined by indirect ELISA. Egg white powder allergenicity was tested on mice sensitized and challenged through oral route by measuring plasmatic histamine concentration, specific and total IgE and IgG levels, and cytokine concentration in spleen cell culture supernatants. Pasteurization of liquid whole egg, from 4 to 10 min at 60°C, improved protein *in vitro* digestibility and decreased ovomucoïd antigenicity, but did not significantly change ovotransferrin and lysozyme antigenicity. Conversely, pasteurization from 4 to 10 min at 66°C decreased protein *in vitro* digestibility and lysozyme antigenicity, but increased drastically ovotransferrin antigenicity. Pasteurization (6 min at 66°C) had a limited impact on the prick test (PT) reactivity of most children. However, two main classes of patients were obtained from PT diameter variations: for 34 children, pasteurization had no impact on PT reactivity, whereas for 20 children, pasteurization significantly decreased reactivity. A large effect was even found for 4 children who had null PT with pasteurized liquid whole egg. No correlation was found between patterns of IgE-binding to egg proteins and patterns of PT-reactivity as a function of pasteurization. Dry heating of egg white powder, from 1 to

10 days at 60°C, improved protein *in vitro* digestibility and slightly decreased lysozyme antigenicity. On the other hand, dry heating over 1 day at 80°C or 90°C decreased protein *in vitro* digestibility and lysozyme antigenicity, but drastically increased ovotransferrin antigenicity. Dry heating of egg white powder up to 7 days at 80°C had a limited impact on egg allergy tested in mice. No significant effect was found on histamine concentration, or specific and total IgE and IgG levels. Only a significant decrease of IL4 cytokine concentration was observed for mice groups fed with dry heated powders. Heat treatments applied to egg products thus have, in most cases, a rather low impact on *in vivo* allergenicity, despite significant changes in protein digestibility and antigenicity.

Keywords: egg protein, allergenicity, immunoreactivity, pasteurisation, dry-heating

EGG_I_CS_1

PHYSICOCHEMICAL CHARACTERISTICS, FUNCTIONAL PROPERTIES AND RHEOLOGICAL BEHAVIOURS OF ULTRASOUND TREATED LIQUID WHOLE EGG

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The physicochemical, functional properties and rheological behaviours of ultrasound (US) treated liquid whole eggs (LWE) were investigated. LWE were treated with ultrasound for 3 or 6 min of exposure time and 150 W or 375 W using a Hielscher Ultrasonic Processor. The pH, dry matter, water activity (a_w), colour analysis (L^* , a^* , b^*), relative foaming capacity (RWC), foam stability and rheological behaviors of the US treated and untreated LWE were compared. The flow ramp, oscillation amplitude, oscillation frequency and temperature ramp (40 and 80 °C) were measured using an oscillatory rheometer. Shear rate ranged from 0.01 to 100s⁻¹ at 150 W. US treated and non-treated LWE samples behaved as non-Newtonian fluids displaying shear thinning which were best fitted to a Herschel-Bulkley flow model. Significant differences ($P < 0.05$) in physicochemical and functional properties of LWE were recorded. US treated LWE had a significant reduction in viscosity from 250 to 120 mPa.s, except when treated at 150W for 3 min, while better foaming properties (control groups 470±17.32; 150 W – 3 min US 493±11.54; 150 W – 6 min US 508.33±12.58; 375 W – 3 min US 480±14.14 and 375 W – 6 min US 486±15.27) were obtained for all US treatments without any significant negative effect on physicochemical composition. The higher US treatment of LWE caused significant reduction in a^* value, control 4.11±0.02; 150 W – 3 min US 4.07±0.01; 150 W – 6 min US 3.93±0.03; 375 W – 3 min 3.91±0.03 and 375 W – 6 min US 3.89±0.03. The pH, dry matter, a_w , and RWC of treated LWE ranged from 7.17±0.05–7.22±0.08; 24.91±0.29–25.01±0.57; 0.95±0.009–0.96±0.008, and 470±17.32–508.33±12.58, while untreated LWE measurements was 7.22±0.08; 25.01±0.57; 0.956±0.001 and 470±17.32 respectively. The results suggest that treatment of LWE with ultrasound significantly improves some of the functional properties.

Keywords: liquid whole egg, ultrasound treatment, rheological behaviours, physicochemical and functional properties.

EGG_I_CS_2

APPLICATION OF IR SPECTROSCOPY TO CLASSIFY EGG WHITE POWDERS BASED ON TECHNOLOGICAL PROPERTIES

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The use of egg white powder (EWP) is widespread in food industries due to its gelling and whipping properties. Many factors affect EWP performance, so that “high gel” or “high foam” products do not always meet end-user expectations. Thus, the aim of this work was to evaluate the suitability of FT-NIR and FT-IR spectroscopy as rapid, easy, and cost-effective tools for the classification of EWP based on technological properties.

FT-NIR and FT-IR spectra of 100 EWP samples with known technological performances, kindly provided by Sanovo Egg Group, were collected and elaborated by suitable chemometric strategies. A DUPLEX algorithm was used for data splitting in calibration and test sets, and different pre-treating methods were applied before Partial Least Squares–Discriminant Analysis (PLS-DA), performed according to gel strength (600 g/cm² threshold), foam height (160 mm threshold) and foam instability (35 ml threshold).

The best model was obtained for foam instability prediction by FT-IR data after linear baseline pre-treatment, with 19 out of 25 samples of the test set being correctly classified.

In conclusion, IR spectroscopy can be considered as a potential tool for a rapid and non-destructive classification of EWP on the basis of gelling and whipping properties.

Keywords: egg white powder, classification, gelling properties, whipping properties, IR spectroscopy.

EGG_I_SO_1

EFFECT OF ORGANIC SELENIUM SUPPLEMENTATION ON THE TECHNOLOGICAL PROPERTIES OF EGG WHITE

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Selenium (Se) is a key constituent of selenoproteins, which are enzymes that play a major role in the antioxidant system. The present study aimed to evaluate the effect of different selenium sources on the technological properties of the egg white. Freshness (Haugh units), white viscosity and foam cohesion were assessed. 1560 Rhode Island layers were randomly assigned one of the two following diets: control diet with 0.3 mg/kg Se as Sodium Selenite or experimental diet with 0.3 mg/kg Se as hydroxy-selenomethionine (OH-SeMet or Selisseo[®]) from 53 weeks of age. Laying performance and

egg quality were assessed at 55 and 60 weeks of age. While the source of selenium did not affect the laying performance, the organic selenium tended to improve shell quality through enhanced static stiffness and fracture force. OH-SeMet also improved the egg freshness after 8 days of storage. Thick white from the experimental group had a significantly higher viscosity under a 0.1 s^{-1} and 1 s^{-1} shear pressure. OH-SeMet numerically improved egg white foam cohesion. This study demonstrates that supplementing OH-SeMet to laying hens is of interest to improve the technological properties of egg white.

Keywords: egg quality, selenium, OH-Selenomethionine, viscosity, haugh units, foam cohesion

EGG_I_SO_2

DEVELOPMENT OF NEW FUNCTIONAL FOOD PRODUCTS FROM EGGS

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Functional food products (FFP) with a beneficial effect on the health of consumers require the development of new technologies that promote the bioavailability and preservation of functional food ingredients (FFI). Eggs of poultry are a unique source of nutrients with high biological and nutritional value with a complete complex of macro- and microelements. The technology of ready-to-use FFP is based on earlier technology developed by us of granulated coagulated protein and mélange which is based on acid-salt hydrolysis during the process of heat treatment of raw materials. To obtain the FFP we used a biofortification approach through enrichment with essential nutrients at various stages of processing food raw materials and obtaining the final product. At the different stages products were added: 1) to the poultry diet - omega-3 fatty acids, selenium, and vitamin E; 2) during heat treatment - calcium and iodine; 3) during preparation of the formulation - an organic form of zinc. Process parameters, methods, and levels of inclusion of FFI were established to ensure the content in the product was not less than 20% of the normal of consumption, assuming that they are bioavailable and remain intact during storage.

This work was supported by the Russian Scientific Foundation [grant number 16-16-04047].

Keywords: biofortification, coagulation, essential nutrients, enrichment, functional egg products

EGG_I_SO_3

NEW FOOD PRODUCTS FROM EGGS

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Eggs are an important source of nutrients and substances with specific functions. However, the variety of convenient products from processed eggs is not large. We have developed technology to produce a new range of products from eggs and their components.

Coagulation of protein, yolk, and a mélange was carried out by light acid-salt hydrolysis combined with heating. The products obtained were a granulated protein (the appearance and taste of which is similar to cottage cheese), a product similar to cheese, granulated mélange, and yolk paste. It was found that their antigenicity determined by ovalbumin was reduced by 4.5 times. Using the granulated protein as a basis an assortment of dessert products with fruit fillers, spicy products with herbs, olives, etc has been developed. Using mélange and yolk as the basis spicy foods and pates have been developed. The composition is presented in the table.

| Mass fraction, % | Granulated | | |
|------------------|------------|-----------|------|
| | Mélange | Protein | Yolk |
| Moisture | 74,5 | 84,3-78,4 | 60,5 |
| Protein | 13,4 | 14,9-18,1 | 12,7 |
| Fat | 10,2 | <0,1 | 23,7 |

This work was supported by the Russian Scientific Foundation [grant number 16-16-04047].

Keywords: egg, egg products, coagulation, chemical composition

EGG_I_SO_4

COLOR CHANGES OF COATED, OZONE AND ULTRASOUND TREATED EGGS DURING LONG TERM STORAGE

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The objective of this research was to evaluate the effectiveness of 4 innovative treatments, shellac (S) and lysozyme-chitosan (LC) coatings, gaseous ozone-O (6 ppm, 4 min) and ultrasound-U (450 W, 4 min) on the colour of eggshell, yolk, and albumin after storage at ambient temperature for 6 weeks. Eggs were white from Lohmann White laying hens at 41 weeks of age. The effectiveness of each treatment and untreated-uncoated control group eggs was evaluated using a Minolta colorimeter with CIE colour space L*, a*, b* values. The lightness and redness of shellac coated eggshells were significantly lower (P<0.05) and the yellow colour (13.27±1.19) was significantly (P<0.05) higher compared to LC coatings (2.08±0.31), gaseous ozone (2.22±0.87) and ultrasound (1.68±0.44) respectively. The albumin L* value of control eggs before storage was 79.67±2.83 and at the end of storage control albumin L value decreased to 69.79±2.28. Discolouration of the albumin may occur during long time storage. The main factor influencing internal egg quality is duration of storage. Treated and coated eggs albumen L values were ranged between 72.95±2.28 to 75.48±2.17 which indicate no difference in albumen colour values with treatments. However, a* values of ozone

treated eggs's albumen were significantly different ($P < 0.05$) from control (-5.78 ± 0.79), S coating (5.69 ± 0.76) and U treatment (-5.61 ± 0.86). The egg yolk L^* value decreased significantly during storage from 54.94 ± 1.90 to 52.51 ± 2.04 . The a^* value of yolk control (11.89 ± 2.79) were significantly different from treatments of S (9.30 ± 2.96), LC (9.45 ± 3.29), O (9.92 ± 3.12) and U (10.12 ± 3.05). This study showed that LC coatings, ozone and ultrasound treatments could be an alternative for maintaining the colour of egg shell and yolk during long-term storage, except shellac wax which produces a yellowish colour surface on eggshells.

Keywords: hen's eggs, colour analysis, non-thermal technology, ultrasound, ozone, shellac coating, lysozyme-chitosan coating, egg quality, storage, shelf-life.

EGG_I_SO_5

DIETARY HIGH-OLEIC ACID SOYBEAN OIL ATTENUATES THE DEPOSITION OF TOTAL n-3
POLYUNSATURATED FATTY ACIDS (PUFA) AND VERY LONG-CHAIN (>20 C) n-3 PUFA INTO EGGS OF
LAYING HENS FED FLAXSEED OIL

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Although chickens can hepatically synthesize EPA (20:5 n-3) and DHA (22:6 n-3) from alpha-linolenic acid (ALA; 18:3 n-3), the process is inefficient. Enzymes of this biosynthetic pathway also catalyze the production of arachidonic acid (20:4 n-6) from linoleic acid (LA; 18:2 n-6). In the present study, the influence of dietary high-oleic acid (OA; 18:1 n-9) soybean oil (HOSO) on egg and tissue deposition of ALA and n-3 PUFA, synthesized from dietary ALA provided by flaxseed oil (FLAX), was investigated in White Leghorn hens fed a reduced LA baseline diet. We hypothesized that reducing the dietary level of LA, as compared to that of previous studies in our lab, would promote greater hepatic conversion of ALA to very long-chain (VLC; >20C) n-3 PUFA, while supplemental dietary HOSO would simultaneously enrich eggs with OA without influencing the egg deposition of n-3 PUFA. Nine 51-wk-old hens each were fed either 0, 10, 20, or 40 g HOSO/kg diet for 12 wk. Within each group, supplemental dietary FLAX was increased every 3 wk from 0 to 10 to 20 to 40 g/kg diet. Compared to controls, FLAX maximally enriched yolk total n-3 and VLC n-3 PUFA contents by 9.4-fold and 2.2-fold, respectively, while the 40 g/kg HOSO treatment maximally attenuated the yolk deposition of total n-3 and VLC n-3 PUFA by 32% and 15%, respectively. In the context of producing a more "heart healthy" value-added egg, these results suggest that dietary OA is not "neutral" with regard to the overall process by which dietary ALA is absorbed from the gut of the laying hen, hepatically metabolized, and deposited into egg yolk either intact or in the form of longer chain/more unsaturated n-3 PUFA derivatives.

Keywords: alpha-linolenic acid, egg yolk, laying hen, oleic acid, very long-chain n-3 polyunsaturated fatty acids

EGG_I_SO_6

EFFECT OF FEEDING VEGETABLE OIL AND JUICE INDUSTRY BY-PRODUCTS TO LAYING HENS ON EGG QUALITY

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The most efficient disposal of by-products resulting from the vegetable oil and juice industry is to use them as animal feeds ingredient. To this purpose, we conducted a 5-week feeding trial on 160 Tetra SL layers (56 weeks), assigned to 4 groups. Compared to the conventional diet formulation given to the control group C (2750 kcal/kg ME and 16.5% CP), the diet formulations for the experimental groups included vegetable oil and juice industry by-products: E1 (9.5 % rapeseeds meal + 3 % grape pomace); E2 (8.70% flaxmeal + 3 % buckthorn meal); E3 (9% pumpkin meal). In experimental week 5, 18 eggs/group were collected randomly and used to determine the quality of the external and internal parameters of the eggs. No significant ($P>0.05$) differences were noticed regarding: egg weight and the weight of the egg components; eggshell breaking strength and the Haugh unit. Yolk colour intensity in group E2 group was significantly ($P\leq 0.05$) greater than in groups C and E1. The albumen pH value of group C eggs (8.95 ± 0.04) was significantly ($P\leq 0.05$) higher than in group E3 (8.78 ± 0.052), which also had the highest proportion (33.33%) of AA grade eggs. The structures of E2 (which included flaxmeal and buckthorn meal) and E3 (which included pumpkin meal) diet formulations had a positive influence on the quality parameters of the eggs.

Keywords: vegetable oil by-products, laying hens, egg quality parameters

EGG_I_SO_7

EFFECT OF THE DRIED TOMATO POMACE ADDED TO LAYER DIETS HIGH IN OMEGA 3 POLYUNSATURATED FATTY ACIDS, ON THE INTERNAL AND EXTERNAL QUALITY PARAMETERS OF THE EGGS

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A 6-week feeding trial was conducted on 120 Tetra SL (53 weeks) layers whose diets were supplemented with dried tomato pomace (DTP), a food industry by-product. The layers, assigned to 4 groups (30 hens/group), received diets with the same basal formulation (17 % CP; 2750 kcal ME). The diet formulations for the experimental groups differed from the conventional diet formulation C, by the inclusion of 5% flax meal and of different levels of DTP: E1 (2.5 %); E2 (5 %) and E3 (7.5%). Samples of 18 eggs/group were collected every 2 weeks and assayed for their quality parameters. Overall, yolk colour intensity was significantly ($P\leq 0.05$) higher in the experimental groups compared

to the control group. Yolk colour intensity increased linearly with the dietary DTP level. No significant differences were noticed in eggshell thickness, eggshell breaking strength and Haugh units. Group E3 (7.5% DTP) recorded the highest percentage of XL eggs (4.15%), compared to the group C (0.8%). The dietary use of DTP in various amounts significantly increased yolk colour intensity

Keywords: layers, dried tomato pomace, egg yolk, quality, colour

EGG_I_SO_8

PROFILE OF FATTY ACIDS OF EGG YOLKS FROM BROILER BREEDERS SUPPLEMENTED WITH CLA

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Conjugated linoleic acid (CLA) improves immunity; however, it may change the saturated:unsaturated (S:U) fatty acids ratio in the yolk, influencing egg quality and increasing the risk of embryonic mortality. This study aimed to evaluate the fatty acid profile of egg yolks from Cobb 500[®] breeders supplemented with CLA. Two breeder flocks fed control or CLA-supplemented (0.025%) diets were raised in a completely randomized design. Yolks of 30 eggs per treatment were grouped in three pools for fatty acids profile determination by gas chromatography. Data were submitted to ANOVA and F test to compare the means at 5% probability. Supplementation led to higher omega-6 composition and percentages of margaric, stearic, linoleic, gamma-linolenic, and arachidonic acids, and lower composition in monounsaturated, unsaturated, and total fat, as well as lower percentages of palmitoleic and oleic acids (P<0.05). Among the alterations, change in linoleic acid amount is important, since it affects egg size. CLA interferes with desaturase enzymes action, changing fatty acids structure. 0.025% CLA supplementation reduced unsaturated fat percentage, but didn't change the S:U ratio. In conclusion, CLA changes the fatty acids profile of the yolk; however, the tested level is safe for breeders, since it did not change the S:U ratio.

Keywords: Breeder nutrition, egg composition, hatching egg, omega-6

MEAT SESSION I

MEAT_I_A_1

SLOW-GROWING BROILERS WITH FREE-RANGE ACCESS: EFFECTS ON MEAT QUALITY

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The market share of free-range and organic poultry meat is a niche market in most countries, but demand is increasing. Meat from free-range or organic broilers is often perceived as healthier, tastier, of better quality, and originating from animals with better welfare than conventional meat. Reasons for differences in meat quality could be due to alternative systems entailing use of slower-growing genetic strains, different diets, low stocking density and provision of outdoor access. Effects of outdoor access are not straightforward. A literature study shows conflicting results regarding e.g. body weight (BW), water-holding capacity, colour, pH, fat and protein content and taste. Differences between studies may be due to different genetic strains, growth rates, diet, range design (e.g. vegetation type) or range use. The latter is rarely being reported, and since broilers are known to make limited use of the free-range area this could impact the results of the studies. Our study aimed to investigate the effect of different levels of free-range use on meat quality. To achieve different levels of range use, different shelter types were used as these are known to be important in attracting chickens to the range. In two production rounds, 8 groups of 50 slow-growing broiler chickens (Sasso XL451) were housed indoors from day 0 – 70 (IN); 16 groups were housed indoors until day 28 after which they were given outdoor access to grassland with artificial shelter (AS; 8 groups) or to a range with dense vegetation (short rotation coppice willow; SRC; 8 groups) until day 70. Free-range use was higher in the groups with access to dense vegetation than those with artificial shelter (42.8 vs. 35.1% of the chickens being outside at a given time; $P < 0.001$). BW at day 70 was higher for IN groups than for AS and SRC (2.79 vs. 2.66 and 2.68 kg; $P = 0.005$). In the breast muscle, L values were lower (54.0 and 53.9 vs. 55.2; $P = 0.021$), and b values higher (14.9 and 14.7 vs. 13.4; $P = 0.001$) in the AS and SRC groups compared to IN; indicating that outdoor access resulted in darker and more yellow meat. AS groups had a higher ultimate pH and lower drip loss than IN. Fat, protein and moisture contents did not differ between treatment groups. AS groups did have a higher PUFA content and PUFA:MUFA ratio compared to IN, with SRC being intermediate. A blind taste panel judged the SRC meat to be less fibrous and more tender than that of AS and IN, and more juicy than IN. Our study indicated improved meat quality and taste for broilers with outdoor-access compared to indoor-housed broilers, but no clear differences between AS and SRC, perhaps due to insufficient differences in range use. Concluding, studies on effects of outdoor access on meat quality are inconclusive, and when differences are found these are often relatively small. Other factors than outdoor access may be more important for differences between free-range or organic and conventional meat. In addition to the factors mentioned before, consumer expectations have been shown to be important, and perceived differences may possibly overrule actual ones.

Keywords: outdoor, sensory characteristics, colour, fatty acid, perception

MEAT_I_A_2

INFLUENCE OF CATCHING METHODS ON THE OCCURRENCE OF LESIONS IN BROILERS

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Catching and carrying of broilers for transport to slaughter might lead to lesions. Based on a recommendation of the Council of Europe (1995) in Germany "Federal Guidelines for Keeping of Fattening Broilers" have been developed and require the catching and carrying of broilers by their two legs only. In preparation of this recommendation, a field study was performed comparing the routine procedure (1 leg per bird) with a procedure in which both legs of one bird were grabbed. Light and heavier birds caught by two catching teams were included in the study. After slaughter and plucking, a camera recorded all birds enrolled in this study, data were processed and the results with respect to lesions were evaluated for each group. Observations: Lesions at the body, the legs and the wings were recorded by a camera, which compared the individual animal against a predefined standard for each body region. For body and legs, lesions were recorded as an accumulation of red and blue pixel in an area of the organ. These lesions were haemorrhages. Wing lesions were divided into haemorrhages and fractures. For detecting wing fractures an expected axis between the wings and the body was defined before the study. Each deviation of the predefined range of this axis was recorded as fracture. The lowest number of haemorrhages was observed on the body, followed by those on the wings and on the legs (table 1).

Keywords: broiler, catching, animal welfare, lesions

MEAT_I_CS_1

SIMULATED TRANSPORT OF SLAUGHTER CHICKENS – EFFECT ON METABOLISM AND MEAT QUALITY

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The last ride in the life of a broiler to the slaughterhouse can vary depending on the weather and the conditions on the truck. Temperature, humidity and transport time are all factors that will affect the welfare and stress levels of the broilers, which may eventually affect the meat quality. In the present experiment, we aimed at identifying the relationship between temperature, humidity and transport time on the metabolism and meat quality traits. Approximately one thousand Ross 308 chickens were bought from a commercial broiler producer and placed in transport cages with 14 broilers in each (approx. 160cm²/kg), and exposed to simulated transport for either 0, 3 or 6 h at 4 different temperatures (5, 20, 28 and 35°C) and two humidity's (High: RH 85, 85, 78 and 70 %; Low: RH 80, 64,

63 and 60% depending on temperature). At the end of the period, 20 broilers per treatment were sacrificed and blood and muscle tissue were sampled. The broilers held in the cages for 6 h had lower serum cortisol, more macro-glycogen in liver and muscle, and less denatured protein 1 h post mortem than broilers held for only 3 h. These characteristics suggest that the broilers had adjusted to the environment and were less stressed, which would be beneficial for meat quality although the animal welfare aspect needs proper investigation.

Keywords: broilers, transport stress, temperature, humidity, transport time

MEAT_I_CS_2

IMPACT AND VARIABILITY OF CARCASS LESIONS IN THE BROILER INDUSTRY

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The aim of this study was to assess the variability in major carcass lesion types between processing plants across Europe. Seven European abattoirs were evaluated. Apart from average values, results are presented by company (names remain anonymous) for lesion scored. This reveals a comparison between the company with the best performance (BEST) and the company showing highest incidence (HIGH) for each scored lesion. On average, 20% of carcasses observed were downgraded due to skin tears near the tail, revealing a variation between BEST and HIGH from 7% up to 31%. Out of these downgraded carcasses, 18% of lesions in the HIGH company were classified as severe. Wing bleeding (19% average; 12% BEST; 28% HIGH) and blood splashes (9% average; 3% BEST; 20% HIGH) were the most common vascular lesions. On average, ossification was (to some extent) compromised in 21% of the birds, with a HIGH of 39% and a BEST of 5%. Based on this study, the HIGH company would lose approximately 9.8% of commercial value due to downgrades found, whereas the BEST company would only lose 1.2%

Keywords: carcass lesion, skin quality, bleedings, downgrades

EGG SESSION II

EGG_II_A_1

BREEDING TECHNIQUES TO IMPROVE EGG NUMBER AND QUALITY

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Egg production and quality are critically important for layer chicken and are also of high importance to broiler breeders as they determine the number and quality of chicks. Over the last decades, selection has been practiced by combining phenotypic records of selection candidates and their relatives using a BLUP animal model. Different traits have been proposed to evaluate egg quality (for example for shell quality: puncture score, specific gravity, breaking strength, dynamic stiffness, shell weight, shell thickness) and statistical models were developed that consider repeated records and the longitudinal nature of egg production and quality, including repeatability, multi-trait, fixed and random regression models. By adapting more adequate statistical modelling, accuracies of estimated breeding values (EBV) can be increased by 10% without any additional costs. Figure 1 gives an example of changes in accuracy of EBV for dynamic stiffness by moving from a repeatability to a multi-trait repeatability model.

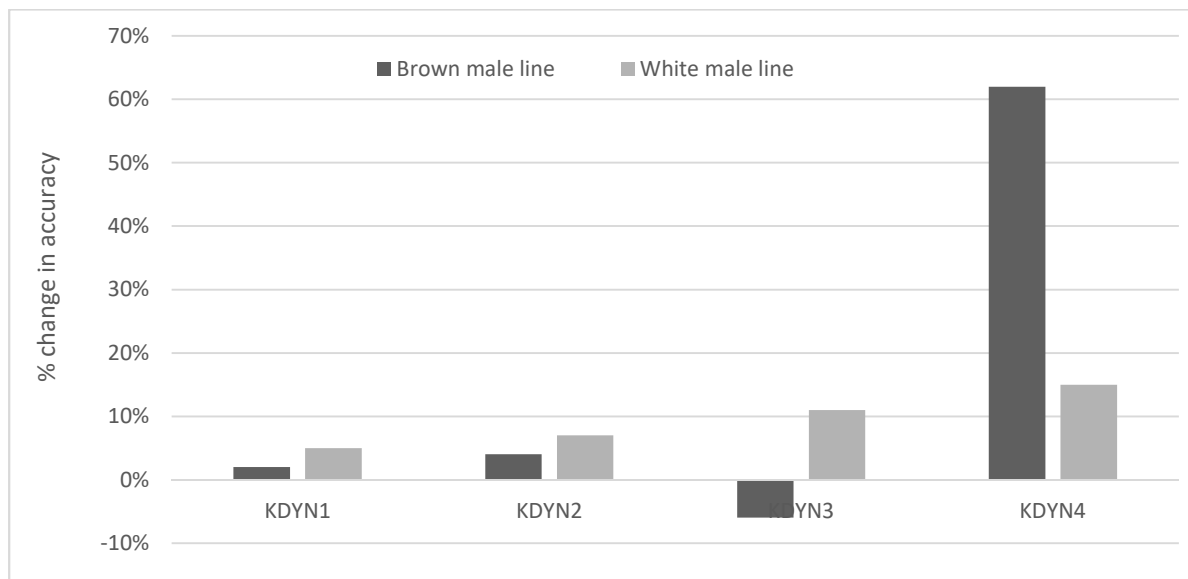


Figure 1. Change in accuracy of estimated breeding values for dynamic stiffness from using repeatability to multi-trait model

Deriving EBV using the assumption that traits are affected by many genes, each with small effects, has led to impressive responses (for example doubling of egg production) but limited understanding of the genetic nature of traits. Since the discovery of genetic markers, including blood groups, RFLPs and microsatellites, multiple genome wide association studies were performed and have identified multiple regions in the chicken genome (Quantitative Trait Loci) associated with egg production and with external (egg shape, egg weight, shell colour, shell strength) and internal (albumen height, yolk weight, meat and blood spots) egg quality. Despite all these efforts, only a few associations were identified with effects large enough to be relevant for industry applications and most of traits were estimated to be polygenic in nature. The chicken genome was sequenced in 2004, which enabled

development of SNP chips for massive, rapid and relatively inexpensive genotyping. This created new opportunities for utilizing genomic information in poultry breeding. A method called genomic selection utilizes markers across the whole genome to obtain EBV, resulting in higher accuracy, lower co-selection of relatives and opportunities to shorten generation intervals, leading to increased response to selection. An example of changes in accuracy by applying genomic vs pedigree-based information with the same set of phenotypes over a wide range of egg production and quality traits in two pure lines is in Figure 2. Accumulation of SNP chip data also increased the power of QTL detection.

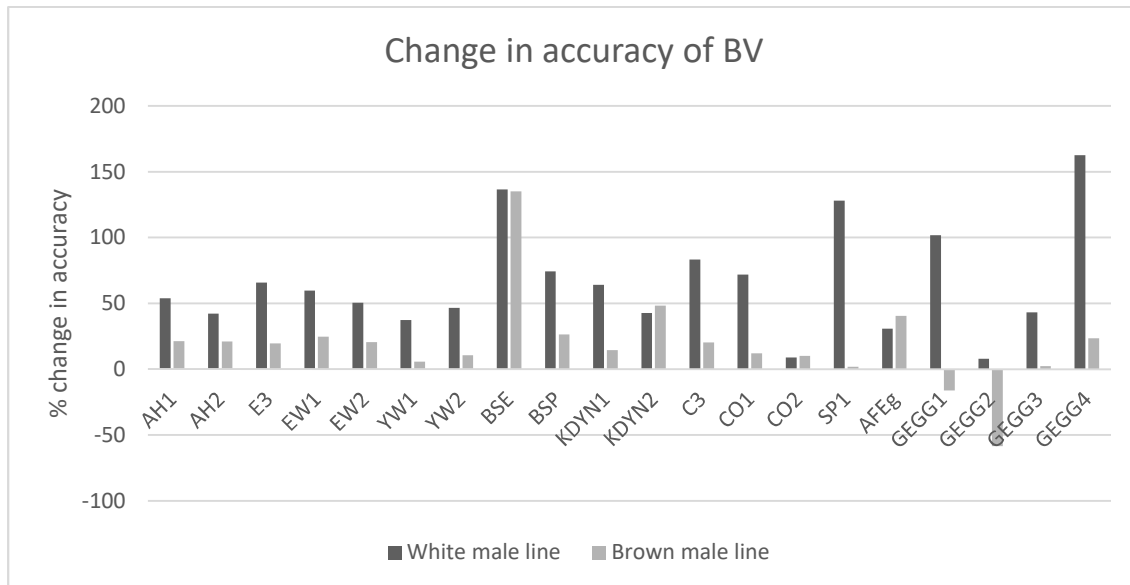


Figure 2. Change in accuracy of estimated breeding values by incorporating genomic information

Furthermore, availability of sequence data allows in-depth analysis of specific candidate genes, for example ovocalyxin-32 for shell quality. Additional information can also be introduced with other types of omics data: transcriptome, proteome, metabolome. In conclusion, the development of new ways to measure egg quality and to estimate the genetic merit of selection candidates provides new opportunities for improving egg production and quality through breeding.

Keywords: egg production, egg quality, modelling, genomic selection, candidate genes

EGG_II_CS_1

RELATIONSHIP BETWEEN HATCHABILITY AND EGG QUALITY TRAITS IN WHITE AND BROWN LAYERS

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In addition to production and egg quality traits, hatchability should be considered in layer breeding programs to maximise the production of first quality chicks. The aim of this study was to analyse the relationship between egg quality traits and hatchability. Data from four generations of white and brown pure line layers, in each two female lines (C and D), were analysed. Information of 89,803 hens was available. A moderate heritability was estimated for hatchability with $h^2= 0.26$ to 0.28 for the white lines and $h^2= 0.23$ to 0.33 for the brown lines. Egg weight was negatively correlated with hatchability in both, white and brown lines, ranging from $r_g= -0.37$ to -0.55 . In the white lines, hatchability was negatively correlated with albumen height ($r_g= -0.27$ and -0.37), and positively correlated with shell breaking strength ($r_g= +0.28$ and $+0.27$). In the brown lines these correlations were almost zero. Yolk proportion was positively correlated with hatchability in white lines ($r_g= +0.35$ and $+0.41$). Furthermore, no relationship was found between hatchability and shell colour or mottling score. To conclude, hatchability is improved by selection, however, at the expense of egg weight. Improving eggshell quality will support the hatchability rate in white lines.

Keywords: layers, breeding, egg quality, hatchability

EGG_II_CS_2

COMPARISON OF THE QUALITY OF EGGS FROM DUAL PURPOSE AND COMMERCIAL HYBRID LAYER GENOTYPES

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In commercial egg production it is common practice to kill the males at hatching due to their poor growth performance. As more and more people believe that this is in contradiction to animal welfare, in several European countries politics is aiming to prohibit this procedure. Alternatives are in-ovo gender determination or the use of dual-purpose genotypes. Dual purpose genotypes combine satisfying egg production and growth rates. In Germany, the Integhof project was launched to investigate the reproduction and growth performance of the dual purpose genotype Lohmann Dual (LD) in comparison to the commercial layer genotype Lohmann Brown (LB). At five time-points during the laying period eggs (500 LD, 500 LB) have been analyzed for indicators of exterior and interior egg quality. Egg mass shell proportion and shell thickness of LD eggs was significantly lower than for LB eggs and shell color was brighter. LD eggs showed lower albumen height and higher yolk

proportion Deposition of pigments seemed to be different between LD and LB eggs. The incidence of blood and meat spots was significantly higher in LD eggs. LD and LB eggs did not differ in fatty acids profiles and sensory attributes.

Keywords: laying hen, dual purpose, shell quality, interior egg quality

EGG_II_CS_3

TEMPORAL EXPRESSION OF HEN UTERINE TRANSCRIPTS AT KEY STEPS OF SHELL MINERALIZATION

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The chicken eggshell is made of 95% of calcium carbonate in its calcitic form and 3.5% of organic matrix. The latter determines its ultrastructure and consequently its biomechanical properties. Four major events of the shell formation are described: (1) deposition and accumulation of metastable amorphous calcium carbonate (ACC) over the eggshell membrane surface, (2) rapid evolution and redistribution of ACC on specific nucleation sites to form calcite aggregates, (3) enlargement of calcite aggregates in larger calcite crystals, and (4) development of column of crystals with a preferred orientation perpendicular to the surface. We used an RNA-sequencing method to determine overexpressed hen uterine transcripts at each key mineralization stages. 4502 differentially expressed transcripts representing 3766 different genes were obtained and grouped in 14 clusters of transcript abundance throughout the calcification process. Gene ontology functional analysis established a list of 223 enriched GO terms belonging to 38 functional groups. Amongst these transcripts, 718 corresponded to potentially secreted proteins and 503 of them were previously identified in eggshell matrix and uterine fluid. This study is a major contribution to the characterization of genes and related proteins involved in the eggshell fabric, which could be used as potential biological markers of eggshell biomechanical properties.

Keywords: eggshell quality, biomineralisation, RNA-Seq, transcripts, functional analysis

EGG_II_SO_1

CUTICLE DEPOSITION DOES NOT AFFECT WATER VAPOUR CONDUCTANCE AND CAN BE MEASURED IN HATCHING EGGS WITHOUT COMPROMISING EMBRYO DEVELOPMENT

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Hatching success is affected by the rate of *water loss or water vapour conductance (WVC)* during *incubation*. Selection for cuticle deposition (CD) improves the egg's natural defence, but thicker

cuticles could negatively impact WVC. The aim of this study was to compare the WVC of eggs with good and poor cuticles. We also investigated if the process of staining the cuticle, that is required for CD measurement, has any detrimental effect on chick development. For WVC, we placed two eggs from hens known to deposit good or poor cuticles in a desiccator and monitored weight loss for seven days. Eggs from broiler breeder (BB, n=84) and White layer (LSL, n=47) pure lines were used. For the chick development experiment we stained and incubated two eggs from 93 BBs. Control eggs were simply wetted. At day 12 of incubation, egg weight loss, chick wet weight and chick developmental stage were measured. We found no evidence that CD influences WVC (BB P=0.380; LSL P=0.118) or that chick development is compromised by the staining method (e.g. developmental stage P=0.429; egg weight loss P=0.281; chick weight P=0.183). We conclude that WVC will not be reduced by selecting for improved CD and that staining for CD can be carried out on fertile eggs without compromising embryo development.

Keywords: cuticle, measurement, chick development, conductance

EGG_II_SO_2

EVALUATION OF EGG QUALITY PARAMETERS IN THE CHANTECLER BREED IN COMPARISON WITH THE SHAVER WHITE LAYER

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Our results have established baseline data for egg characteristics of the North American Chantecler, a dual-purpose chicken breed developed in Québec, in two feather colour morphs: partridge (CP) and white (CW). Seventeen egg-related parameters were measured for floor-rearing CP eggs (n=20) and CW eggs (n=26) in comparison with cage-rearing commercial Shaver White eggs (SW) (n=30). The parameters included egg weight (EW), egg width (EWI), egg length (EL), egg shape index (ESI), yolk colour score (YCS), yolk weight (YW), yolk percentage (YP), albumen weight (AW), albumen percentage (AP), haugh units (HU), egg shell weight (ESW), egg shell percentage (ESP), egg shell colour score (ESC), egg shell thickness (EST), yolk/albumen ratio (YAR), meat spots (MS) and blood spots (BS). EL (59,06mm ± 1,68, 61,37mm ± 2,63, 58,10mm ± 2,25), ESI (0,74 ± 0,04, 0,71 ± 0,04, 0,75 ± 0,03), HU (48,95% ± 13,33, 43,71% ± 12,88, 68,90% ± 12,45), YCS (9,55 ± 0,51, 9,24 ± 0,60, 8,9 ± 0,31), ESC (74,50 ± 6,86, 75,39 ± 7,61, 5,00 ± 0,00), ESW (7,74g ± 0,80, 8,24g ± 0,73, 8,90g ± 0,85), ESP (12,45% ± 0,87, 12,73% ± 0,95, 14,54% ± 1,45), YW (18,62g ± 2,49, 20,11g ± 2,86, 17,93g ± 1,64) and AW (41,39g ± 9,67, 41,54g ± 9,89, 36,02g ± 5,33) varied greatly among the groups (p<0.05), in CP, CW and SW, respectively. ESI, HU, ESW and ESP were lower in CP and CW than in SW, while YW and AW were higher in CP and CW than in SW. Darker YCS and a wider range for ESC (beige to brown) were observed for CP and CW than for SW. On the other hand, no significant differences (p>0.05) were found for EW, EWI, EST, YP, AP, BS, MS and YAR among the 3 groups.

Keywords: Chantecler breed, egg parameters, egg quality, niche market

EGG_II_SO_3

EGG QUALITY IN LAYING HENS UNDER LED LIGHTING WITH VARIABLE COLOR TEMPERATURE

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The evaluation of the effects of different color temperatures in LED lamps on egg quality was performed on 4 groups of commercial cage-housed Shaver layers (100 birds per group in 20 5-bird cages) from 140 to 320 days of age using an intermittent lighting regime: 2L:5D:3L:2D:3L:9D. Color temperatures in LED lamps were: in control group 1, 3000K during all 3 light periods; in group 2, 3000K during 1st and 3rd light periods and 5000K during 2nd light period; in group 3, 5000K during 1st and 3rd light periods and 3000K during 2nd light period; in group 4, 3000K during the first half of all 3 light periods and 5000K during the second half. Light intensity was similar for all groups (10 lux). Average egg weight in groups 2 and 4 was lower compared to control, in group 3 significantly higher (62.3 vs. 61.2 g in control, $P < 0.001$); average yolk weight was significantly higher in groups 3 and 4 ($P < 0.001$) compared to control while albumen weight was higher only in group 3 ($P > 0.05$). The deposition of vitamins was the best in group 3 compared to all other treatments: carotenoids by 23.6-43.5%, vitamin A by 6.3-14.6%, vitamin E by 18.5-44.5%, vitamin B2 by 134-33.2%. The results showed that the regime followed in group 3 allowed improvements in egg quality while maintaining the productive performance.

Keywords: LED lighting, color temperature, egg quality, egg production, feed conversion ratio

EGG_II_SO_4

PRESERVATION OF EGG QUALITY USING GRAPE POMACE CAKES AS A NATURAL ANTIOXIDANT IN THE DIETS OF LAYING HENS ENRICHED IN OMEGA 3 FATTY ACIDS

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The presence of polyunsaturated fatty acids in layer diets presumes the use of antioxidants. A 4-week trial was conducted on 180 Lohmann Brown layers assigned to three groups. Compared to the conventional diet C, the diets for groups E1 and E2 also included 5% flax meal. The flax meal diets included, as antioxidants, 100 mg vitamin E/kg feed (E1) and 2% grape pomace cakes (E2). Forty eggs/group were collected randomly at the end of the trial, 10 eggs/group being stored at +20°C and 10 eggs/group at +4°C for 14 and 28 days. The Haugh unit values were not significantly ($P > 0.05$) different between the eggs from the three groups stored at +20°C for 14 days (30.82 for C; 31.82 for E1 and 32.54 for E2) and 28 days (27.54 for C; 30.18 for E1 and 31.87 for E2). On the other hand, significant differences ($P \leq 0.05$) were noticed for the eggs stored at +4°C for different periods of storage. The recorded values were as follows: between 61.74 (14 days) and 43.34 (28 days) for group C; between 64.31 (14 days) and 48.67 (28 days) in group E1 and between 63.56 (14 days) and 48.58

(28 days) in group E2. Only group E2 had 10% eggs, stored at +20⁰ C for 14 days, with grade A freshness, compared to 0% for groups C and E1 and 20% eggs, stored at +40C for 14 days, with grade AA freshness, compared to 0% for groups C and E1. The grape seeds cakes had comparable effects to vitamin E on the preservation of egg quality over time.

Keywords: quality, eggs, natural antioxidants, grape pomace cakes

MEAT SESSION II

MEAT_II_A_1

ROLE OF POULTRY MEAT IN A BALANCED DIET AIMED AT MAINTAINING HEALTH AND WELLBEING

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Poultry meat is a valuable source of several nutrients, generally at higher concentration than most other foods' relative to caloric content, although many different factors such as the species, the genetic background, the animal's diet, the farming systems (organic, free range, intensive), the cut, the presence of skin, the cooking procedure have been shown to influence some compositional aspects of the meat. Most of the essential nutrients are present in poultry meat and are highly bioavailable: high biological value proteins, unsaturated fatty acids, iron, zinc, selenium, and vitamin B complex. Poultry meat, like other meats and foods of animal origin, has high-quality proteins, due to their richness in all essential amino acids. Meat from poultry contains a lower amount of connective tissue and collagen in comparison to meat from other animals; this promotes its digestibility. The fat content of poultry meat depends on the species (turkey is leaner than chicken), the feeding, the cuts, and the presence of skin. Skin is the main source of fat, the fat content in the main cuts from chicken and turkey range from 1 to 15% but cuts including skin had higher values. Commonly, the leg portion, namely drumstick, and other dark meat parts have higher fat and calorie contents. The fat content of poultry meat is significantly higher in unsaturated fatty acids and lower in saturated fatty acids compared to those of red meat. The content of n-3 long-chain polyunsaturated fatty acids (n-3 LC-PUFA) can be further increased using appropriate feeding, and a genotype-based selection has also been suggested to produce poultry meat with high eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) content, possibly representing an alternative to fish. Poultry meat is a source of vitamin B complex – particularly B₁ (thiamine), B₂ (riboflavin), B₃ (niacin), B₆ (pyridoxine), and B₁₂ (cobalamin) and fat-soluble vitamins such as A, D, and E – and minerals, particularly iron and zinc as well potassium, phosphorus, sodium, magnesium, calcium, and copper. In addition to the essential nutrients, scientific studies have revealed that the poultry meat contains several bioactive compounds, like conjugated linoleic acid (CLA), glutathione, taurine, anserine, carnosine and carnitine that are associated with protection against oxidative stress and with other health benefits. The content of the most of these bioactives can be increased as well by appropriate feeding. Future perspective indicates poultry meat as a promising functional food to improving the health and wellness status of individuals. Poultry meat is frequently more affordable than other meats, and it can make many positive contributions to the diet of those on low incomes and in developing countries; not surprisingly “a chicken in every pot” has been a politicians' quotation.

Associations between meat consumption and risk of chronic disease and cancer have been investigated in several epidemiological studies. There is no association between poultry consumption and risk of colorectal adenomas or other cancers. Evidence of an association between unhealthy dietary patterns (characterized by red and processed meat, sugary drinks and salty snacks, starchy foods, and refined carbohydrates) and risk of certain cancers may be mediated by lifestyle factors.

Keywords: poultry meat; chicken meat; turkey meat; nutritional value; balanced diet; human nutrition

MEAT_II_CS_1

BROMATOLOGICAL EVALUATION OF BREAST OF BROILERS FED XYLANASE AND PROTEASE COMBINED WITH TWO LEVELS OF PHYTASE

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This study evaluated breast composition in broilers fed xylanase and protease combined with two levels of phytase. A total of 1,536 male Ross 308 AP95 chicks were allotted in a completely randomized design with eight treatments and six replicates of 32 birds each. The experimental diets were supplemented with xylanase (9,600 BXU/kg), protease (300 U/kg), and phytase (750, 1500 FTU/kg). On the 42nd day, a total of 48 birds were slaughtered and breast samples were collected for moisture, protein, fat, ash, calcium, phosphorus, sodium, potassium, zinc, and selenium analysis. Data were submitted to Scott Knott test (P <0.05). No significant difference occurred for moisture, protein, fat, ash, calcium, phosphorus, and selenium. Sodium levels were higher in birds fed 750 FTU phytase, 750 FTU phytase + xylanase, and 750 FTU phytase + xylanase + protease; potassium levels were higher for diets containing 750 FTU phytase, 750 FTU phytase + protease, 1500 FTU phytase + protease, and 1500 FTU phytase + xylanase + protease, and zinc for diets containing 750 FTU phytase, 750 FTU phytase + xylanase, 750 FTU phytase + xylanase + protease, 1500 FTU phytase, and 1500 FTU phytase + protease. Breast meat mineral composition was affected by enzyme supplementation in broiler diets.

Keywords: broiler, phytase, protease, xylanase

MEAT_II_CS_2

ANTIBACTERIAL EFFECT OF BUFFERED ORGANIC ACID AND CALCIUM SALT ON *CAMPYLOBACTER* IN BROILER CHICKENS

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Objective: The amount of food poisoning caused by *Campylobacter* from chickens remains high, causing significant public health problems. The objective of this study was to investigate the efficacy of an antibacterial solution containing buffered organic acid and calcium salt in preventing *Campylobacter* infection in broiler chickens. Methods: An antibacterial solution (calcium propionate (15%) with sugar cane vinegar saturated with sea shell calcium was diluted with sodium acetate buffer (10mM, pH 4.8) to make 0.05%, 0.1% and 0.2% antibacterial solutions. Chickens were fed either water or one of the three anti-bacterial solutions from birth until day 14. Chickens were then

housed in cages. At day 17, 2.8×10^4 CFU/ml *C. jejuni* was orally administered to chickens. From day 1 to day 7 after *C. jejuni* administration, cloaca swab samples were obtained and incubated for detecting *C. jejuni*. Results: By day 7, 50% of chickens became positive in the water group. In the 0.1% and 0.2% antibacterial solution groups, 0% and 22.2% of chickens were positive at day 3 and 6, respectively. In conclusion, this study demonstrated that drinking 0.1% of an antibacterial solution—buffered organic acid and calcium salt—to broiler chickens from birth could inhibit *C. jejuni* infection.

Keywords: *Campylobacter*, sugar cane vinegar, *C. jejuni*, buffered organic acid and calcium salt, broiler chicken

MEAT_II_SO_3

IS IT POSSIBLE TO REDUCE UNDESIRABLE EFFECTS OF T-2-TOXIN WITH A PHYTOBIOTIC BLEND?

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Fusarium mycotoxins are contaminants in poultry diets worldwide. Among them birds are sensitive to T-2 toxin, as it causes losses in production and induces lipid peroxidation. In present study potential beneficial effects of a hepatoprotective phytobiotics (HERBAMIX Hepar®) were investigated when T-2 toxin contamination was in the diet. Two week old Cobb 500 cockerels (n=60) were randomly divided in 6 experimental groups. Birds were fed with commercial broiler diet free of T-2 toxin in the control (C), or contaminated in two different concentrations in the treatment groups (T1=3 mg/kg feed, T2 =5 mg/kg feed). One of the control (CH) and two of the treatment groups (T1H, T2H) received HERBAMIX Hepar® (0.4ml/l) - containing a mixture of milk thistle, artichoke and peppermint extracts - in the drinking water. During the experimental period, on days 7 and 14, production traits, lipid peroxidation and glutathione redox parameters (MDA, GSH, GPx) in blood and liver samples were measured. Growth rate was significantly lower due to T-2 toxin contamination (T1, T2, T1H, T2H) compared to controls (C, CH), but this effect was somewhat mitigated by the phytobiotics (CH, T1H, T2H compared to C, T1, T2). GPx activity and GSH concentration have been significantly increased due to T2 toxin contamination (T1, T2) by the time of the first samplings both in the blood plasma and liver, which shows the induction of the glutathione redox system. This effect was less prominent when HERBAMIX Hepar® was also consumed, which presumably is related to its antioxidant components. Altogether, HERBAMIX Hepar® might be a good option to reduce the effects of T2-toxin in broiler nutrition.

Keywords: chicken, nutrition, T2-toxin, phytobiotics, glutathione redox system

MEAT_II_SO_5

BIOCIDE AND ANTIBIOTIC SUSCEPTIBILITY OF *E. COLI* ISOLATES FROM BROILER HOUSES AFTER CLEANING AND DISINFECTION

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Farm disinfectants are widely used in primary production, but there is an increasing concern that the use of biocides is selecting for antibiotic resistance. To monitor antimicrobial susceptibility, *Escherichia coli* was isolated from environmental samples taken after cleaning and disinfection at 25 broiler houses. Two hundred isolates were subjected to a panel of 13 antibiotics and for each isolate the MIC (Minimum Inhibitory Concentration) was determined via broth dilution. For a selection of 57 isolates, biocide susceptibility testing was performed by determining the MBC (Minimal Bactericidal Concentration) of three frequently used disinfectants. Results showed high levels of resistance to ampicillin (77%), ciprofloxacin (60%), tetracycline (52%), sulfamethoxazole (61%), trimethoprim (56%) and nalidixic acid (46%). About 59% of the isolates were resistant to four or more antimicrobial agents, and only 14% were susceptible to all 13 antibiotics tested. The MBC of benzalkoniumchloride, formaldehyde and glutaraldehyde were 0.027 g/L (n=55), 0.093 mL/L (n=57) and 1.25 - 2.50 mL/L (n=56), respectively. No trend was observed between the susceptibility of the isolates and the respective in practice applied disinfectants.

Keywords: antibiotic resistance, biocide susceptibility, *E. coli*, broilers, disinfection

MEAT_II_SO_6

BROMINATED FLAME RETARDANTS IN BROILER CHICKENS

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Brominated Flame Retardants (BFRs) are synthetic substances primarily used as additive in insulating materials. These lipophilic compounds can bioaccumulate in animal tissues, leading to human exposure *via* food ingestion, and are suspected to act as endocrine disruptors. In 2015, an epidemiological study was carried out in 57 French broiler farms to quantify two families of BFRs (hexabromocyclododecane, HBCDD and polybrominated diphenyl ethers, PBDEs) in broiler breast muscle. One week before slaughter, five animals were euthanized; breast muscles were sampled and

pooled for further analysis. Eight PBDE congeners and 3 HBCDD stereoisomers were quantified in muscles using respectively gas chromatography coupled to high resolution mass spectrometry (GC-HRMS) and liquid chromatography coupled to tandem mass spectrometry (LC-MS/MS). Analysis revealed no PBDE congener in 16 samples (28 %) and no HBCDD stereoisomer in 31 samples (54%). The overall concentration of the 8 PBDE congeners and HBCDD stereoisomers exceeded 1 ng/g of fat in 17 samples (30%) and in 3 samples respectively. The results were similar to those obtained in the French surveillance studies since 2012, confirming that chicken meat produced in France contributes little to human dietary exposure to BFRs.

Keywords: broiler chicken, brominated flame retardant, persistent organic pollutant, chemical food safety

MEAT_II_SO_7

WEIGHT AND MEAT QUALITY AS WELL AS SENSORY ATTRIBUTES OF DUAL-PURPOSE CHICKEN AND COMMERCIAL BROILER

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In Germany, laying-hen production kills over 40 million male chicks per year. The ethical issues associated with this practice have triggered increasing research into alternatives, one of these is breeding dual-purpose chickens. This study analyses differences between commercial broilers (Ross, N=30) and dual-purpose chickens (LD, N=30). Both lines were raised under same conditions and feeding with a commercial diet for 42 d (Ross) and 77 d (LD). The results shows significant ($P < 0.05$) differences between the lines in all weight parameters, whereas Ross are bigger, and in most of quality parameters. 24 h after slaughter the pH-values are higher in breast meat (*MPS*) of Ross (5.83 vs. 5.69), and electrical conductivity (EC) is lower (4.47 vs. 7.43). *MPS* of LD shows higher drip loss and shear force values, and the *MPS* are darker (L^*) and more red (a^*). Sensory analysis (trained expert panel) of cooked *MPS* on the appearance, odor, flavor, and texture depicts that LD meat is "sourer", "tougher", "juicer" and has an increased off-odor ("stall smell") compared to Ross meat. In addition, Ross meat is "sweeter". The lower pH-values of LD meat are reflected in the "sour" taste. Low pH can be problematic for meat industry when manufacturing meat products. The attribute "tougher" for LD meat correlates with the higher shear force values. For consumers, chicken meat is associated with tenderness; therefore the "tougher" LD meat maybe disfavored, but concerning of animal welfare, a higher use of this kind of chicken is desirable.

Keywords: dual-purpose chicken, weight, meat quality, sensory

MEAT_II_SO_8

COMPARISON OF CARCASS TRAITS AND MEAT QUALITY OF BROILER CHICKEN ROSS 308 AND ISA DUAL HYBRID

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The aim of the study was to evaluate carcass traits and meat quality characteristics of fast (Ross 308) and slow (ISA Dual) growing chickens at 2 kg of slaughter weight. Cockerels of both genotypes were fattened under identical conditions. The physical and chemical meat characteristics were detected in cockerels in the *Pectoralis major* muscle (20 birds per each genotype). The Ross 308 reached 2 kg live weight at 32 days of age and ISA Dual at 74 days of age. The dressing out percentage and the thigh percentage were not affected by genotype. The Ross had higher breast percentage ($P<0.001$) and lower abdominal fat percentage ($P<0.005$) than Dual. Meat colour was not affected by genotype; however, pH ($P<0.001$) and cooking loss ($P<0.001$) were higher in the Ross than in Dual. From chemical composition, significantly higher dry matter (7%), crude protein (10.0%), hydroxyproline (12%), 32% lower ether extract and 61% lower cholesterol was in Dual compared to Ross. *Musculus Pectoralis major* of Dual contained 50% higher number of muscle fibres per 1 mm² which had 18% lower fibre cross sectional area than in Ross. It can be concluded that the Ross chickens had better carcass traits than Dual. However, meat quality and chemical composition of meat was better in ISA Dual.

Keywords: chicken, *Pectoralis major*, physical parameters, chemical composition, muscle fibre

MEAT_II_SO_9

QUANTIFICATION OF MEAT DERIVED FROM VARIOUS POULTRY SPECIES IN MEAT PRODUCTS

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To protect the consumer against incorrectly labelled meat products, it is necessary to have reliable methods for clear identification of varying animal components. Not only correct labelling of meat products with respect to the existing animal species is of high relevance, but also methodology for quantification is required, which should allow the precise determination of animal tissue in a given product.

Primer systems and appropriate probes were designed on the basis of the mitochondrial *cytochrome b gene*, both to identify and to quantify the poultry species, turkey, chicken, quail, guinea fowl and pheasant in canned preserved emulsified sausages of different composition (6 batches) by means of a pentaplex real-time polymerase chain reaction (PCR) system. All batches contained 9 % pork additionally. Using the TaqMan technology various fluorophors such as ROX, JOE, FAM, DY682 and ATTO633 as well as Black Hole Quencher (BHQ) 1 and 2 were applied. Standards between 0 and 50 ng of DNA were used.

The results were acceptable for the different poultry species with the exception of quail, as the calculated percentages for quail were in every case 3 – 6 times higher than expected.

The resulting elevated percentages for quail may be due to a higher number of mitochondria in their muscle tissue and the subsequently isolated higher concentration of mitochondrial DNA, which was subsequently used in the PCR analysis.

Key words: poultry species, mitochondrial DNA, real-time PCR, quantitation

MEAT_II_SO_10

EFFECTIVENESS OF IMMERSION TREATMENTS WITH ACETIC AND CITRIC ACIDS AND MODIFIED ATMOSPHERE PACKAGING AGAINST *CAMPYLOBACTER JEJUNI* IN POULTRY

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Raw poultry is a well-recognized source of *Campylobacter jejuni*. The aim of this study was to evaluate the combined effect of a mixture of acetic and citric acids and packaging in modified atmospheres on the growth of *Campylobacter jejuni* in poultry. Fresh chicken legs inoculated with 5 log cfu/g of *Campylobacter jejuni* were dipped into a mixture containing 1% acetic acid and 1% citric acid. Control legs were treated with distilled water. Inoculated samples were packaged under different gas mixtures: vacuum, 20% CO₂ /80% N₂, 40% CO₂/60% N₂ or air. Significant differences (p<0.05) in mesophiles and psychotrophs counts were found between the legs treated with a mixture of acetic and citric acid and the control legs after treatment. Legs washed with a mixture of 1% acetic and 1% citric acid solution showed a significant (p<0.05) inhibitory effect on *Campylobacter jejuni* compared to control legs, being about 1.51 log units lower after treatment. No significant reduction in *Campylobacter jejuni* counts was observed in samples packaged in modified atmospheres. In conclusion, immersion of chicken legs in a mixture of 1% acetic acid and 1% citric acid solution can reduce *Campylobacter jejuni* populations on fresh poultry. Modified atmospheres are not able to reduce *Campylobacter jejuni*.

Keywords: food safety, pathogens, poultry, modified atmosphere packaging, *Campylobacter*

MEAT_II_SO_11

BROILER CHICKENS TRANSPORT AND IT EFFECT ON MEAT QUALITY

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Consumer demand for improved product standardization defines production trends in the poultry industry. Therefore, appropriate pre-slaughter management practices that ensure animal welfare and focus on food quality and safety should meet such requirements. This study assessed the effects

of transport during rainy and dry seasons for long (90 km) and short (15 km) distances. The experiment followed a completely randomized design with four treatments in a factorial scheme (2 seasons: rainy and dry) x 2 (distances: short – 42min and long – 2h:09min), with four replicates. In the rainy season (summer), the transport distance determined significant alterations in meat quality. For longer distances, it was recorded the highest temperatures (31.1°C) and relative humidity (65.4%) inside the load, resulting a tendency of dark, firm and dry meat (DFD), average of meat pH 6.08 ($p<0.01$) and with lower cooking losses (CL), 12.77% ($p<0.01$). In the winter (dry season), the climatic conditions inside the load were 28.8°C and 37.6%, respectively. Broiler chickens transported in the winter had meat pH (5.93) classified as "normal", however, with higher cooking CL (14.37%). For shear force, neither season nor journey length has any significant effects upon tenderness of the evaluated meat. In conclusion, the combination of summer season and long distance tended to develop DFD meat, thus, special attention should be given when chickens are transported to slaughter in the summer or periods of high humidity.

Keywords: broiler, cook loss, microenvironment, pH, texture

MEAT_II_SO_12

PREVALENCE OF *SALMONELLA* IN POULTRY MEAT

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Raw poultry is a well-recognized source of *Salmonella* spp. and many surveys have confirmed the presence of this pathogen on poultry. The presence of *Salmonella* in poultry receives major attention because of the importance of this bacteria as causative agent of human foodborne illness. The present study was conducted to determine the prevalence of *Salmonella* in poultry meat.

One thousand and seventy eight samples were taken in the period 2009-2012. Samples were taken from whole carcasses, and meat portions (wings, legs and breasts). *Salmonella* was isolated from 47 samples (4,35% of the samples analysed). The highest prevalence was observed in 2011 (8.72%) and the lowest in 2010 (2.16%). These results are similar to those reported in the EU by EFSA (2.8% in 2014 and 3.5% in 2013).

Higher prevalence of *Salmonella* was found in carcasses than in meat portions. Twelve different *Salmonella* serovars were isolated from poultry meat: S. Virchow, S. Infantis, S. 4.12b, S. 4i.1 S. Anatum, S. Hadar, S. Haifa, S. Kentucky, S. Lisboa, S. Matadi, S. Typhimurium and S. Toulon. The predominant serovar was S. Virchow, being found in 14 isolates. These results differ from those reported by EFSA in 2014, since the most frequent serovar types found in poultry meat in the EU were S. Infantis and S. Enteritidis.

Keywords: food safety, pathogens, poultry meat, *Salmonella*

EGG SESSION III

EGG_III_A_1

EXTENDING THE LAYING CYCLE OF LAYING HENS- CAN EGG QUALITY BE SUSTAINED?

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Extending the production cycle in laying hens and producing 500 eggs in a single laying cycle until 100 wk of age appears to be a realistic goal to reach by 2020. Field reports suggest that this might be feasible even today, in 2017. However, results of a field study conducted in 2014 on Belgian layer farms and observations in (long term) studies conducted at ILVO and EPC in Belgium suggest that there are considerable differences between layer hybrids regarding their potential for an extended laying cycle. Results of the field study indicated that laying hens were kept in production on average until 80 wk of age, but end of lay ranged between 74-92 wk. Egg quality was assessed at 60 wk and at the end of the laying period. Although internal and shell quality declined, and variability between eggs increased, egg quality was still acceptable at end of lay. Flocks were depopulated before decreasing shell quality could cause economic losses. This suggests that some commercial flocks in 2014 might have already had a potential to be kept beyond 80 wk of age. However, there are several bottlenecks in extending the production period of layer flocks: not only egg quality, but also persistency and bone quality declines as hens become older. Genetic selection programs address these problems by including new traits as selection criteria (e.g.: clutch length, dynamic stiffness) and new molecular breeding methodologies (genome-wide studies and identification of quantitative trait loci). However, improved genetic potential of highly prolific layer hybrids can only be realized in the field if nutrition and management are both optimized in extended production cycles. In fact, extended production cycle starts at day 1 of rearing. Growth during rearing and the early laying period determine for a great part, how a flock will perform and how long the laying hens can be kept in production. Initial pullet weight at the onset of lay is related to total egg output, and growth during this period determines how egg size will increase during the start of lay. Perhaps in extended production cycles more robust birds with higher bone Ca reserves having a delayed start of lay could maintain persistency and eggshell quality for longer. Therefore, adjusted lighting programs might need to be applied already during rearing if the goal is to keep hens in production until 100 wk of age. From onset of lay, maintaining gut health and the integrity of the intestinal segments, with special attention to the duodenum – the main site of Ca and P absorption – is a pre-requisite for maintaining eggshell quality in extended laying cycles. In addition, there might be a potential to improve Ca utilization and consequently shell quality in aged laying hens in alternative feeding systems, such as split feeding, where nutrient supply better matches requirements during the daily egg formation cycle compared to in conventional systems where one diet is fed during the day. Results of long-term studies at EPC indicate that split feeding can have a potential not only to improve feed efficiency but also to decrease cracked eggs % in the last phase of the production cycle. In general, an overall strategy is needed which includes different nutritional aspects and management practices to tackle specific problems related not only to egg(shell) quality but also to health and welfare problems (such as bone integrity, gut health) to successfully extend the production period.

Keywords: egg quality, laying hen, extended cycle, sustainability

EGG_III_CS_1

UPDATE OF THE UV INSPECTION OF SHELL EGGS TO IDENTIFY THE PRODUCTION SYSTEM OF ORIGIN

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Food fraud is a concern for European consumers. In Spain, it's suspected that some eggs sold as free-range eggs have been laid in cages. In 2005, Gregory et al. developed a method to identify eggs produced in conventional cages. This technique is based on the detection under UV black light of 2 parallel lines on the eggshell which correspond to where the egg has made contact with the wire floor. The recent evolution of cage design, in furnished cages as well as in non-cage systems, could have changed the reliability of this technique and the optimum sample size. 3,000 fresh eggs from 6 models of furnished cages and 1,200 eggs from 6 designs of free-range systems were inspected using a 250 W BlackLight UV hand lamp. In every case, eggs were laid by 2 different flocks (young and older hens). The sample size was 300 eggs by flock. Several types of shell marks were identified and classified. Parallel lines were detected in 40.1% of cage eggs, while similar and possibly confusing marks were seen in only 0.8% of free range eggs. The majority of these marks persisted until the end of best-before date of consumption. We conclude that UV inspection of eggshell is still a reliable method to detect fraud in retail eggs.

Keywords: egg inspection, food fraud, housing systems

EGG_III_CS_2

CUTICLE QUALITY GENETICS IN LAYERS AND BROILERS

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The cuticle is a glycosylated protein layer that covers the outside of the eggshell, forming a barrier to the transmission of microorganisms, and its variability determines protection. In this study, we wanted to extend our previous study, in which we observed that 30% of the variation in cuticle deposition was genetically determined, other genetically distinct chicken lines and to determine the ability to predict cuticle deposition later in the laying period (1000 to 1500 hens per line). Heritability in the same Rhode Island Red line as used previously was found to be 0.49 ± 0.12 and 0.43 ± 0.12 at 32 and 50 weeks of age, respectively. The genetic correlation between the two

measurements was 0.96 ± 0.04 . In genetically distinct lines, notably in a line of broilers, the heritability was 0.24 ± 0.04 , and in a white leghorn line 0.31 ± 0.10 . Therefore, the heritability estimates are moderate to high in all the lines examined and one measurement should be sufficient to predict future performance. We did not observe any significant genetic correlations between egg colour and cuticle, with estimates ranging from -0.33 to $+0.37$, with errors nears the size of the estimate in five different populations. These results combined, reinforces the belief that a single cuticle measurement could be incorporated successfully into breeding programmes. Funded by BB/K0070921/1.

Keywords: oviduct, vitelline, cuticle, fertility, antimicrobial

EGG_III_SO_1

PRELIMINARY RESULTS OF INCREASING DIETARY LEVEL OF HYBRID RYE, WITH OR WITHOUT THE NSP-HYDROLYZING ENZYME, ON THE PERFORMANCE AND EGG QUALITY IN LAYING HENS

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The aim of the study was to determine the effect of increasing the dietary level of hybrid rye, without or with the addition of NSP-hydrolyzing enzyme, on laying performance and egg quality. A total of 240 Isa Brown hens were allocated to 10 treatment groups with 12 replicates (cages) of two hens given the iso-caloric and iso-nitrogenous experimental diets from week 26 to 37. A 5×2 factorial arrangement was used with following experimental factors: dietary level of hybrid rye (RL; 0, 10, 15, 20 or 25 %) and addition of endo-1,4-beta-xylanase (E; 0 or 200 mg/ kg). The increasing RL in the diet had no effect on number of eggs produced, total egg mass, mean egg weight, feed intake or feed conversion ratio. There were no positive effects of adding E on these performance indices. Most of the internal egg and eggshell quality parameters were unaffected by the experimental factors ($P > 0.05$). Only the yolk colour (DSM scale) and yolk mass were significantly decreased by increasing the RL ($P < 0.05$). The results of this study suggest that rye may be incorporated up to the level of 25% in the diet of laying hens without any negative effects on egg quality or hen performance.

Keywords: hybrid rye, xylanase, laying hens, laying performance, egg quality

EGG_III_SO_2

CUTICLE DEPOSITION OCCURS IN THE SHELL GLAND (UTERUS) AND NOT THE VAGINA DURING THE TERMINAL PHASE OF SHELL FORMATION

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The cuticle, which forms the outermost protective layer of the egg, is produced during the terminal phase of shell formation but it is not known if it is produced in the shell gland or vagina. The aim of this study was to establish if Ovocalyxin-32 (OCX-32), a precursor protein of the eggshell cuticle is localized in the SGP or the Vagina when oviposition is endocrinologically manipulated. Immunocytochemistry for OCX-32 was carried out on SGP and vagina tissues derived from laying hens injected with GnRH or AVT to induce premature oviposition. The % area of cells staining positive for OCX-32 was determined by analyzing 4 areas per tissue using ImageJ software. The cuticle quality and the colour of the eggs laid before and after treatment were also determined using an established method. AVT induced oviposition had a large and negative effect on cuticle and pigment deposition whereas there was little change following GnRH injection, despite both causing oviposition at the same time. The % area of ciliated surface epithelial cells staining positively for OCX-32 was higher in the AVT derived SGP tissues than for GnRH ($22.7 \pm 1.7\%$ v $16.0 \pm 1.8\%$; $P=0.016$, $n=10/11$). There was no specific staining for OCX-32 in the vagina from either treatment confirming that the cuticle is deposited in the shell gland pouch (uterus) and not the vagina.

Keywords: cuticle, egg, oviduct

EGG_III_SO_3

EGG QUALITY AND YOLK FATTY ACID PROFILE IN LAYERS FED DIETS SUPPLEMENTED WITH N-3 PUFA, VITAMIN E, AND SELENIUM

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The possibility of production of multi-enriched functional eggs with different antioxidants as nutraceuticals was studied on White Leghorn layers (cross SP-789, 140-200 days of age; 6 dietary treatments with 6 replicates of 5 birds per treatment). The control wheat-based diet 1 contained 3.62 and 0.14% of n-6 and n-3 PUFAs, vitamin E 10 ppm and selenium (Se) 0.2 ppm. In treatments 2-6 sunflower oil was substituted by flaxseed oil (3%); in treatments 2-3 5% of flaxseed cake was added; in treatments 4-6 10%. In treatments 2-3 contents of n-6 and n-3 PUFA were 2.09 and 1.97%, vitamin E 100 ppm, Se 0.5 ppm; in treatments 4-6 1.82 and 2.35%, 250 ppm and 0.5 ppm, respectively. Se sources: Sel-Plex in diets 2 and 4, DAFS-25 (Russia) in diets 3 and 5, and sodium selenite in diet 6. Layers fed diets 2-6 showed better laying performance ($p>0.05$); egg weights did

not change. For diets 2-6 nutrient deposition per 100 g of edible egg parts fell within the following ranges: Se 43.1-61.8 µg; vitamin E 4.47-8.35 mg; SFA 2696-2959 mg; MUFA 3445-3637; n-6 PUFA 1321-1630; n-3 PUFA 767-807 mg; in control these parameters were 28.3 µg, 2.31 mg, 3119 mg, 3642 mg, 2181 mg, 172 mg, respectively. We conclude that supplementation of diets for layers with Se, vitamin E, and a source of n-3 PUFAs allows production of functional eggs. Financed by Russian Science Foundation, grant 16-16-04047.

Keywords: laying hens, egg quality, fatty acid profile, egg production, n-3 polyunsaturated fatty acids, selenium, vitamin E

EGG_III_SO_4

EFFECT OF HIGH FIBER (8%) LAYER DIETS ON SERUM AND EGG CHOLESTEROL

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Although fiber is regarded by many nutritionists as a mere diluent of poultry diets, new experimental evidence suggests that fiber can generate several beneficial effects e.g. increasing intraluminal viscosity and the entero-hepatic recirculation of bile acids and lipid metabolism; body weight regulation, through both hunger suppression and diminished nutrient absorption and therefore economic efficiency). A 5-week feeding trial was conducted on 200 Tetra layers (28 weeks) assigned to 5 groups, housed in an experimental hall under controlled environmental conditions (temperature: 23.81±1.54°C; humidity: 64.76±11.93%), and 16h/24h light regimen. The control group (C) received a conventional diet (2780 kcal/kg metabolizable energy; 17.5% crude protein; 4.39% crude fiber). Compared to C formulation, E1 formulation included 23% sunflower meal, which increased the dietary fiber (8%). The other 3 experimental diet formulations differed from E1 formulation by the presence of phytoadditives or cellulolytic enzymes: E2 (0.015% enzyme); E3 (0.015% phytoadditive) and E4 (0.015% enzyme + 0.015% phytoadditive). Blood samples (6 samples/group) and egg samples (18 eggs/group) were collected at the end of the trial and assayed for their cholesterol concentration. Serum cholesterol was lower ($P \leq 0.05$) in group E1 (109±4.62 mg/dL) than in group C (145±6.11 mg/dL). The use of a formulation with 8% cellulose, with an addition of 0.015% enzyme and 0.015% phytoadditive resulted a significant decrease in cholesterol content in egg yolk with 7.6% of group C (4.39% cellulose).

Key words: Cholesterol, high fibre diet, layer

EGG_III_SO_5

CHARACTERIZATION OF EGG SHELL CUTICLE BY FTIR AND SEM IN TABLE EGGS

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The thickness and completeness of coverage of the eggshell cuticle layer influence egg resistance to bacterial penetration. However, cuticle quality is susceptible to change with hen age and/or processing. Eggs collected from brown (Rhode Island Red) and white (White Leghorn) Lohmann flocks (28-29, 48, 70 weeks) were either unwashed or washed, and cuticle was assessed by Fourier transform infrared spectroscopy (FTIR), Scanning Electron Microscopy (SEM) and Energy-dispersive X-ray spectroscopy (EDS). SEM confirmed that the cuticle plug within the eggshell pore was unaffected by washing. EDS revealed that the phosphorus content of the pore inner surface was higher in white eggs than in the surrounding mineral. FTIR of washed and unwashed brown eggs showed an increase in total cuticle protein and decrease in carbonate (mineral) signal with increasing age of hen; washing reduced the cuticle signal. In washed white eggs, the total cuticle protein decreased with increasing age of hen, with corresponding increase in the mineral signal. No differences were observed in the carbonate signal and total cuticle protein of washed and unwashed white eggs, indicating little impact of washing on the cuticle. These novel FTIR measurements suggest complexity in the age-related cuticle changes, which differ between white and brown eggs.

Keywords: eggshell, cuticle, FTIR, pathogens, antimicrobial

EGG_III_SO_6

VARIABILITY AND INTERACTION OF SOME EGG PHYSICAL AND EGG SHELL QUALITY ATTRIBUTES DURING THE ENTIRE LAYING HEN CYCLE

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Some egg physical (egg weight, width, length, shape index and surface) and eggshell attributes (weight and shell percentage, thickness, breaking strength, L*, a*, and b*), their variability and relationships during the entire laying hen cycle were investigated. A total of 8,000 eggs were collected every 5 wks, from 30 to 81 wks of hens age (10 samplings of 400 eggs/house), in 2 poultry houses equipped with enriched cages. ANOVA, Bivariate Correlation and Principal Component Analysis (PCA) were used. An increase of egg weight, surface and eggshell lightness (L*) associated to a reduction of eggshell percentage, breaking strength and redness (a*) were observed as the hen aged (P<0.05). Overall, the coefficients of variation were < 5% for width, length, shape index, and

egg surface; from 5 to 10% for egg weight, shell weight, shell percentage, shell thickness, L*, and b*; > 10% for eggshell breaking strength, and a*. According to the PCA, the highest changes are related to egg physical attributes (32%) and to eggshell breaking strength, shell percentage and thickness (26%). The egg physical attributes are strongly correlated each other, whereas a slight correlation between eggshell breaking strength and colour was evidenced (-0.231 and 0.289 respectively for L* and a*; P<0.01).

Keywords: egg, eggshell, quality attributes, multivariate data analysis, laying hen

EGG_III_SO_7

DIETARY MEANS TO IMPROVE EGG YOLK FATTY ACID PROFILES OF JAPANESE QUAIL

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The study aimed to assess the effect of linseed oil and grape pomace on the fatty acid profile of yolk lipids in eggs from Japanese laying quails (*Coturnix coturnix japonica*). One-hundred-sixty Japanese laying quails (*Coturnix coturnix japonica*) were randomly allocated into four dietary treatments: control – corn oil (CO), CO + dried grape pomace (GP), linseed oil (LO), LO + GP. Data was analysed by ANOVA. Birds fed LO had ten-fold higher (p<0.0001) level of α -linolenic acid (ALA) and lower (p<0.001) percentages of: linoleic acid, γ -linolenic acid (GLA) and arachidonic acid (AA). GP increased ALA in egg yolk (p<0.0001) by almost 35%. However, lower levels of C18:1 *cis* and C18:1 *trans* in groups with grape pomace was observed. There was GP by LO interaction, as LO addition to the feed decreased (p<0.001) levels of C20:0 and C23:0. The results showed interaction (P<0.05) between the addition of LO and GP resulting in the lowest level of LA and AA but also in the highest amount of ALA and eicosatrienoic acid (C20:3 ω -3). It can be concluded that supplementing diets with LO and GP can increase ω -3 fatty acids and lower levels of ω -6 fatty acids in egg yolk.

Keywords: grape pomace, ω -3 fatty acids, linseed oil, quail, eggs

EGG_III_SO_8

CHANGES IN INTERNAL QUALITY OF EGGS DURING STORAGE DEPENDING ON HOUSING SYSTEM

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The aim of the study was to evaluate changes in internal egg quality during 21 days of storage (storage temperature 20 °C) in eggs from enriched cages and free-range. In both housing systems,

eggs were collected at 26, 38 and 51 weeks of age. Eggs were analysed 0, 2, 7, 14 and 21 days after laying, in total, 900 eggs (30 eggs from each housing and time of storage). Egg weight was affected by housing system ($P \leq 0.001$) and decreased with time of storage ($P \leq 0.001$) approximately 4% from enriched cages and 7% from free-range. Significant interaction of housing system and storage time resulted in higher Haugh unit scores for caged eggs ($P \leq 0.001$) which decreased faster with storage time ($P \leq 0.001$). Similar trends were observed with increased albumen pH. Albumen percentage was higher in eggs from free-range ($P \leq 0.05$) and in both housing systems decreased with storage time by approximately 5% ($P \leq 0.001$). Ovotransferin and ovalbumin content was not affected, whereas lysozyme was higher in free-range eggs ($P \leq 0.001$) but during storage it decreased by 7% in eggs from cages and 9% in free-range eggs. Results of the study show that free range eggs have lower initial internal egg quality but slower deterioration during storage compared to enriched caged eggs. However, lysozyme content was higher and decreased faster in free-range eggs than in egg from cages, and can negatively affect egg safety during storage.

Keywords: egg, storage, cage, free range, lysozyme

EGG_III_SO_9

LEAD AND ARSENIC EXPOSURE FROM NON-COMMERCIAL EGG SOURCES

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Consumer preferences for local (non-commercial) shell eggs are a growing market. Non-commercial sources of eggs, including small local farmers and backyard flocks, vary in flock management and egg handling practices which can negatively affect the quality and safety (biological/chemical) of eggs. In this case study, lead (Pb) and arsenic (As) levels were evaluated in shell eggs from a small backyard flock located in rural northern Alabama. As a potential contaminant source, the flock's environmental soil was analyzed (via ICP-AES), which indicated concentrations of Pb at 1835 ppm and As at 61 ppm. In perspective, the United States (US) Environmental Protective Agency (EPA) requires clean-up in soils with Pb and As at 400 ppm and 0.4 ppm, respectively. Egg (yolk and albumen) analysis (via ICP-MS) indicated Pb and As concentration ranges from <0.02 ppm to 0.05 ppm and <0.02 ppm to 0.04 ppm, respectively. Comparatively, the EPA permissible level for As is 0.010 ppm in drinking water; whereas, the Food and Drug Administration states a maximum Pb level of 0.05 ppm in juices and 0.1 ppm in candy. The presence of Pb and As in eggs from non-commercial sources has potential public health risks, which necessitates further investigation.

Keywords: egg safety, lead, arsenic

EGG_III_SO_10

IMPLEMENTING A 5S PROJECT TO REDUCE WASTE PROCESS IN EGG PROCESSING PLANT

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The purpose of this research was to minimize waste and optimize productivity by implementing a 5S workplace organization methodology program into the egg processing facilities located in Bandırma, Turkey. The Japanese first developed a 5S system as a means of improving operational efficiencies, reducing operational steps, improving the overall cleanliness, efficacy, safety and productivity of the processing plant and ensuring processing operations whilst reducing waste. The 5S philosophy's five S's are sort, set in order, shine, standardize and sustain. The objective of this study was to evaluate implementing of a 5S systems into an egg processing plant to reduce waste and non-value adding activity while improving product quality. The processing plant was divided into 4 different areas (laboratory, egg product production area, cake, and technical workshop) for improvement in management and assigning responsibilities to different individuals. After the study the overall success grade in 5S project's team was 99.04; 98.43; 93.84 and 99.27 for each department, respectively. The highest improvement score was achieved in technical department and lower score reported in integrated cake production line after 5S has been implemented in first time within 6 months of study. The results reported that, the application of 5S system can help reduce waste for operational efficiencies. In particular, this study showed that 5S methodology could be applicable to an egg processing plant for maintaining the productivity in the long-term.

Keywords: egg waste, processing, operational efficiency

MEAT SESSION III

MEAT_III_A_1

GLOBAL EXPRESSION ANALYSIS IN BREAST MUSCLE: CLUES FOR DEVELOPMENT IN HEALTH AND DISEASE

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We have conducted global expression analyses of proteomes and transcriptomes in breast muscle between; a) pedigree male (PedM) broiler and a heritage breed (BPR, Barred Plymouth Rock), b) PedM broilers exhibiting high and low feed efficiency (FE) phenotypes, and c) commercial broilers with and without advanced wooden breast myopathy. A tool used for interpretation of these datasets is Ingenuity Pathway Analysis (IPA, Qiagen) that organizes data into expression networks, canonical pathways, and predictions of activation or inhibition of upstream regulators; all of which provide clues for understanding fundamental mechanisms in normal muscle and in wooden breast myopathy. Global expression datasets from these different studies can be compared using the overlay function of IPA. As expected, the PedM broiler exhibited mechanisms associated with rapid growth and muscle development compared to the unselected BPR line. The PedM broiler muscle also exhibited gene expression associated with a higher amount of slow twitch muscle fibers compared to BPR. A high level of perilipin 1 expression observed in the PedM compared to BPR muscle suggests that an adipose sensitive lipase pathway is present in PedM muscle but not in the BPR heritage line. In comparing muscle from healthy broilers to those with wooden breast myopathy in commercial broilers, angiopoietin (ANGPT), which stimulates capillary formation and increases blood flow in muscle, was predicted to be activated in wooden breast. When proteomic data from the high-low FE dataset was overlaid on the ANGPT network generated from wooden breast dataset, it was determined that ANGPT would be inhibited in the high FE muscle suggesting that high FE would not contribute to WB development at least with respect to ANGPT. Interestingly, NFE2L2 was predicted to be activated in both wooden breast and in muscle in the higher FE PedM. Transforming growth factor beta 1 (TGFB1) was predicted to be activated in both wooden breast and in the PedM broiler FE model using the overlay function of IPA suggesting a commonality between these datasets. Collectively, the results of these global expression datasets provide insight into mechanisms associated with normal breast muscle metabolism, feed efficiency, and in wooden breast myopathy.

Keywords: muscle, global expression analysis, broilers, barred Plymouth Rock, myopathy, feed efficiency

MEAT_III_CS_1

UNRAVELLING THE CAUSE OF WHITE STRIPING IN BROILERS USING METABOLOMICS

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Metabolomics was applied for identifying the cause of white striping (WS), a serious concern for the poultry industry. Fifty-two *Pectoralis major* samples ranging from no to severe WS were analysed by GC-MS and LC-QTOF/MS yielding 599 metabolites per sample. Results showed that the TCA cycle was altered significantly ($P < 0.01$) and exhibited opposing directionalities, with increases in citrate (2-fold) and malic acid (2-fold). This opposing directionality enables the TCA cycle to produce high-energy phosphates through matrix level phosphorylation and, therefore, produce energy despite hypoxia. The fatty acid oxidation was limited due to disturbances in carnitine levels. A 3-fold decrease in stearoyl-carnitine was measured ($P < 0.01$). Accumulation of especially long-chain fatty acids also took place. Levels of cis-5-tetradecanoyl-carnitine especially back-up this theory since this is used as a marker for beta-oxidation defects and showed a 4-fold increase in WS cases ($P < 0.01$). Likely, mitochondrial β -oxidation was inhibited, while less oxygen sensitive peroxisomal β -oxidation continued. Metabolism of arginine increased, shown by a 3-fold increase in citrulline, presumably to increase blood flow. Taurine increased 2-fold, which has a protective role in hypoxic conditions. Combined, our data confirm that hypoxia is the most likely cause/initiator of WS, presumably caused by the animal outgrowing its vascular support system.

Keywords: broilers, white striping, metabolomics, hypoxia

MEAT_III_CS_2

MYOPATHY OCCURRENCE AND MEAT QUALITY IN BROILER CHICKENS: EFFECT OF GENOTYPE, GENDER, AND LIGHT PROGRAM

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To evaluate the effect of genotype (Cobb vs. Ross), gender and light program (14L:10D vs 18L:6D) on myopathy occurrence and meat quality, 800 chickens were reared under controlled conditions. At commercial slaughter (44 d of age), 192 *P. major* (24 per group) were examined for white striping (WS), wooden breast (WB), and meat quality. Chi square test and PROC MIXED of SAS evaluated differences in myopathy occurrence and meat quality among groups, respectively. The genotype did not affect myopathy (on average WS: 76.9%; WB: 6.26%), but some meat traits changed (cooking losses: 27.0% vs. 29.3%; shear force: 2.29 vs 2.55 kg/g in Cobb vs. Ross; $P < 0.01$). Females were less affected by WS (70.5% vs. 83.3%; $P < 0.05$) and WB (3.13% vs. 9.38%; $P < 0.10$) than males and showed lower ultimate meat pH (5.92 vs. 5.98; $P < 0.01$), cooking losses (26.4% vs. 29.9%; $P < 0.001$), and shear force (2.26 kg/g vs 2.58 kg/d; $P < 0.01$). Under 14L:10D, chickens were less affected by WS (64.6% to 89.5%; $P < 0.001$), and showed lower meat shear force (2.20 vs. 2.64 kg/g; $P < 0.05$) and fat content

(1.87% vs 2.29%; $P < 0.05$) than under 18L:6D. In conclusion, myopathies changed with gender and light program, whereas meat quality was affected also by genotype.

Keywords: genotype, gender, management, myopathies, meat quality

MEAT_III_CS_3

SPAGHETTI-MEAT ABNORMALITY: IMPACT ON MUSCLE HISTOLOGY AND MEAT QUALITY TRAITS

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During the last few years, a muscular abnormality termed spaghetti-meat (SM) exhibiting extremely soft and stringy *Pectoralis major* muscle and often associated with white striping (WS) has emerged. Accordingly, this study aimed at evaluating the effects of SM and/or WS on meat quality and histological features in broilers. Thus, 96 *P. major* muscles were selected into two independent trials from homogeneous flocks (47 d of age and 2.8 kg of live weight at slaughter) and classified as follows: Normal (N), WS, SM and WS/SM. Each fillet was cut in order to separate the superficial layer from the deep one and both used to assess proximate composition, histological features, colour, pH and protein profile. Muscle abnormalities resulted in several degenerative features and significantly affected proximate composition, with the alterations being more pronounced within the superficial layer of the fillets. Indeed, SM and WS/SM exhibited remarkably lower ($P < 0.001$) protein coupled with an increased ($P < 0.001$) moisture level, whereas WS displayed higher ($P < 0.001$) lipid content. Moreover, a more intense post mortem proteolysis leading to the formation of high molecular-weight fragments was observed. In conclusion, the occurrence of SM seems to involve more pronounced alterations in respect to WS.

Keywords: Broiler, abnormality, spaghetti meat, histology, quality

MEAT_III_CS_4

QUALITY TRAITS OF PECTORALIS MAJOR MUSCLE IN BROILERS WITH DEEP PECTORAL MYOPATHY

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Genetic selection has led to a significant improvement in growth rate and breast yield in broilers. Rapid growths, particularly associated with muscle degenerations, have been implicated in meat quality. Deep pectoral myopathy (DPM) is characterized by necrosis and atrophy of *P. minor* muscle. Management conditions that cause wing flapping is thought to be the major cause of DPM. Quality traits of *P. major* muscle of broilers with DPM have not been well understood yet. The present experiment was conducted to evaluate meat quality, fatty acid composition and oxidative status of

P. major muscle of broilers with DPM. *P. major* of commercial broilers (Ross-308) obtained from one flock was scored as normal (N), DPM-I an acute inflammatory lesion with numerous haemorrhages, DPM-II pink to plumb coloured muscle with early coagulative necrosis and DPM-III progressive degeneration with green necrotic areas. Increased pH₂₄, drip loss and calcium content was observed for muscles with DPM-I and DPM-II compared to N fillets classified as DPM-II which also had the lowest protein content. Occurrence of DPM decreased PUFA content and increased MDA activity and redness in *P. major* muscle. These results obtained in *P. major* muscles of broilers with DPM may underlie the muscle degeneration.

Keywords: broiler, deep pectoral myopathy, *Pectoralis major*, fatty acid, meat quality

PLENARY SESSION II

PLEN_II_P_1

CAMPYLOBACTER: MAJOR HUMAN AND CHICKEN PATHOGENS

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The World Health Organisation (WHO) has declared that *Campylobacter* spp. are the most important food-borne pathogens in the developed world. It is estimated that ~1% of the population of the EU is infected each year and in the UK it is believed that ~700000 cases occur annually. The two main species responsible for human infection are *Campylobacter jejuni* and *C. coli*. In the UK, the former causes ~90% of cases and the latter ~10%. *Campylobacter* infection can be severe and the main symptoms in infected people are acute abdominal pain, fever and profuse diarrhoea, which can be bloody, particularly in children. In around 1% of cases *Campylobacter* infection has long term consequences such as reactive arthritis and IBS. A variety of vehicles/sources of human infection has been identified and include contaminated water, raw milk and puppies and kittens with diarrhoea. The most important source/vehicle, however, is contaminated chicken and various studies have identified that up to 80% of human cases are chicken-associated. Outbreak investigations, examination of contamination patterns of chicken carcasses and studies on sporadic infections (the majority of cases) have shown that chicken contaminated with *Campylobacter* poses two health threats. These are: high numbers of the bacteria on the carcass surface, and levels of up to 10^9 /carcass have been reported, which is a cross-contamination threat, and contamination of muscle and liver, which poses a health threat if these tissues are not cooked properly. In the UK, contaminated liver and dishes derived from it are currently the most important vehicles of infection in outbreaks. It is not known with any certainty which sort of contamination poses the greatest threat to public health. Much of the current control focus in the UK is on reducing carcass surface levels of *Campylobacter*. There is no doubt that gross food hygiene failures such as putting cooked meat or salad vegetables on to uncleaned surfaces contaminated previously by chicken is a high risk for infection. What has not been done is to establish the risks and pathways of infection when low numbers of *Campylobacter* are found on kitchen surfaces. There seems to be a general belief that presence equals risk and while it would be better not to have *Campylobacter* cells on a cupboard handle, for example, there is a need determine the actual risk this poses. One of the problems with the current focus on reducing surface contamination levels is that it is informed by papers published over 10 years ago when much less was known about the *in vivo* behaviour of *Campylobacter* in chickens and its heat resistance. The bacteria can show extreme heat resistance when attached to chicken muscle surfaces and its pathogenic behaviour in chickens (see below) means that edible tissues are contaminated more frequently than thought previously. It is often said, even in papers published in the last 12 months, that *Campylobacter* is a commensal in chickens. There is a large body of evidence, going back to 1981, showing quite clearly that this is not the case. When chickens are infected with *Campylobacter* they can suffer from diarrhoea, damage to intestinal mucosa and reduced welfare and performance. Some papers have reported raised mortality and field studies support these observations. It is important to recognise that the interactions between *Campylobacter* and its chicken host can depend strongly on the bacterial strain and bird type. One *Campylobacter* and one type of chicken does not always show an infection profile that is representative of other bird and bacterial types. The damage caused to gut mucosa by some *Campylobacter* strains and some chicken types facilitates extra-intestinal spread to edible tissues. *Campylobacter* can also cause the disease Vibronic Hepatitis and work has shown that there is a

direct correlation between the observed macroscopic levels of disease of the liver and numbers of the bacteria. The presentation will focus on risks to chicken and human health posed by the extra-intestinal spread of *Campylobacter*. This will include discussion of data from both field and laboratory studies.

Keywords: *Campylobacter*, chicken, zoonoses, health, welfare

PLEN_II_P_2

MICROBIOLOGICAL RISK FROM SHELL EGGS AND THEIR PRODUCTS

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Salmonella Enteritidis has been responsible for occasional cases of infection in the UK and elsewhere for over 100 years. However, its emergence as a pandemic chicken meat- and egg-associated global public health problem in the late 1980s caused the largest and most persistent epidemic of foodborne infection attributable to a single subtype of any pathogen. In England and Wales alone, more than half a million people became ill during the course of the epidemic. The epidemic was particularly associated with the consumption of contaminated chicken meat but more importantly, shell eggs. A reduction in numbers of infections started after the introduction of vaccination for *Salmonella* Enteritidis and other control measures in chicken breeding and the production and distribution of eggs and chicken meat. In March 1991, the Advisory Committee on the Microbiological Safety of Food (ACMSF) set up a sub-group to consider the extent to which eggs were responsible for the incidence of foodborne disease due to *Salmonella*. A Department of Health (DH) funded survey of the prevalence of *Salmonella* contamination of eggs from retail outlets in the high street in 1991 showed that *Salmonella* were isolated approximately 1% of boxes of six eggs. Despite extensive measures adopted by industry to address the problem, a follow-up survey in 1995/96 demonstrated that the situation had not improved. Accordingly, the ACMSF established a second sub-group in 1998 to consider the factors which determine the presence of *Salmonella* contamination in or on eggs, and to assess existing measures to reduce *Salmonella* contamination of eggs, the contribution of vaccination and competitive exclusion, and the storage, handling and use of eggs. The Chief Medical Officer and the FSA have previously highlighted the risk associated with eating raw and lightly cooked eggs and issued public health advice on the safe handling and use of eggs. The Agency's advice historically has always been that eating raw eggs, eggs with runny yolks or any food that is uncooked or only lightly cooked and contains raw eggs may cause food poisoning, especially in 'at risk' groups, and that for others, cooking eggs thoroughly is the safest option if you are concerned about food poisoning. In 2015 the FSA Agency considered it was appropriate to review its existing advice to determine whether or not it remains applicable and proportionate, and the ACMSF agreed to establish a sub-group to examine the subject again. The purpose of the group was to assess the current level of microbiological risk to consumers (including vulnerable groups, i.e. the very young, the very old, the pregnant or the immunocompromised) from raw or lightly cooked shell eggs and their products and to assess how the risk with respect to *Salmonella* had changed since the last ACMSF report on this subject in 2001. The remit of this group focussed on all commercially available edible shell eggs and liquid and frozen eggs including those on retail sale and used in catering establishments, those products produced in the UK and shell eggs and liquid and frozen eggs produced in the EU and those imported from third countries. In contrast with previous sub-groups, this group was also tasked with reviewing other microbiological hazards that may be

present in eggs and egg products; although *Salmonella*, and in particular *Salmonella* Enteritidis, was still the main focus.

In this presentation, the emergence of *Salmonella* Enteritidis as a major foodborne pathogen will be considered in more detail, with particular focus on eggs. The findings of the most recent ACMSF report, which was published last year, will be discussed and the recommendations of the report will be highlighted. These will be considered in the context of public health advice on the safe handling and use of eggs.

Keywords: eggs, salmonella, food safety, risk-assessment

EGG SESSION IV

EGG_IV_CS_1

CUTICLE DEPOSITION ENHANCES THE EGGS NATURAL DEFENCE AND IS A TRAIT WHICH DOES NOT TEND TO DECREASE WITH BIRD AGE

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Cuticle deposition can be measured using staining combined with spectrophotometry and genetic parameters for this trait have been established and are favourable for selection in both egg and meat types of chicken. This study aimed to confirm the role of this trait on the trans-shell penetration of bacteria and to determine if cuticle deposition changes with bird age.

Bacteriology experiments were carried out using two eggs from hens depositing either good or poor cuticle in both a broiler breeder (BB n= 73) and Rhode Island Red layer (RIR n=46) pure line. For BB eggs we found a significant effect (P=0.023) of shell penetration by the *E. coli* and the amount of cuticle deposition. For RIR eggs tested with *Salmonella enteritidis* there was a similar relationship (P<0.001). The effect of bird age on cuticle deposition was examined in the same populations by sampling individuals every 3-5 weeks from early to late lay (BB n=108; RIR n=27). Cuticle deposition varied between samples (BB P<0.001; RIR P=0.077), but it did not decrease with bird age. This finding was confirmed in another study of 1900 RIR layers where cuticle deposition at 30wks was not significantly different from that at 51wks. Cuticle deposition therefore enhances the eggs defence in both egg and meat types of chicken and does not appear to reduce in quality with age unlike many egg traits.

Keywords: eggshell, cuticle, bacteriology, safety, bird age

EGG_IV_CS_2

ASSESSING THE IMPACT OF EGG SWEATING ON SALMONELLA ENTERITIDIS PENETRATION INTO SHELL EGGS

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Some research has shown that egg sweating can increase *Salmonella* Enteritidis (SE) penetration through the shell into egg contents when refrigerated eggs are transitioned through warmer temperatures. Sweating can occur during egg tempering before washing to minimize thermal cracks. To investigate sweating, a 2x2 factorial of SE inoculation and sweating were compared during a 6 wk storage period at 4°C. Shell rinse, shell emulsion, and egg contents were sampled, enumerated and assessed for SE prevalence. After wk 1, the SENS (inoculated, not-sweated) shell rinse had higher SE counts (0.32 log₁₀ CFU/mL) than the other three treatments, where no SE was enumerated. In subsequent wks, no SE counts were obtained from the egg samples. The SENS shell rinses had significantly higher SE prevalence than the SES (inoculated, sweated) rinses in wks 1 (100% vs. 34.3%), 2 (57.6% vs. 22.2%), and 3 (38.2% vs. 11.1%; P<0.05). Egg sweating did not increase SE shell penetration prevalence across treatment or week of storage (P<0.05). The decreasing trend of SE prevalence observed over the study indicates that refrigeration is effective at inhibiting SE growth. These results indicate that sweating occurring during transport and delivery as practiced in the US is not harmful to egg safety.

Keywords: shell eggs, egg safety, *Salmonella*, condensation, sweating

EGG_IV_CS_3

REDUCING THE LEVEL OF SALMONELLA INFECTED POULTRY TABLE EGG FLOCKS BY A CONTROL AND ELIMINATION STRATEGY – THE DANISH SUCCESS!

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The incidence of human salmonellosis rose in Denmark during the 1990, causing the National Salmonella Control Programme for the enhanced control of Salmonella in the table egg production to be implemented in 1996. The processes are a part of the Danish Parliament and Government's general objective of improving the quality of Danish food. Since the launch of the programme, the percentage of flocks infected with Salmonella has decreased more than 20 %. In 1998 the number of infected flocks was about 100. In 2015 we had no infected laying flocks. All types of Salmonella are included in the program, no matter what types of Salmonella had been verified – the flock can no longer deliver shell eggs to the market. A special guarantee in the EU for the table egg production

was achieved in 2012, and no infected flocks were found in 2015, even though each flock is being tested by sock samples every second week. The level of infected table egg flocks is now 0 %. The programme is a 'top-down' control effort and an elimination strategy. There is a zero tolerance for all Salmonella types in the poultry products in Denmark. The programme comprises code of practice guidelines, import restrictions of animal material, biosecurity guidelines, heat-treated feed, and control by national officials. No vaccination has been used in the program. Conclusion: It's possible to reduce the number of Salmonella infected poultry flocks by control and elimination strategies.

Keywords: *Salmonella*, elimination, quality, food safety

EGG_IV_CS_4

IMPACT OF THE USE OF AN ALTERNATIVE BACTERIAL TECHNOLOGY IN HATCHERY ON THE VIABILITY OF BROILER CHICKS (UNTIL SLAUGHTER AGE)

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After previous research which demonstrated the efficiency of COBIOTEX Biofilm to substitute formalin in setters, this complementary work compares two alternatives: a nucleus including several selected strains (with ISB06 *Bacillus Amyloliquefaciens* registered as Biocide TP3) versus a complex of essential oils (EO). After cleaning and disinfection, spraying of COBIOTEX in setter or 3 fumigations of EO during hatching. Seven repetitions were performed in setters and the 2x20 flocks were studied in production. Bacteriological parameters (swabs; chicks liver-yolk) and mortality at 10 and 57 days, % culling were followed. Starting from the same post disinfection status in both setters, the bacterial complex COBIOTEX reduced significantly the Enterobacteria and Fecal coliforms (-2.6 log, $p < 0,05$) in comparison with the EO at the end of hatching period. Chick's lower microbiological load is associated with lower liver-yolk contamination in with COBIOTEX use. There was a significant mortality reduction on the first 10 days of production (-22%, $p < 0,05$) which was maintained until slaughter. This selected bacterial nucleus is more efficient than the treatment with EO on pathogenic flora control in hatcheries. This new prophylaxis approach represents an efficient alternative sanitary strategy in broiler hatcheries and in ensuring chick quality in production.

Keywords: hatchery, setter, bacteria, formalin, essential oils

ANALYSIS OF THE HYGIENOGAM INFORMATION AND HYGIENOGAM SCORES OBTAINED AFTER
CLEANING AND DISINFECTION OF POULTRY HOUSES IN FLANDERS DURING THE PERIOD 2007 TO
2014

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Cleaning and disinfection (C&D) of poultry houses is essential to manage farm hygiene, and to prevent and control zoonoses and animal diseases. Hygiene monitoring on total aerobic flora through sampling with agar contact plates is used to evaluate the proper execution of C&D and results in a hygienogram score between 0 and 5 (ranging from very good to very bad respectively). Scores and information of these so-called hygienograms were recorded (n = 19739) and analyzed. The hygienogram score showed a decreasing trend over the years suggesting a general hygiene improvement between 2007 and 2014. Differences were found between the husbandry systems with barn/aviary system having the lowest score compared to floor housing, furnished cage and battery. Scores of production houses were higher compared to breeding and rearing houses. Lower scores were obtained when a cleaning product was used. Differences in scores between disinfectants with certain active components were found. Disinfection with peracetic acid - hydrogen peroxide combined disinfectants or formaldehyde gave the lowest scores. In addition, disinfection protocols using 2 different disinfectants showed improved results compared to the use of 1 disinfectant. Finally, disinfection carried out by an external firm resulted in a lower score compared to disinfection done by the farmer.

Keywords: poultry farm, cleaning, disinfection, hygiene score, hygienogram

EGG_IV_SO_2

EFFECT OF TITANIUM DIOXIDE ON EGG SHELL QUALITY

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Titanium dioxide (TiO₂) is commonly used as an inert marker to enable determination of dietary available energy and nutrient digestibility in poultry diets. However, there is a lack of information on its impact on egg quality when fed to layers. An experiment was conducted to study the effect of TiO₂ on egg quality and egg shell variables. A wheat soybean basal diet was manufactured to be nutritionally adequate following breeder's recommendations. The basal diet was then split in two as half was supplemented on top with 5 g/kg TiO₂, and the rest was fed as it is for 4 weeks. Forty-two 53 weeks old Hy-Line hens were randomly allocated to 14 enriched cages, at 3 hens per cage. Eggs were collected and numbers recorded on a daily basis, and were weighed each once per week. The egg quality and egg shell variables were measured using eggs collected during the last three days of the study. Feed intake was also measured. Birds fed TiO₂ free diet has thicker eggshell (P<0.05) but no differences (P>0.05) were observed among the rest of the studied variables. Further research is needed to study the effect of TiO₂ on egg shell quality.

Keywords: titanium dioxide, layers, egg shell

EGG_IV_SO_3

EGGSHELL AS A SOURCE OF HIGHLY DIGESTIBLE CALCIUM

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The technology for production of eggshell-based mineral concentrate (EMC) was developed and experimental batches produced. Calcium content in EMC is 35.8%, phosphorus 0.3%; the preparation is pathogen-free. Medical and biological tests of the preparation were performed on rats fed diets with 0, 1.5 and 3.0% of EMC; growth efficiency parameters and nutrient balance were determined. Body weight gain, protein efficiency ratio (PER), net protein utilization (NPU) and protein digestibility in supplemented treatments were significantly higher compared to the control (p<0.05). Significantly lower circulatory concentrations of cholesterol (by 20%, p<0.05) and higher concentrations of albumin (by 7%, p<0.05) and Ca (by 30%, p<0.05) were found in rats fed experimental diets. Ca availability in experimental treatments was 81.7 (1.5%EMC) and 87.9% (3%EMC) vs. 33.4% in control. There were no acute or sub-acute toxic effects, even when the dose fed corresponded to a 16-fold increase in daily Ca requirement. Ca digestibility from the product was

2.6 times higher compared to inorganic Ca from low-salt diets. Feed supplementation with EMC improves metabolism of protein, lipids, and minerals, and positively affects body weight gain.

Key words: eggshell, calcium, digestibility, protein efficiency, by-product utilization

MEAT SESSION IV

MEAT_IV_A_1

LOW ATMOSPHERIC PRESSURE STUNNING FOR THE POULTRY INDUSTRY

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Low Atmospheric Pressure Stunning (LAPS) is a novel approach to pre-slaughter stunning of poultry in which birds are rendered unconscious by gradual decompression which reduces oxygen tension in the atmosphere to achieve a progressive anoxia (hypobaric hypoxia). The advantages of this approach are similar to controlled atmosphere stunning whereby birds are not shackled while conscious and all birds are reliably and irreversibly stunned. However, there are concerns that birds undergoing LAPS could experience discomfort or pain. In a series of studies examining the responses of broilers to LAPS, we have applied behavioural, physiological and neurophysiological approaches to assess welfare. LAPS is associated with a gradual loss of consciousness and we have used spectral analysis of the electroencephalogram (EEG) to characterise this, employing previously validated median frequency thresholds for sedation and unconsciousness. We have also used key behavioural indicators to determine the likelihood of negative experiences during the conscious phase. Slightly altered LAPS curves are applied at different temperature settings (TS) to allow for the changes in air density. We characterised the responses of broilers exposed to LAPS in 30 triplets at two temperature settings (TS3 (applied at 13-18°C); TS4 (applied at 5-12°C)). In a separate trial we also examined the influence of illumination of the chamber during LAPS and the effect of sham treatment (placement in the chamber without LAPS being applied) in a 2x2 factorial design (20 pairs of birds per treatment), at TS4 only. In each triplet/pair, one bird was instrumented for recording of EEG and ECG, and the behaviour of all birds was recorded. Birds showed a consistent sequence of behaviours during LAPS (ataxia, loss of posture, clonic convulsions and motionless) which were observed in all birds. Leg paddling, tonic convulsions, slow wing flapping, mandibulation, head shaking, open bill breathing, deep inhalation, jumping and vocalisation were observed in a proportion of birds. TS4 was associated with shorter LOP latencies than TS3 (TS4=62.3±1.1s; TS3=57.5±1.2s (P<0.001)), but in Trial 2 illumination had no effect (dark=54.7±1.3s; light=55.9±1.2s (P=0.250)). The durations of consciousness related behaviours (e.g. standing and sitting) were predictably increased in the sham treatment. During LAPS, EEG spectral analysis revealed progressive decreases in median frequency and increases in total power (PTOT), followed by decreases in PTOT before the onset of an isoelectric state (brain death). TS had no effect on latency to F50<6.8Hz (equivalent to general anaesthetic plane/unconscious), but illumination and sham treatment did (LAPS/dark=39.1±6.3s; LAPS/light=53.6±11.8s; sham/dark=12.8±5.2s; sham/light=88.0±29.5s (P<0.001)). Illumination stimulated brain activity and dark induced sleep, but slow-wave EEG was seen in both treatments. ECG measurements showed that the latency to pronounced bradycardia in LAPS was affected by TS (TS3=52.5±4.5s; TS4=46.7±2.2s (P= 0.021)). In Trial 2, bradycardia was absent in the sham treatment and was not affected by illumination (dark=42.5±1.9s; light=49.3±4.8s (P=0.078)). These results

demonstrate that responses to LAPS are consistent across temperature settings and that the hypoxic conditions associated with decompression are responsible for the observed behavioural and physiological responses. To specifically investigate whether LAPS is associated with pain, we recorded the behavioural responses of birds to LAPS with and without administration of an opioid analgesic (butorphanol). A blocking design was used in which pairs of birds receiving either analgesic or sham treatments were allocated to three types (analgesic/analgesic, analgesic/sham, or sham/sham). The observer was blinded to pair type. Again, birds showed a consistent sequence of behaviours during LAPS and administration of butorphanol had no effect on the range and patterning of behavioural responses. There were some differences in behaviour latencies, counts and durations. For example, latencies to ataxia, mandibulation and deep inhalation were delayed by analgesic treatment, but the duration of ataxia and other behaviours related to loss of consciousness were unaffected. Fewer birds receiving analgesia showed jumping and slow wing flapping behaviour compared to controls, which suggests these may be pain related. However, these behaviours were not seen in all birds and occurred after the onset of ataxia, suggesting that the results may reflect a smoother induction to unconsciousness in analgesed birds. Collectively, the results do not provide convincing evidence that birds undergoing LAPS are experiencing pain. While there were effects of analgesia on some aspects of behaviour, these could also be explained by potential sedative, dysphoric and physiological side effects of butorphanol. Collectively, the results suggest that LAPS is largely equivalent to controlled atmosphere stunning with anoxic gases, and our findings indicate that the process may meet the criteria of allowing slaughter to be performed without avoidable fear, anxiety, pain, suffering and distress. This evidence is currently being considered by EFSA to facilitate approval of the method in the EU regulatory framework.

Keywords: hypobaric hypoxia, low atmospheric pressure stunning, behaviour, electroencephalogram, animal welfare

MEAT_IV_CS_1

IMPACT OF LOW ATMOSPHERE PRESSURE STUNNING OF BROILERS ON BREAST SKIN SALMONELLA AND CAMPYLOBACTER POST-DEFEATHERING AND BREAST FILLET MEAT QUALITY

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Abstract: Low atmosphere pressure stun (LAPS) is a method of controlled atmosphere poultry slaughter that decreases atmospheric pressure (0.2 ATM) inducing unconsciousness and death. Following feed withdrawal periods of 4, 6, 8, or 10 hours, broilers were slaughtered using LAPS or electrical stunning (USA parameters). Prevalence of *Salmonella* and *Campylobacter* on post-defeathered breast skin and breast meat quality was assessed following carcass chilling with ice/water immersion or on ice pack. Direct plating revealed that from LAPS carcasses, no *Salmonella* (0/40) was detected compared to electrically stunned carcasses (6/40). No significant differences in *Salmonella* recovery were detected following enrichment, for *Campylobacter* (95%+), or among feed withdrawal durations. Breast fillets from LAPS stunned birds had significantly lower pH at 0.25 to 2 hours postmortem, significantly lower L*, higher a*, and lower thaw loss than electrically stunned. Breast fillets from water immersion chilled carcasses had significantly lower temperature

from 0.25 to 4 hours postmortem, resulting in higher pH at 1 and 2 hours postmortem and shorter sarcomere length when deboned at 2 hours postmortem. These results indicate that post-defeathering, LAPS breast skin may have lower *Salmonella*. Although meat quality was significantly different, those differences were small and may not be detectable by sensory analysis.

Keywords: low atmosphere pressure stun, meat quality, broiler, *Salmonella*, *Campylobacter*

MEAT_IV_CS_2

INFLUENCE OF DIFFERENT SCALDING PROCEDURES ON MICROBIAL LOAD OF POULTRY CARCASSES – INITIAL RESULTS

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Poultry processing is a highly automatized process. Each step influences the microbial load of the carcasses. While some process steps lower the bacterial count and inactivate or remove pathogens, cross contamination should be minimised. The present study was conducted over two years to compare the influence of three different scalding procedures on the Enterobacteriaceae count (EB): conventional immersion scalding, immersion scalding with pasteurisation of the water, Aeroscalder® using hot moisturised air as scalding medium. In three commercial slaughter plants breast skin samples before/after scalding, after plucking and after chilling, were taken and examined for EB. In addition scalding water samples were analysed to evaluate the risk of cross contamination. After the first sampling year no statistical differences were seen for EB on breast skin samples between the three slaughterhouses. From an initial 6 log contamination, an up to 4 log reduction could be achieved after chilling. Plucking showed the biggest influence on the reduction as expected. EB could not be detected in the scalding water samples of the Aeroscalder. In the second sampling year the first processing steps before and after scalding and plucking will be more closely examined to better understand possible differences between the scalding techniques.

Keywords: poultry, meat, processing, scalding, microbiology

MEAT_IV_CS_3

ON-LINE DETECTION OF WOODEN BREAST SYNDROME IN CHICKEN FILLETS BY HYPERSPECTRAL NEAR-INFRARED IMAGING

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During the last years the muscle syndrome wooden breast (WB) has become a serious challenge to the poultry meat industry. WB is a term for abnormal muscle tissue in the chicken breast, which makes the breasts appear as pale, hard and out-bulging. A rapid on-line method for detection and grading of this syndrome would allow 1) automatic quality sorting of fillets to different products and

2) large scale industrial registering of WB so that possible causes for the disease related to production regimes can be understood. WB can be detected by the use of near-infrared spectroscopy because the tissue has significantly higher moisture content and a lower protein content. It also has a higher share of loosely bound water due to muscle fiber degeneration. In this work a sample set of 197 fillets was measured by an on-line NIR scanner and used for training and calibration. A test set was recorded under industrial conditions and contained spectra from 55 normal fillets and 24 WB. Classification based on NIR obtained 99.5–100% correct classification of WB versus normal fillets. The NIR scanner was then used to detect incidence rates of WB in three broiler flocks where a high number of fillets (9063, 6330 and 10483) were measured. Prevalence of WB of 0.1%, 6.6% and 8.5% were estimated for these flocks based on the complete sample volumes.

We will explain the spectral features, which enable this kind of grading. The main feature is related to water binding and can be quantified by shifts in the water absorption peak around 980 nm. These spectral changes correspond well with water binding properties measured by nuclear magnetic resonance.

Keywords: wooden breast, NIR spectroscopy, water binding properties, on-line detection, nuclear magnetic resonance

MEAT_IV_SO_1

EFFECTS OF A COATED BETAINE BASED PRODUCT ON PERFORMANCE AND MUSCLE MEMBRANE INTEGRITY IN HEAT-STRESSED BROILER CHICKENS

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Exposure to high temperatures could affect meat quality, through alterations in muscle membrane permeability and metabolism. Giving anhydrous betaine to broilers can reduce heat stress effects, related to osmoprotective properties. Nevertheless, its hygroscopicity limits its use in feed plants. This study aims at validating the impact on broiler performance and muscle integrity of a fat coated form of anhydrous betaine over a non coated form. Day old male Ross chicks allocated in 40 cages of 4 birds with 6 to 7 replicates per group, received one of the following feeds: negative control (NC), NC+ 250, 500 or 1000mg/kg anhydrous betaine (respectively AN250, AN500, AN1000), NC+ 250 or 500mg/kg coated betaine (BC250 and BC500). High temperatures were applied between 21 and 34 days with the following daily schedule: 24°C from 6 pm to 8 am, 28°C from 8 to 11 am, 30°C from 11 am to 3 pm and 28°C from 3 to 6 pm. Performances tend to be improved for all groups compared to NC, with the best result for BC500. Blood analysis on groups NC, AN500 and BC500 showed a tendency to reduce the skeletal muscle-derived isoenzyme creatine kinase with both betaine forms, especially with the coated one (-9.1% and -19.9% for non coated and coated forms, respectively). This could reflect a reduction of heat stress related damage to muscle membrane. A numerical decrease of plasma glutamic-pyruvic transaminase was observed (-41% and -26% for non coated and coated forms, respectively), which may indicate lower cellular injury related to hyperthermia, and there was an increase of glutathione peroxidase. This study confirms the potential of anhydrous betaine, especially when coated, to reduce the effects of heat stress in broilers.

Keywords: coated betaine, muscle integrity, heat stress, broiler chicken

MEAT_IV_SO_3

EARLY GROWTH AND METABOLIC CHARACTERIZATIONS OF TWO CHICKEN LINES DIVERGENTLY SELECTED ON THEIR BREAST MEAT ULTIMATE pH

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In chicken, the ultimate pH (pHu) of meat is largely determined by the muscle glycogen content at slaughter age. A divergent selection on the *Pectoralis major* pHu allowed the creation of the pHu+ and pHu- lines, which represent a unique model for studying the genetic and physiological control of the carbohydrate reserves and the meat quality. Several characteristics have been measured in the two lines at hatch then at 5 days of age. At hatch, the pHu+ and pHu- lines presented equivalent body weights and breast muscle yields. However, the pHu- line shows a higher glycaemia than the pHu+ line, a difference that will persist until slaughter age. After 5 days, the pHu+ and pHu- lines were already divergent in terms of glycogen (and pHu) and muscle yield, for a similar body weight. Differences between both lines observed at hatch and at 5 days were associated with regulation of signalling pathways involved in protein synthesis and muscle glycogen turnover. Furthermore, pHu+ and pHu- chicks have at hatch the ability to respond differently to nutrients and hormones consistent with the fact that after only 5 days of feeding, significant differences in yield and muscle glycogen contents exist between the two lines.

Keywords: chicken, metabolism, glycogen, muscle

MEAT_IV_SO_4

EFFECT OF THE WOODY BREAST CONDITION ON THE COLOR CHARACTERISTICS OF COOKED BROILER BREAST MEAT

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The woody breast condition (WBC) affects texture quality of cooked broiler breast fillets but WBC effects on meat color are relatively unknown. The objective of this study was to evaluate the effect of WBC on the cooked color characteristics of breast meat. Broiler breast fillets were collected from

a commercial plant and sorted into normal and severe WBC categories based on palpable hardness and rigidity throughout the breast fillets. Samples were cooked to 76°C. Color (CIELAB L*a*b*) on both the ventral and dorsal surfaces of cooked fillets was measured using a Minolta spectrophotometer CM-700d. On the ventral surfaces (skin-side), WBC caused an increase in the a* and b* values, but a decrease in the L* values by approximately 12 units. Similar relationships were observed on the dorsal surfaces (bone-side), but the absolute color value differences were smaller than on the ventral surfaces. In WBC fillets, L* values on the dorsal surfaces were approximately 1 unit lower and b* values were approximately 1 unit higher than in normal meat; however, a* values were unaffected by the WBC. Results demonstrate that the WBC influences the surface color of cooked breast meat and can cause noticeable differences in the cooked meat appearance.

Keywords: chicken, poultry, ventral, dorsal, L*a* b*

MEAT_IV_SO_5

INVESTIGATING THE EFFECT OF POST-SLAUGHTER DEBONING TIMES ON TEXTURE OF BREAST FILLETS FROM FAST-GROWING BIG BROILERS

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Big broilers are affected with wooden breast leading to quality issues such as tough meat texture. Toughness is possibly enhanced due to deboning broilers at 2-3 h *post-mortem* with incomplete resolution of *rigor mortis*. In a two-part study, we investigated the effects of delayed deboning times on meat quality and optimized them to obtain tender fillets. Breast fillets deboned at 2, 16, 20 and 24 h from big broilers (n = 90) were compared to normal, severely woody, and medium sized fillets. Data indicated that the texture of extended deboned fillets was tender (significantly low toughness values) when compared to woody fillets. There was no statistical difference between cook loss, color, and Blunt MORS (BMORS) (p<0.05) when compared to each other. Another study was conducted to evaluate if deboning times can be used to improve meat quality. Toughness values significantly reduced (p<0.05) with an increase in deboning times from 2 to 26 h. Peak force and shear energy values at 0 h decreased (p<0.05) correspondingly from 21.86 N and 264.15 N.mm to 16.16 N and 205.17 N.mm after 10 h *post-mortem*. In conclusion, extended deboning time of from 6-26 h can significantly help improve texture of breast fillets from fast-growing broilers.

Keywords: extended, debone, wooden, breast, texture

PLENARY SESSION III

PLEN_III_P_1

EGG QUALITY: HYGIENE IN THE HATCHERY AND CHICK QUALITY

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Although the majority of eggs produced on UK poultry units are used directly for human consumption, just under 20% of them will be set in hatcheries to produce day old chicks to be grown for meat. Eggs of both layer and breeder strains are incubated to produce multiplication stock and replacements. With their different selection backgrounds, layer and breeder eggs tend to need different incubation conditions. Good hatchability and chick quality is always dependent on eggs being incubated so as to achieve the correct embryo temperature, the correct gas exchange and water balance, regular turning and the correct hatching time. Due to their history of selection for strong shells which resist water loss during storage, commercial layer eggs tend to lose less water, take in less oxygen and so produce less heat and take slightly longer to incubate than eggs laid by broiler breeds. For this reason, it is unusual to incubate both genotypes in the same hatchery. Several factors contribute to delivering good chick quality, but a key one is keeping the egg contents free of pathogens. The structure and quality of the egg has an important part to play in maintaining good hygiene through the process of egg storage and incubation so that chick quality is optimised. Although the egg contents are usually sterile at the time of lay, the eggs are not laid in a sterile environment, and so shell surface contamination is inevitable: the dirtier the surface the eggs are laid onto, the higher the risk of contamination. Eggs must be given a shell surface disinfection before they leave the farm, but, with the types of disinfectants available increasingly restricted, disinfection may not be 100% effective. Once eggs are in the hatchery, the warm humid conditions required for embryo growth are also ideal for microbial growth. An understanding of how the structure of the shell permits the correct water and gas balance makes it easier to make rational decisions choosing disinfection chemicals and delivery systems, and in running an incubation programme. A hen's egg will have between 6,000 and 10,000 respiratory pores distributed over the whole eggshell, with a higher density around the air cell. Their diameter is such that bacteria and even fungi are small enough to pass (grow) through the pore into the egg contents. Most of the time microbial growth into the egg is prevented by cuticle plugs over the pores, and the anti-microbial proteins within the shell membranes. However, the protection these offer will be limited if the egg is allowed to get wet, especially if the water is colder than the egg contents, already dirty or has a high iron content. Egg disinfectants or washers which damage the cuticle plugs will also increase contamination rates, especially if the eggs are stored for any time.

Keywords: Egg quality, egg hygiene, hatchery

MANAGEMENT OF INCUBATION TEMPERATURE DURING EMBRYONIC MYOGENESIS AS A TOOL TO
MANAGE MEAT QUALITY

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In chicken embryonic development of skeletal muscles (myogenesis) could be separated in two distinct steps, an innervation independent between ED 3-8 and an innervation dependent step between ED 8-14. Within these periods primary and secondary myotubes are formed by fusion of certain lineages of fast, intermediate and slow myotubes followed by specific arrangement of these cells. The new muscles show specific proportions and distributions of fast-twitch-glycolytic (FTG), fast-twitch-oxidative (FTO) and slow-twitch-oxidative (STO) muscle fibres. During further embryogenesis the skeletal muscles mainly grow by hypertrophy of the muscle fibres, especially during the post-hatch period (Miller and Stockdale 1986). Composition and size (cross-sectional area) of the muscle fibres have an impact on the muscle metabolism. As a change of the muscle metabolism influences the growth of the animals and the muscle-to-meat-transition after slaughter, an impact on the meat quality characteristics should be also considered, if the muscle structure/ metabolism has been altered. An important factor influencing the in ovo development of avian embryos is the incubation temperature. As it can be easily modified, the impacts of temperature alterations during embryogenesis have been investigated in several studies (Loyau et al. 2015). These investigations differed in poultry egg species (e.g., turkeys, laying hens, broiler), embryonic days (ED) of manipulation (e.g., ED 7-10, ED 10-13, ED 7-16, ED 16-18), incubation temperatures during manipulation (e.g., 36.7 °C, 38.7 °C, 39.5 °C) or daily duration of the manipulation (e.g., 3 h/ day, 12 h/ day, 24 h/ day). In many studies the incubation temperature was changed to primarily influence the post-hatch thermoregulation abilities (thermotolerance) of the birds. In these investigations the manipulation period was often shortly before hatch (ED 16-18, Loyau et al. 2015). In other investigations the incubation temperature was altered during embryonic myogenesis (ED 3-14, Loyau et al. 2015). In many of the latter studies the growth characteristics and muscle-to-meat-transition after slaughter of the animals were analysed. Post-hatch growth is due to hypertrophy of the muscle fibres. As this alteration influences the muscle metabolism, an impact on the muscle-to-meat-transition and meat quality parameters like pH, colour, shear force could be assumed. Therefore we investigated in different studies, if the slaughter and meat quality characteristics of 35-day-old broiler were changed after increasing the incubation temperature (+ 1 °C) at different periods during embryonic myogenesis (ED 3-6, 7-10, 10-13). Incubation of broiler eggs at higher temperatures between ED 3-6 resulted in significantly ($P \leq 0.05$) higher drip loss but lower shear force results of these broilers in comparison to the normally incubated animals. However, no effects on the slaughter characteristics could be obtained in these investigations. In contrast to this, incubation of the broiler eggs at higher temperatures between ED 7-10 resulted in sex-dependent effects with higher ($P \leq 0.05$) slaughter and breast weights in the female and comparable values in the male broiler incubated at higher incubation temperatures between ED 7-10 compared to the normal incubated animals. The meat quality results were not influenced by the temperature alteration, except for the shear force values, that were again lower ($P \leq 0.05$) in the breast muscles of broiler

incubated at higher temperature between ED 7-10. Higher incubation temperatures between ED 10-13 resulted in sex-independent effects with higher ($P \leq 0.05$) slaughter weight and yellowness and lower drip loss and shear force values in these broilers compared to the normal incubated birds. However, the breast muscle weights were only higher ($P \leq 0.05$) in the female broiler incubated at higher temperature not in the male animals. The data indicate that alteration of the incubation temperatures affects the growth and meat quality characteristics of the broiler post-hatch, but these effects depend not only on the period during embryonic myogenesis, but also on the sex of the broiler. The sex-dependent differences need further investigations.

Keywords: poultry, incubation temperature, embryonic myogenesis, meat quality

EGG SESSION V

EGG_V_A_1

DIETARY FACTORS IMPROVING EGG SHELL QUALITY: AN UPDATED REVIEW WITH SPECIAL EMPHASIS ON MICROELEMENTS AND FEED ADDITIVES

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Eggshell formation challenges the calcium metabolism of hens. Poor eggshell quality remains a limiting factor for extending the egg laying period. Eggshell strength depends on the supply of shell precursors in the uterus, mainly Ca, and on its fabric controlled by the organic matrix proteins secreted by the uterus. Numerous papers explored ways to improve Ca supply and highlighted that dietary Ca level and its form were the main elements to increase Ca retention, a prerequisite for optimizing eggshell quality. Ca must be delivered in adequate form to stimulate Ca appetite and its solubilization along the gut. Vitamins and trace elements are also crucial and affect shell quality either by favoring Ca supply (vitamin D) or by direct action on eggshell fabric (Cu, Zn, Mn), being cofactors of proteins contributing to the shell mineralization *in utero*. Supplying vitamin D or its metabolites increases Ca retention, but not Ca uterine secretion. The vitamin D metabolite, 25 (OH) D3 can be provided for hens with hepatic metabolic disorders, and thus can improve shell quality in the late production stages. The 1(OH) D3 metabolite, present in *S. glaucophyllum* (0.012–0.032 µg/g dry wt) and in *Cestrum diurnum* (1µg/g dry wt.), stimulates calcium absorption and in some case eggshell quality (EFSA, 2015). In hens exposed to heat stress, the supply of vitamin C (300-400 mg/kg) has some beneficial effects on egg production, eggshell quality and bone strength. Eggshells from hens fed a Mn deficient diet (<7 mg) show lower eggshell thickness, translucent areas due to alterations in eggshell ultra-structure in the mammillary layer. Mn is a component of Galβ1,3-glucuronosyltransferase (GlcAT-I), an enzyme involved in the synthesis of proteoglycans that interfere with calcite morphology and control shell breaking strength. Zinc (Zn) is a component of carbonic anhydrase, a key uterine enzyme in supplying shell carbonate. Cu contributes to eggshell membrane formation as a cofactor of lysyl-oxidase involved in lysine derived cross-linking. It is, therefore, current practice to supply hen's diets with Cu, Zn, Mn from inorganic or organic sources for reinforcing eggshell strength. Numerous additives (probiotics, prebiotics, organic acids and essential oils or plant extracts) have been evaluated for improving eggshell quality. There are believed to improve intestinal health and consequently intestinal Ca retention (Swiatkiewicz et al., 2015). The results exploring the efficiency of these additives are variable and their mode of action is not fully characterized. Fructan, inulin or oligofructose have been reported to improve eggshell breaking strength in aged hens, probably by increasing the intestinal retention of Ca. Amongst the numerous publications on pre and probiotics (>50 since 10 years), half showed a positive effect of low magnitude on shell quality. Short chain organic acids (0.05% or 0.078%, mixture of formic, butyric, propionic and lactic acid) have also been shown to improve eggshell breaking strength or thickness in aged hens, probably because of a higher solubility and absorption of calcium. Finally, there are also reports demonstrating that mixtures of essential oils or traditional medicinal herbs (fenugreek, cumin, turmeric, Yucca....) occasionally increase eggshell quality (>60 papers) but the tested products and mixture are too variable to conclude on the efficiency of a particular product.

Keywords: eggshell vitamin trace element pre- probiotics plant extracts

EGG_V_CS_2

EGG QUALITY OF LAYING HENS FED DIETS CONTAINING SOLUBLE AND INSOLUBLE FIBER

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The use of dietary fiber improves laying hens development, affecting nutrient digestibility. Thus, this study aimed to evaluate the inclusion of different levels and sources of crude fibre in the diet of laying hens on internal and external egg quality. The experiment was developed with 420 Bovans White hens aged 19 weeks in a completely randomized design in a factorial arrangement 3x2 + 1, three levels of dietetic crude fiber (2.5%, 3.0%, 3.5%), a soluble (wheat bran) and insoluble (sugarcane bagasse) fiber sources compared to a control corn and soybean diet with six replicates of 10 birds each. 24 eggs per treatment were collected on the last day of the 27th, 28th, 29th and 30th week of age to measure internal and external egg quality – specific gravity, eggshell, yolk and albumen percentage. Higher egg weights were obtained with 3.0% sugarcane bagasse (56.4g) and wheat bran (55.5g) diets at 28 weeks and 2.5% of cane bagasse (54.5g) and 3.0% of Wheat bran (56.3g) at 29 weeks (p <0.05). No differences occurred for the other variables evaluated. The use of dietary fibre for laying hens may increase egg weight and does not adversely affect quality parameters.

Keywords: dietetic fibre, external egg quality, internal egg quality

EGG_V_CS_3

THE EFFECT OF BOILED TOMATO WASTE POWDER ON LAYER PERFORMANCE AND EGG QUALITY

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This experiment evaluated the effect of boiled tomato waste powder on layer performance and egg quality. Tomato waste used in this experiment was surplus mature tomato unsold from the last harvesting. The tomatoes were boiled in boiling water (100 °C) for 8 minutes to convert their lycopene structure from *trans* to *cis* which can be easily absorbed by the poultry digestive tract. Lycopene is a natural antioxidant that can lower cholesterol. This experiment was performed using

200 Isa Brown hens with 80 % hen day egg production (HDEP). A completely randomized and replicated design was used with 5 treatments of boiled tomato waste powder (0, 3, 6, 9 and 12 %) to a layer diet. The diet was arranged so that it was iso-nitrogenous (16%) and iso-calorific (2600kcal/kg). Feed consumption, HDEP, egg weight, egg mass, feed conversion, albumen height, eggshell thickness, eggshell strength were measured. Results showed that boiled tomato waste powder in the diet had no effects ($P>0.05$) on feed consumption (116,5-121,6 g/d), HDEP (83,3-89,8%), egg weight (62-62,9 g), egg mass (51,6-55,9 g/d), feed conversion (2,18-2,19), albumen height (69,2-81,2 HU), eggshell thickness (0,409-0,430 mm), and strength (3,43-4,63). In conclusion, there was no negative effect of including up to 12 % boiled tomato waste powder on layer performance and egg quality.

Keywords: boiled tomato waste powder, lycopene, diet, layer performance, egg quality

MEAT SESSION V

MEAT_V_A_1

BREAST MEAT MYOPATHIES IN MODERN BROILER CHICKEN LINES

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In recent years there have been increased reports of novel myopathies affecting the quality of chicken breast meat in a range of broiler breeds, these specifically affect the *Pectoralis major* muscle and have been named “Wooden breast” and “White striping”. The incidence of these conditions is sporadic and variable and the exact aetiology and pathophysiology of these conditions are currently unknown. It has been suggested that the cause of the myopathies is genetic selection for increased growth rates and breast yield. Data published by the author indicated that, whilst there is a genetic component to the myopathies, the non-genetic factors contribute to greater than 65% of the variance in the incidence of white striping of breast muscle and more than 90% of the variance of the incidence of wooden breast in broiler chickens. Furthermore the genetic correlation between body weight and breast yield with the breast muscle myopathies were both ≤ 0.248 indicating that there are factors other than growth and breast yield involved with the manifestation of the myopathies. Identifying and understanding the role of the non-genetic factors in the pathophysiology of breast muscle myopathies is essential for reducing the incidence at the flock level. The growth, performance and health of any livestock animal are intrinsically dependent on the environmental conditions and management strategies on the farm along with the nutritional specification of the feed provided. Consequently the growth and development of breast muscle myopathies is reliant to these environmental factors. The relationship between these factors and the manifestation of breast muscle myopathies will be presented in this paper. Optimal muscle growth is heavily dependent upon the activity of the satellite cells within the muscle tissue which provide support for muscle fibre growth. Early chick development and environmental conditions play a critical role in the establishment of adequate satellite cell populations required for muscle growth as the bird ages. As the broiler chicken grows it is important that all of its nutritional and physiological demands are met to ensure correct muscle development. Therefore, good management of the modern broiler chicken is essential to its performance; we will highlight how different aspects of flock and house management can impact upon the incidence of breast muscle myopathies. In addition to management strategies, research has shown that nutrition plays a critical role in meat quality. Trials have shown that poor fat quality, low antioxidant levels and high dietary amino acid density can increase the likelihood of myopathies occurring. Additionally the use of novel nutritional approaches have been implemented and found to reduce the incidence and severity of breast muscle myopathies. The data presented here describes the relationship between the genetic and non-genetic factors influencing breast muscle myopathies. It shows that in the long term the low genetic basis for the development of breast muscle myopathies can be exploited through balanced selection, but the non-genetic factors have a greater influence and will have a more immediate effect at reducing the incidence of the myopathies at the flock level.

Keywords: broilers, breast, meat, myopathy, muscle

MEAT_V_CS_1

EFFECT OF FEEDING SYSTEM AND AGE ON MUSCLE FIBRE DEGENERATION IN TWO BROILER CHICKEN GENOTYPES

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To evaluate how age, genotype (Cobb500 vs. Ross308) and feeding regime (AL: ad libitum; ER: early restricted from 13 to 23 d of age; LR: late restricted from 27 to 37 d; restriction rate: 80% of *ad libitum*) affected muscle fibre degeneration (MFD) associated to white striping and wooden breast, the *Pectoralis major* of 144 male chickens were sampled at 23, 36, and 48 d of age for histological analyses and scored from 0 to 3 (normal, mild, moderate, severe MFD). PROC GLIMMIX of SAS evaluated the effect of main factors and interactions. When age increased, MFD worsened from 1.25 to 1.88 and 2.42 (P<0.001). The feeding system had no main effect, but interaction with age tended to significance (P<0.10): at 23 d, MFD score was 1.28, 1.06, and 1.41 in AL, ER, and LR broilers; at 36 d, the score was 2.14 to 1.92 and 1.58; at 48 d, 2.37, 2.44, and 2.44. Finally, Cobb chickens exhibited lower MFD than Ross (1.67 vs. 2.03; P<0.01). In conclusion, MFD appeared early, increased with age, and changed with genotype; feed restriction lowered MFD only during the restriction period. Further improvements of feeding strategies may contribute to control broiler myopathies.

Keywords: myopathies, feeding strategies, histology

MEAT_V_CS_2

FEED ADDITIVES TO CONTROL *CAMPYLOBACTER* IN BROILERS: WHAT IS THE OUTCOME AFTER 4 YEARS OF RESEARCH?

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Campylobacter is responsible of the most commonly reported zoonosis in the European Union with more than 226,000 human cases in 2015. The poultry reservoir, especially broiler meat, is generally recognized as one of the most-important sources for human campylobacteriosis. The measures to control *Campylobacter* targeted essentially the primary production level, and feed additives are one of the investigated solutions. From 2012 to 2016, efficacy of different feed additives to decrease *Campylobacter* counts in broilers was evaluated. Commercial or new products (i.e. probiotics, prebiotics, plant extracts, and organic acids) alone or in combinations were tested in vivo in experimental husbandries or in field conditions for some of them. Broilers contaminated with *Campylobacter* were fed either with a control diet (additive free) or with a supplemented diet. *Campylobacter* loads were assessed and the comparison

between control and treated groups was performed using statistical analysis based on multiple comparison tests. A summary of these studies will be presented. A promising reduction of 2-3 log CFU/g was observed for several additives in experimental husbandries. In addition, an overview of the main issues and challenges regarding the use of feed additives as a control option against *Campylobacter* in broilers will also be discussed.

Keywords: *Campylobacter*, control strategy, broilers, feed additive

MEAT_V_CS_3

EVALUATION OF ACUTE PHASE PROTEINS IN MEAT JUICE TO ASSESS FEBRILE ('DARK') CARCASSES DURING POULTRY PROCESSING

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Dark red major pectoral muscles can be indicative of a febrile carcass (presence of pathology) or be related to deficient bleeding during the slaughter process. Differentiation of the different causes of dark carcasses is needed, especially when high numbers of dark carcasses are condemned from what appear to be healthy birds from farms with good performances. It has been demonstrated in pigs that meat juice (MJ) is an adequate matrix in which the health status of the animal is reflected. To evaluate, for the first time, acute phase proteins (APPs) in poultry MJ, both serum and MJ was collected from 40 non-febrile (40-41.5°C) and 40 febrile (>42°C) animals aged 30-46 days. Alpha-1-acid glycoprotein (AGP), ovotransferrin (Ovt) and ceruloplasmin (Cp) were determined using chicken specific immunoassays. AGP ($p < 0.0001$) and Ovt ($p < 0.05$) were significantly higher in the serum of febrile animals. The MJ AGP ($P < 0.0001$), Ovt ($P < 0.0001$) and Cp ($P < 0.0001$) were also significantly higher in these birds. When APP concentrations were determined from MJ collected from 35 healthy carcasses and 52 dark carcasses considered febrile there were no significant differences between AGP concentrations ($P = 0.0750$). Both Ovt ($P < 0.0001$) and Cp ($P < 0.05$) were significantly higher in the *normal* MJ. These results demonstrates that while APPs in MJ can be used to differentiate febrile carcasses, further work to understand the causes of dark carcasses is required as the MJ APPs concentrations of dark carcasses are not consistent with a febrile condition in the live bird.

Keywords: meat juice, biomarker, febrile, APP, condemnation

MEAT_V_SO_1

IS WHITE STRIPING OCCURRENCE A QUALITY ISSUE EVEN FOR TURKEY BREAST MEAT?

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In the past few years, some abnormalities in broilers (i.e. white striping and wooden breast) have occurred. Even in turkey breast muscles, presence of superficial white stripes has been observed for several years, however it is not well known if there are similarities with the abnormality occurring in broilers. Thus, this study aimed at evaluating the consequence of white striping (WS) on quality traits of turkey breast meat. For this purpose, 48 *P. major* muscles were selected into two independent trials from homogeneous flocks of heavy male turkeys (20 wks of age and 21 kg of live weight at slaughter) and classified as follows: 24 Normal (N) and 24 severe WS cases. Technological properties were assessed on both raw (ultimate pH, colour, drip and cooking losses, and shear force) and marinated meat (uptake, cooking loss and shear force). Overall, WS breasts exhibited 20% higher weight as well as impaired water holding/binding capacity (increased drip loss, and cooking loss as well as reduced marinade uptake; $P < 0.05$). On the other hand, no relevant effects on pH, colour and instrumental meat tenderness were observed. In conclusion, presence of white stripes also seems to be associated with some negative effects on turkey meat quality, but of a lower extent if compared to what previously observed in broiler meat.

Keywords: turkey, abnormality, breast meat, white striping, quality

MEAT_V_SO_2

THE EVALUATION OF DIFFERENT INCUBATION CONDITIONS INDUCED HIGH ALTITUDE ON BREAST MUSCLE DEVELOPMENT IN BROILER EMBRYOS AND CHICKS

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The commercial broiler industry is strongly influenced by high altitude (HA). The aim of study was to investigate the influences of high incubation temperature (HT) and oxygen (O₂) supplementation (OS) on breast muscle (BM) development of broilers at HA (1720 m). A total of 720 eggs obtained from a broiler breeder at sea level (2 m) was incubated as 6 groups; control maintained at 37.8 °C and 21 % O₂; exposed to 23.5 % O₂ from day 0 to 11 (OS₀₋₁₁) and day 12, or 18 to 21 (OS₁₂₋₂₁; OS₁₈₋₂₁); or at 38.5 °C from d 12, or 18 to 21 (HT₁₂₋₂₁; HT₁₈₋₂₁). At hatch, male and female chicks were raised for 6 days. BM was excised from 10 embryos at 13, 15, 17, 19 and 21 days of incubation and 14 chicks 3 and 6 days post hatch. The relative BM weight was calculated as a percentage of absolute weight embryo/chick. The incubation conditions (IC) had no effect on BM during the prenatal period. The absolute and relative BM increased in the HT₁₈₋₂₁ and OS₁₈₋₂₁ at 6 days due to significant interactions among incubation condition, chick age and sex. In conclusion, OS treatment from 18 to 21 of incubation compared to other incubation conditions at HA may improve BM development of female chick.

Keywords: high altitude, oxygen, high incubation temperature, breast muscle development, broiler

MEAT_V_SO_3

WARNING SYSTEM APPROACH FOR VETERINARY MEAT INSPECTION IN POULTRY SLAUGHTERHOUSES

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The European Union recommends implementing alternative methods for meat inspection using risk analysis principles. To this aim, we developed an alternative method for poultry meat inspection based on a two-level warning system: information flow from observers to controllers. It was tested on a sample of slaughterhouses for one year in 2012-2013. All slaughtered flocks were inspected according to this method and all data were continuously recorded (indicators, events, actions). The analysis included 2,558 flocks, representing more than 17 million poultry. Half of the flocks showed at least one of the indicators on alert. Among them, 91% of alerts were detected by the observers, and 87% of alert transmissions were well received by the controllers. Our results highlighted the following areas of improvement: updating of some warning criteria, communication optimisation between stakeholders, and enhanced feedback. In conclusion, this warning system guarantees the achievement of sanitary meat inspection thanks to a system based on risk analysis, in which tasks are shared and skills and knowledge are optimised. The alert system is efficient thanks to its ability to detect alerts early, this is ensured by adapted warning criteria, and enables a harmonisation of practices and communication.

Keywords: poultry, meat, sanitary inspection, alert system

MEAT_V_SO_4

ADVANCED TECHNOLOGIES FOR DETECTION AND ANALYSIS OF BROILER MEAT QUALITY WITH NOVEL MYOPATHIES SUCH AS WOODY BREAST

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Fast-growing big broilers (>6 lbs live weight) present meat quality challenges due to novel myopathies such as woody breast (WB) and white stripping (WS). Moreover, modern broiler strains with efficient feed conversion ratios capable of reaching 6.2 lbs using 1.89 lbs feed/lb meat in

just 48 days you may encounter new myopathies resulting in meat quality issues. The issue is further complicated by the fact that traditional methods to study WB WS meat quality are inadequate. The industry and researchers must develop modern advanced technologies for accurate detection and analysis of meat with novel myopathies. Research was conducted to study the application of Elastography, MRI (7 Tesla) and Bioelectrical Impedance Analysis (BIA) to detect differences between WB and normal breast (NB) meat. Observations were validated using cook loss, BMORS texture analysis and cryohistology. Data was analysed using ANOVA at $p < 0.05$. MRI provided a 3-dimensional view of the entire breast fillet indicating that woody breast is dispersed unevenly within the fillet. T1 relaxation time of woody breast tissue (914-950 ms) was higher ($p < 0.05$) than normal tissue T1 (845 ms). BIA values of woody and normal breast meat were significantly different ($p < 0.05$). Cryohistology of woody areas indicated higher collagen infiltration than in normal tissue. BIA, MRI and Elastography can be used to detect and analyze broiler meat with novel myopathies.

Keywords: bioelectrical impedance analysis, MRI, rapid detection

MEAT_V_SO_5

GROWTH AND DEVELOPMENT OF MEAT COMPONENTS IN TWO DISTINCT STRAINS OF CHERRY VALLEY PEKIN DUCKS BETWEEN 0-113D.

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It is important to understand growth and development to help inform decisions about agricultural efficiency and strain compositions. This trial was designed to compare the growth and development of males and females of two distinct Cherry Valley Pekin duck strains; small early (SE) maturing and large late (LL) maturing. Carcass composition was assessed on regular intervals from day 1-113. Carcass parts and organs were dissected and weighed using a standardised procedure. Bodyweight (BW), Leg meat (LM) and breast meat (BM) are reported in this study. Data from 444 birds were analysed over 96 timepoints using a Gompertz 4 parameter model, R square values were > 0.95 . Analysis of the curves and comparison of point of inflection (POI) indicate that females reach maturity before males (BW POI 1-3d dependant on strain). LM develops before BM based on POI (LM 15-22d, BM 31-39d dependant on sex and strain). As expected the SE reaches POI before LL for each carcass part (BW POI -5.79d, LM POI -6.75d and BM POI -5.28d). From the raw data at 106d the LL BW (m+f) was 1.793kg heavier than the SE BW at the same age. These models allow predictions on meat yield at different stages of development.

Keywords: Pekin duck, bodyweight, growth curve, breast meat, leg meat

POSTER ONLY SESSION

MEAT_V_PO_1

CAN A DRIED CHLORELLA VULGARIS ALGAE/DUCKWEED FEED INGREDIENT ENHANCE SKIN PIGMENTATION FOR CHICKEN SKIN AND EGG YOLKS?

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This trial utilized young broilers to test whether including a dried *Chlorella vulgaris* algae/ duckweed product in the feed at modest levels influenced growth and efficiency of broilers. The dried algae product was formulated into a mash broiler starter feed at 0, 2.5, 5.0 and 10% of the diet and fed to broilers. Birds were raised from 1-21 days of age in Petersime batteries with eight replicates per treatment and five mixed-sex broiler chicks per battery pen. Feed and water were offered *ad libitum* and lighting was continuous. No significant differences were recorded for body weight. Feed conversion efficiency was elevated in broilers fed algae, with birds fed 2.5 and 5% showing significantly higher levels (1.33 vs 1.38). Algae inclusion significantly darkened the color of the feed, so we included a subjective measure of broiler leg coloration at 21 days using a Hoescht Skin color chart that measures broiler skin coloration from 1 (lightest) to 7 (darkest). Skin color (measured on all birds in each replicate) increased with increasing algae level [2.00 (Control), 2.70, 2.92 and 3.50]. If properly valued as a protein source, this feed ingredient may prove to be a source of pigmentation for broiler skin and egg yolks.

Keywords: algae, *chlorella vulgaris*, duckweed, broiler, pigmentation

MEAT_V_PO_2

CHEMICAL COMPOSITION AND MEAT COLOR OF ORGANIC AND CONVENTIONALLY RAISED CHICKENS

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In this study, the chemical characteristics and color of breast meat were compared between organic chickens (autochthonous breed, Banat naked neck) and conventional broilers (Cobb® 500). The autochthonous hen breeds were raised until 120 d of age according to the principals of organic production. Broilers were reared in conventional production systems for 6 weeks. At the end of the rearing period, 12 birds (6 males and 6 females) from each system were slaughtered and chemical composition (dry matter, protein, fat and moisture contents) and color (CIE-L*a*b*) of skinless breast meat were measured. The composition (dry matter, protein, fat and moisture) and color (lightness (L*), redness (a*)), of the breast muscle were significantly affected (P > 0.05) by the strain and rearing system. The meat from organic chickens had a significantly higher (P < 0.01) content of protein (23.34% w/w versus 21.58% w/w), dry matter, and significantly lower (P < 0.05) content of

lipid (0.08% w/w versus 0.28% w/w) and moisture (69.70 w/w versus 73.87 w/w). Cobb® broilers presented higher lightness (L*) and lower redness (a*) of breast meat. It can be concluded that, the autochthonous chickens provided added benefit to consumers regarding meat quality than conventional broilers.

Keywords: autochthonous breed, broiler, chemical characteristics, meat colour

MEAT_V_PO_3

THE EFFECTS OF DIETARY VITAMIN E ON PRODUCTIVITY AND MEAT QUALITY IN BROILERS

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The trial was aimed at determining the effects of different dietary vitamin E levels in broiler diets on the productive performance and meat quality. Three groups of Cobb-500 broilers (35 birds per treatment housed in separate cages) were fed diets containing the following levels of vitamin E according to growth phases 1-14, 15-21, and 22-36 days of age: control treatment 1 - 80, 60, and 50 ppm, respectively; treatment 2 - 90, 70, and 60 ppm; treatment 3 – 100, 80, and 70 ppm. Higher dietary levels of vitamin E resulted in higher ADG (58.84 and 59.79 g/bird/day in treatments 2 and 3 vs. 57.73 in control), and better FCR (1.67 in treatments 2 and 3 vs. 1.69 in control), $P < 0.05$. Increased levels of dietary vitamin E improved deposition of vitamin A in liver (by 25.39 and 52.44% in treatments 2 and 3 compared to control at 21 days of age; by 27.89 and 29.14% at 35 days of age). Concentrations of products of fat oxidation in chilled breast meat from treatments 2 and 3 after 15 days of storage at -18°C were 1.9 and 2.0 times lower compared to control; in thigh meat 2.1 and 2.5 times lower (according to acid values). We conclude that increased dietary levels of vitamin E improve quality and shelf life of broiler meat.

Key words: broiler chicks, productivity, antioxidants, storage, peroxides.

MEAT_V_PO_4

MEAT QUALITY IN FREE RANGE BROILERS

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The trial was performed in conditions of a small poultry farm to evaluate meat quality in free range broilers (cross “Smena”). 70 day-old broilers were randomly allotted in 2 groups; control group C was reared to 6 weeks of age on the floor without access to range, experimental group FR was reared to 9 weeks of age on the floor with free access to the range. Average live bodyweight in FR group at 9 weeks of age was 2850 g, in C group at 6 weeks of age 2146 g. Mortality level in FR group was higher by 2.8% compared to control. Eviscerated carcass weight in FR group was 2112 g, in C group 1534 g, corresponding to yields 74.1 and 71.5%, respectively. The carcasses of FR group were

more intensely pigmented and had better market appearance. Protein content in breast meat in FR broilers was higher by 0.57%; yield of skin and subcutaneous fat higher by 0.98%. Taste and aroma scores of meat were higher in FR broilers. The conclusion was made that prolonged rearing of broilers with access to range can improve slaughter yields and consumer attractiveness of broiler carcasses as well as taste and aroma scores of meat.

Keywords: broilers, live bodyweight, mortality, meat quality

MEAT_V_PO_5

THE EFFECTS OF DIETARY DIHYDROQUERCETIN AND ARABINO GALACTAN ON MEAT QUALITY IN BROILERS

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The trial was conducted using 2 groups of cage-housed Cobb-500 broilers (35 birds per treatment in separate cages) in the Institute's vivarium. The aim was to determine the effects of an additive containing dihydroquercetin (natural antioxidant) and arabinogalactan extracted from the bark of Dahurian larch (*Larix gmelinii*) on broiler growth efficiency and meat quality. The combined inclusion of dihydroquercetin (3.6 ppm) and arabinogalactan (3.6 ppm) into the crumbled diet (corn-wheat-soybean meal, with minimal level of animal-derived feedstuffs) improved productive performance: live BW at 35 days of age was 1713.57±3.97 g vs. 1648.14±28.11 while FCR was 1.637 vs. 1.791 in the experimental and the control group (P<0.05). The amount of peroxides in stored chilled meat was also lower in the experimental group: peroxide value (defined by iodometric titration) in chilled homogenates of meat, skin, and subcutaneous fat after 7 days of storage were 4.72 mEq O₂/kg vs. 5.19 (P>0.05). Since poultry meat is widely used in infant and dietetic foods its fortification with antioxidants can be used to decrease the amounts of oxidized fats in poultry meat, to produce functional foodstuffs, and to extend the shelf life of chilled broiler meat.

Key words: broiler chicks, growth efficiency, antioxidants, storage, peroxides

MEAT_V_PO_8

ACCUMULATION OF γ -HEXABROMOCYCLODODECANE (γ -HBCDD) IN MUSCLES OF FAST- AND SLOW-GROWING BROILERS

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Hexabromocyclododecane (HBCDD) is a brominated flame retardant included in some insulating materials used in livestock buildings, which has been detected in meat. The aim of the current study is to investigate the fate of this lipophilic contaminant in fast- (FG) and slow-growing (SG) broilers. First, an experiment involving FG and SG broilers exposed to HBCDD through feed during 42 and 82 days, respectively, showed that breast muscle (BM, *Pectoralis major*) is similarly concentrated in HBCDD in the two strains, while leg muscles (LM, thigh + drumstick including intermuscular fat) was 5 and 10 times more concentrated than BM in FG and SG broilers, respectively. Second, a physiologically based pharmacokinetic model was developed and validated using the previous data. Different compartments (total and lipid weights) were represented: plasma, liver, BM and LM, adipose tissue and the rest of the animal. After ingested HBCDD was absorbed and one part was eliminated by hepatic metabolism, it was distributed to tissues by the plasma, through a partition coefficient defined as the ratio between their respective neutral lipid concentrations. The model, calibrated for different strains and sex, will be used to assess the risk of meat contamination by HBCDD in different chicken production systems.

Keywords: meat, lipophilic contaminant, modelling, fast-growing broiler, slow-growing broiler

MEAT_V_PO_10

EFFECT OF THE GRAPE SEEDS MEAL USED AS NATURAL ANTIOXIDANT IN ENRICHED OMEGA-3 FATTY ACIDS DIETS ON BROILER MEAT QUALITY

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The inclusion of antioxidants in broiler diets helps maintain polyunsaturated fatty acids and prevents quality deterioration. A 3-week trial was conducted on 120 broilers at 14 days of age assigned to 3 groups. All diet formulations had the same basal structure with corn, wheat, soybean meal and flax meal. Compared to group C diet, the diets of the experimental groups had 2% (E1), and 3% (E2) defatted grape seed meal. Six broilers/group were slaughtered on the final experimental day, and 6 samples of breast and thigh were collected and used to determine basic chemical composition, pH and malondialdehyde (MDA) concentration. The pH value was significantly ($P \leq 0.05$) lower in the

thigh from group E1 (6.23 ± 0.04) than in groups C (6.41 ± 0.06), and E2 (6.42 ± 0.04). MDA concentration, after 7 days of meat samples refrigeration, was lower (not statistically significant) in the experimental groups than in the control group, both for the breast meat (0.088 ± 0.033 mg/kg in group E2, and 0.064 ± 0.024 mg/kg in group E1, vs. 0.139 ± 0.088 mg/kg in group C) and for the thigh samples (0.554 ± 0.315 mg/kg in group E1, and 0.605 ± 0.157 mg/kg in group E2 vs. 0.688 ± 0.244 mg/kg in group C). We conclude that the use of defatted grape pomace meal improved the oxidative status of broiler meat.

Keywords: broilers, polyunsaturated fatty acids, grape seeds meal, meat quality

MEAT_V_PO_11

MEAT QUALITY OF BROILER STRAINS FED ON FINISHER DIETS CONTAINING SOYBEAN MEAL OR A COMBINATION OF ALTERNATIVE PROTEIN SOURCES AND LEVELS

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Meat quality characteristics including color lightness, redness, yellowness (CIE L*, a*, b*), cooking loss (CL), shear force (SF) and sensory evaluation of two broiler strains Cobb 500 and Avian 48 fed one of 8 finisher rations containing different protein sources and levels were investigated. A total of 1440 unsexed day old chicks of each strain were housed in control house. At 19-35 days birds fed eight finisher diets consists of 4 control diets based on soy bean meal (SBM) and 4 test diets using a 15% combination of alternative protein sources [2.5% corn gluten meal (CGM), 5% sunflower meal (SFM) and 7.5% dried distiller grains with soluble (DDGS)] . Total protein levels in the control and test diets were 21, 20, 19 and 18% respectfully. Results showed no differences among the test and control treatments with regard to CL and sensory evaluation in each strain. The same trend was observed with color (L*, a*, b*) at each protein level. SF values of test diets for each protein level were better than control diets in both strains. Results indicated that combination of alternative protein sources (CGM, SFM and DDGS) may be used as substitution for SBM in finisher broiler diets in either strain from 19-35 days of age for the enhancement of meat quality when total protein is 20 and 21%.

Key words: cobb 500, avian 48, meat quality, protein sources, finisher diets

MEAT_V_PO_12

EFFECTS OF DIETARY ORGANIC ZINC AND ORGANIC ACIDS ON CHEMICAL COMPOSITION AND ANTIOXIDANT STATUS OF BROILER MEAT

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The purpose of this study was to evaluate the effects of chelated zinc and organic acids supplements, on the proximate composition and oxidative stability of broiler muscle tissues (breast, thigh). The trial was conducted on 90 Ross chicks aged 2 days, assigned to 3 experimental groups, with 30 chicks/group. At the end of the experiment 6 chicks/group were slaughtered and samples of breast and thigh were collected. The E1 diet differed from C by the replacement of inorganic Zn with chelated Zn. The E2 diet differed from C by the replacement of the inorganic Zn with chelated Zn and 0.15% organic acids supplement. No significant differences were registered, regarding crude protein and crude fat concentrations. The crude ash concentrations increased for E2 (C: 4.65±0.24%; E1: 4.66±0.23%; E2: 4.96±0.26% for breast meat and C: 4.27±0.14%; E1: 4.05 ± 0.25%; E2: 4.69 ± 0.21% for thigh meat). TBARS values didn't differ significantly between groups, both for breast or thigh meat. After 4 days of storage on 2.22±0.25^oC, TBARS values were significantly decreased for E2 group compared with C and E1 for breast meat (C: 0.036±0.005 mg/kg; E1: 0.030±0.004 mg/kg; E2: 0.025±0.004 mg/kg). The results indicate that chelated zinc and organic acids supplements improve nutritional quality of broiler meat after storage.

Keywords: organic acids, chelated zinc, broiler, nutritional quality

MEAT_V_PO_13

INFLUENCE OF THE WOODY BREAST CONDITION ON THE MARINATION AND QUALITY OF INTACT AND PORTIONED BROILER BREAST FILLETS

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The distinct tactile and histological characteristics of the woody breast (WB) myopathy are more evident on the ventral-cranial surface of broiler breast fillets. The objective of this study was to determine the influence of WB on the processing performance and quality of horizontally portioned breast fillets. Normal (no WB) and WB butterfly fillets (n=19) were assigned control (non-marinated) or marinated (vacuum-tumbled with salt-phosphate marinade) treatments. Fillets were processed and measured as either intact fillets or dorsal and ventral fillet portions. For both intact fillets and portioned samples, marinade uptake and retention were lower (P<0.001) in WB meat. Dorsal fillet portions exhibited greater (P<0.0001) marinade uptake and retention than ventral portions. In non-marinated samples, cook yield was lower (P<0.01) in WB meat. In marinated intact fillets and ventral

portions, cook yield was lower ($P<0.01$) in WB meat. The cook yields of normal and WB dorsal portions were similar following marination. For both marinated and non-marinated ventral fillet portions, WB meat exhibited greater ($P<0.0001$) cooked shear force than normal meat. Shear force was similar between normal and WB dorsal portions. Data demonstrate that the negative influences of WB on marination, cooking, and texture properties are most severe in the ventral portions of the *Pectoralis major* muscles.

Keywords: woody breast, meat quality, marination, breast fillet portioning

MEAT_V_PO_14

EFFECT OF DIETARY N-6/N-3 FATTY ACID RATIO AND FEEDING PERIOD ON GROWTH PERFORMANCE AND MEAT FATTY ACID PROFILE OF BROILER CHICKENS

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A study was conducted to evaluate the effect of different dietary ratios of n-6/n-3 fatty acid (FA) and feeding period on broiler growth performance and FA composition of breast meat. A total of 450 one-day-old Ross 308 broilers were allocated to 6 experimental treatments as a result of the combination of 3 dietary n-6/n-3 FA ratios (10:1, 5:1 and 1:1) and 2 feeding periods (0-6 and 3-6 weeks of age). Each treatment had 3 replicate pens of 25 chicks each. There was no interaction between the ratio of n-6/n-3 FA and feeding period for all the variables. Body weight gain and feed conversion ratio were poor in broilers fed a 1:1 dietary ratio of n-6/n-3 FA ($P<0.01$). The profiles of n-6 FA, especially C18:2n-6 were lower, while the profiles of n-3 FA, especially C20:5n-3 and C22:6n-3 were higher in broilers fed 1:1 dietary ratio of n-6/n-3 FA ($P<0.001$). Consequently, the n-6/n-3 FA ratio was lower in broilers fed 1:1 dietary ratio of n-6/n-3 FA ($P<0.001$). Feeding period had no effect on any parameters. In conclusion, the 1:1 dietary ratio of n-6/n-3 FA enhanced the proportion of n-3 FA and decreased n-6/n-3 FA in broiler breast but decreased the performance of broilers.

Keywords: n-3/n-6 fatty acid ratio, feeding period, broiler, performance, meat

MEAT_V_PO_15

EFFECT OF ADSL AND CAPN1 GENE ON GROWTH AND PURINE CONTENT AND THEIR RELATIONSHIP IN KORAT CHICKEN

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Functional chicken meat may help to address some of the problems associated with aging. Gout occurs more commonly in older people. It is due to elevated levels of uric acid in blood. Uric acid is formed when purines are broken down and diets rich in purines may sometimes lead to gout. Purines are chemical compounds related with growth development, and they are found in chicken meat. Therefore, optimize purines content in the body of chicken to maintain growth and produce chicken meat with lower purines is our breeding goal. Objective of this study was to study the relationship between growth and purine derivatives (PD) and association between genes involved in the pathway of PD synthesis. Adenylosuccinate lyase (ADSL) gene, and calcium-activated neutral proteases (CAPN1) gene were used in this study since ADSL is involved in PD pathway, while CAPN1 is involved in growth development. Six hundred Korat crossbred chickens were raised, bodyweight (BW), and breast meat samples were collected at 2, 4, 6, 8, and 10 weeks of age. The PD; adenine, guanine, xanthine, and hypoxanthine, were analyzed by HPLC. ADSL and CAPN1 genes were genotyped. Significant negative, and positive correlation between BW and guanine were detected at 6 and 8 week of age, respectively ($P < 0.05$). Association between BW, PD, and the genes were analyzed, and a significant association between genotypes and BW at 4, 6 week of age were detected. The results suggest that PD and growth, and the genes for growth have a relationship. The mechanism of the relationship remains to be clarified.

Keywords: ADSL gene, CANP1 gene, Korat chicken, functional meat, purine

MEAT_V_PO_16

SALMONELLA INFANTIS, A POTENTIAL HUMAN PATHOGEN FROM BROILER MEAT IN CROATIA

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Salmonella infections are a serious medical and veterinary problem world-wide and cause great concern in the food industry. In humans can produce symptoms ranging in severity from intestinal disturbances to death. Due to complex preventive measures in poultry production, mostly targeted to *S. Enteritidis* and *S. Typhimurium* the number of salmonellosis in Europe gradually decreases, but still represent a matter of concerns among food-borne diseases. On farm *Salmonella* status may influence the prevalence of *Salmonella* at the slaughterhouse, which will consequently determine the extent of consumer exposure. The most frequently reported serovars in Europe in 2015 for *Gallus gallus* were *S. Infantis*, *S. Enteritidis* and *S. Mbandaka*, and the two most common serovars isolated from broiler meat were *S. Infantis* and *S. Enteritidis*. For the same period, *S. Infantis* was the most frequent serovar (85%) in broiler meat in Croatia, as well as in broilers (51%) before slaughter. *S. Infantis* was confirmed as the cause of human salmonellosis in several countries. Although reported in Croatia, number of human cases is still low (0.7%), but almost 42% human salmonellosis are not serotyped. Applying no measures on *Salmonella* serovars other than *Enteritidis* and *Typhimurium* in primary production, opens possibility for other *Salmonella* to be a threat for human health.

Keywords: poultry, broilers, meat, *Salmonella Infantis*

MEAT_V_PO_17

THE EFFECT OF GENOTYPE, GENDER AND FEEDING REGIME ON CARCASS YIELD AND MEAT QUALITY OF BROILER CHICKENS

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The aim of the study was to investigate the effect of two feeding restriction levels and gender on carcass yield of Ross 308 and Cobb 500 broiler chickens. There were three groups of feeding regime: control group was fed *ad libitum* during the whole experiment, while remaining groups were 65 (R65). and 80% (R80) feed restricted from 8th to 14th day of age and then fed *ad libitum* until slaughter. Chickens were slaughtered at 35 days of age and carcass yields, pH and colour of breast meat were determined. Carcass weight was affected by interaction of genotype and feeding regime ($P \leq 0.001$), and a higher carcass weight was observed in Ross and R80. However, dressing-out percentage, breast meat percentage or meat/bone ratios were not affected. Abdominal fat percentage ($P \leq 0.001$) was higher in females and thigh meat percentage in males ($P \leq 0.05$). Breast pH ($P \leq 0.001$) and lightness ($P \leq 0.001$) were higher in females. In conclusion, it was found that some carcass traits and meat quality were modified by gender, whereas effects of genotype and feeding regime were negligible.

Keywords: chicken, genotype, sex, restriction, carcass yield

MEAT_V_PO_19

EFFECTS OF USING DIFFERENT FEEDING STRATEGIES ON THE QUALITY AND OXIDATIVE STABILITY OF BREAST MEAT FROM BROILERS UNDER HEAT STRESS

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Heat stress negatively influences meat quality owing to oxidative stress. This study examined effects of Actigen[®] (Alltech Inc.) on breast meat quality from heat stressed birds. Actigen[®] is a second-generation mannan oligosaccharide extracted from yeast cell wall (*Saccharomyces cerevisiae*) known to affect gut health and immune responses of broilers. In this study broilers (1200) were fed either a corn-soybean meal control diet, or corn-soy diet with 400 mg Actigen[®]/kg, for 49 days. They were subjected to cyclic heat stress from d19 (36°C for 6h, and 22°C for 18h). Lipid and protein oxidation, cooking loss and puncture force were evaluated on breast meat at retail storage days 0, 4, 7. Glutathione peroxidase (GPx) activity was quantified post-harvest. Data were subjected to analysis of variance. Lipid oxidation in meat increased throughout storage for all treatments, but was lower ($P = 0.0432$) in samples from Actigen-supplemented broilers on display d0. On d7, protein carbonyls were 66.8% lower ($P = 0.0023$) in meat from broilers fed Actigen-supplemented diets. Cooking loss

or puncture force did not differ between treatments. Chicks fed Actigen[®] exhibited a 32.2% increase in GPx activity ($P < 0.05$) compared to control. The results revealed improvements in oxidative stability of breast meat through dietary Actigen[®] supplementation, but no differences in textural properties. Dietary supplementation with Actigen[®], due to its effects on absorptive capacity and immune modulation may be used to aid oxidative stability of meat from heat stressed broilers.

Keywords: heat stress, nutrient intervention, oxidation, meat

MEAT_V_PO_20

OCCURRENCE OF WOODEN BREAST IN BROILERS FED DIETS WITH XYLANASE AND PROTEASE IN COMBINATION WITH INCREASING LEVELS OF PHYTASE

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The appearance of myopathies such as wooden breast, characterized by the stiffening and pallor of the pectoral muscles, increases broiler carcass condemnation. The use of enzymes in the diet could be an alternative to minimize muscle damage. This study evaluated the occurrence of wooden breasts in broilers supplemented increasing levels of phytase with the addition of xylanase and protease. 1536 male Ross 308 AP chicks (AP95) were allotted in a completely randomized design with eight treatments and six replicates of 32 birds each. Experimental corn-soybean meal diets were formulated according to the Brazilian tables and supplemented with xylanase (60g/ton), protease (500g/ton), and phytase (750 and 1,500 FTU). On the 42nd day, 33 birds per treatment were slaughtered and wooden breast occurrence was evaluated. The scores were classified into three levels (normal, moderate, and severe). Data were submitted to the Kruskal-Wallis and Bonferroni tests ($P < 0.05$). No significant difference ($P = 0.28$) was observed for wooden breast scores, average of 24.2% of breast lesions for all treatments. However, the use of protease in diets combined with FTU phytase presented the best results (10% condemnations). Enzymes combination in diets can contribute to the reduction of wooden breast in broilers.

Keywords: fast growing broilers, myopathy, phytase, wooden breast

MEAT_V_PO_21

EFFECT OF THE DIET WITH CAMELINA SATIVA OIL OR EXPELLER CAMELINA MEAL ON SENSORY QUALITY AND FATTY ACID PROFILE OF BROILER CHICKEN MEAT

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The aim of this study was to determine the effect of camelina oil or expeller camelina meal on sensory quality and fatty acid composition of *Pectoralis major* muscle. The experiment was carried out on 480 chickens Ross 308 which were divided into 3 dietary treatments. Group I (control) received the rapeseed oil, while the experimental groups were fed on diets containing: 6% camelina oil – group II or 10% expeller camelina meal (meal left after mechanical extraction of oil from *Camelina sativa* seeds) – group III. The sensory properties of cooked meat and fatty acid composition were investigated. As expected, the analysis of fatty acid profile of *Pectoralis major* muscles showed that the camelina oil or expeller significantly ($P<0.05$) reduced the proportion of SFA and MUFA fatty acids and increased ($P<0.01$) the concentration of PUFA-3, mainly ALA (C18:3) and EPA (C20:5). It was found ($P<0.01$) that the ratio of fatty acids ω -6/ ω -3 significantly decreased in group II and III. Camelina oil improved the juiciness of cooked meat. Based on the obtained results, it was confirmed that camelina oil or expeller camelina meal can be an effective way of modifying the fatty acid composition of meat lipids. Furthermore, camelina sativa oil improved some sensory traits of meat.

Keywords: broiler chicken, camelina oil, expeller camelina meal, meat quality

MEAT_V_PO_22

ANTIOXIDANT CAPACITY OF CHICKEN CULINARY PARTS DURING FROZEN STORAGE

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Freezing is still a popular method of meat shelf-life prolongation. However, although the method assures food safety, it also has impact on quality and consumer acceptance. The latter relies mostly on oxidation processes active at low temperature. The objective of the study was to measure the effect of frozen storage on oxidative stability and antioxidant capacity of chicken meat. Sixty Hubbard chicken carcasses were collected and cut up to collect culinary parts, frozen and stored at -18°C up to 180 days. Oxidation assays (TBARS, DPPH, ABTS) and sensory analyses were performed on fresh and frozen meat. Fresh *Pectoralis* muscles had the lowest extent of oxidation ($0.9\text{-}1.1\ \mu\text{g MDA/g}$ for *P. major* and *minor* respectively), whereas the highest values were found in the drumstick ($5.1\ \mu\text{g MDA/g}$). Oxidation of leg meat continued, while breasts were stable through the whole period of frozen storage. Meat from backs and wings went through oxidation after 90 and 180 days of storage respectively. Freezing decreased ability of meat, especially breasts, to scavenge free ABTS radical, while increased potential of DPPH radical removal in wings after 30 days of storage. Sensory quality of all culinary parts was acceptable up to 90 days of storage. Cut up chicken carcass can be stored at frozen state up to three months without any apparent quality changes.

Keywords: radical scavenging, meat, oxidation, freezing, quality

MEAT_V_PO_24

THE EFFECT OF PROBIOTIC ON MEAT QUALITY IN BROILER CHICKENS VACCINATED AGAINST COCCIDIOSIS

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The aim of study was to evaluate the effect of dietary supplementation with probiotic on slaughter parameters and properties of the *m. pectoralis superficialis* of broilers vaccinated with live anticoccidial vaccine. The experiment was designed as a 2 × 2 factorial with 8 replicate pens per treatment (8 male Ross308 chicks per pen) conducted from 1 to 42d of age. Treatments included either no anticoccidial vaccine or a single dose of anticoccidial vaccine (Livacox T[®], administered at 1d of age), with or without supplementation with a soluble probiotic Protexin. On day 43 of age, 8 broilers with average body weight were chosen from each group for slaughter to analyse carcass yield, proportion of breast muscles, giblets and abdominal fat, properties of breast muscles: pH, drip, thawing and thermal losses, shear force, texture, muscles and skin colour (CIE L*a*b*). There was a significant effect of vaccination with increased carcass yield, higher percentage of gizzard, increased hardness and gumminess of breast muscles and decreased lightness and increased yellowness of skin. The supplementation with probiotic significantly decreased yellowness of skin and increased the thawing losses of breast muscle. There were no significant interactions between experimental factors regarding any of the studied parameters.

Keywords: broiler chickens, anticoccidial vaccine, probiotic, meat quality

MEAT_V_PO_26

PROTEIN FRACTIONAL SYNTHETIC RATE OF DIFFERENT TISSUES IN BROILER CHICKS DETERMINED BY AN ORAL TRACER PROCEDURE.

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Measuring fractional synthetic rate (FSR) of muscle and other tissue proteins in chicks could help inform feed formulation and evaluate dietary ingredients to meet the demands of different growth stages. Also, a model for the pathophysiology of disease could be developed to evaluate the cost of

disease. Sixty, one day old broiler chicks were given deuterium oxide (D₂O) orally, at a dose of 1% body weight. Blood samples were collected pre-and post-administration at -0.5, +1.5, 3, 6, 9, 12, 24, and 48h. Deuterium enrichment was measured in plasma free amino acids (AA). Protein-bound AA were measured in albumin, muscle, liver, intestine and heart, in both males and females. Gas chromatography mass spectrometry GCMS was used to measure deuterium enrichment in AA. Protein FSR was calculated using alanine as precursor. Deuterium elimination rate was between 78 and 130 % day⁻¹. Liver FSR was the fastest: 106.5 and 108.1 % day⁻¹ in males and females, respectively. Muscle FSR was slowest at 70.2 and 65.7% day⁻¹. Fat free mass was 49.7 g and 43.1 g in males and females, respectively. Fat percentage was 12.5 and 13.6 %. This method is sensitive and easy to apply. It could help to estimate protein FSR at all life stages in health and disease conditions. That could help in development of diet formula and could help in understanding pathophysiology of disease

Keywords: fraction synthesis rate, deuterium oxide, heavy water, chicken and broiler

MEAT_V_PO_27

PURE ORGANIC SELENIUM IMPROVES POULTRY MEAT STABILITY

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Selenium (Se) is involved in cellular redox regulation through various selenoproteins, glutathione peroxidases, thioredoxin reductases or methionine sulfoxide reductase. The present study aimed to evaluate the effect of a pure source of selenium, hydroxy-selenomethionine (OH-SeMet or Selisseo[®]) on broiler meat (breast and thigh) quality and stability. A total of 135 000 broilers (mixed-sex Ross 308) of 21 days of age, received either a control diet (0.3 mg/kg of Se as sodium selenite) or the experimental diet (supplemented with 0.2 mg/kg of Se from OH-SeMet). After two weeks of dietary supplementation, from 22 to 35 days, breast meat and thigh meat parts were sampled. Se content, pH_u, water content, Kreis indicator for lipid oxidation, hydrogen sulfide, hydrolysable N, were measured from day of slaughter up to 8 days of storage. OH-SeMet improved by more than 2 times muscle Se content which reduced drip loss. The stability of the meat, measured by Kreis indicator and hydrogen sulfide level being significantly positive, was preserved 2 days more for breast meat and 1 day more for thigh meat with OH-SeMet. Those results support a positive effect of OH-Selenomethionine in broiler diets to improve meat quality parameters and freshness during storage conditions.

Keywords: broiler meat, meat quality, selenium, OH-Selenomethionine, drip loss, meat stability

EFFECTS OF PARTIAL CORN REPLACEMENT BY SORGHUM IN BROILER DIETS ON PERFORMANCE,
CARCASS CHARACTERISTICS AND MUSCLE TISSUE pH

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Sorghum is an interesting energy ingredient in poultry diets due to its similar nutritional composition to corn. Nowadays, sorghum crop has extended in semiarid areas due to the adaptability to low fertility soils, has low production costs as compared to corn, and could be an alternative in the context of climate change. The study was conducted to evaluate the effects of dietary partial corn replacement by white sorghum (WS) on performance, carcass parameters and pH of meat in broilers. One-day-old unsexed Cobb 500 broilers (n=400) were randomly assigned in 2 groups with 4 replications per treatment. The broilers were fed with isocaloric and isonitrogenous corn-soybean meal control diets (C) or corn-WS-soybean meal diets (WS) for 35 d. The WS (9.91% CP and 3207 kcal/kg ME) proportion in diets was 275.4 g/kg (starter), 307.0 g/kg (grower) and 332.7 g/kg (finisher). Results showed that performance (BW gain, FI and FCR) or carcass traits (carcass yields, breast, leg, wings, liver and abdominal fat percentage) at 35 d were not affected by the inclusion of WS in diets. The pH values of breast (*Pectoralis major*) and leg (*Biceps femoris*) muscle at 30 min. and 24 h after slaughter were not influenced by the treatment. Our results indicate that partial corn replacement with WS is suitable for broiler diets, with no adverse effects on performance or meat quality parameters.

Keywords: broilers, white sorghum, carcass parameters, meat pH.