

determined to be 14.21%. This BRF will be used to correct future IAAO studies involving AA requirements and availability in hens.

**Key Words:** Bicarbonate retention factor, Broiler breeder layer, Indicator amino acid oxidation

**216 The egg is refractory to soy sterol enrichment through alteration of the hen's diet.** R. G. Elkin\* and E. S. Lorenz, *The Pennsylvania State University, University Park, PA.*

Coronary heart disease (CHD) is the leading cause of death in the United States. Elevated levels of plasma total cholesterol (TC), and particularly plasma low density lipoprotein-cholesterol (LDLC), are primary contributing factors to CHD. Dietary plant sterols (phytosterols) have been shown to significantly reduce plasma TC and LDLC in humans, primarily through inhibition of cholesterol absorption in the gut, and are potentially effective agents for CHD risk reduction. Phytosterol-containing products are currently being marketed in the form of margarine spreads, dairy products, salad dressings, snack bars, and tablets. Conspicuously absent are phytosterol-enriched eggs, which represent a potential value-added product. In a 28-d experiment, eight 32-wk-old White Leghorn hens each were fed either a basal corn-soy-based layer diet, or the basal diet supplemented with a total of 1 g of soy sterols (61 parts sitosterol, 27 parts campesterol, and 12 parts stigmasterol; weight basis)/100 g of diet. Hen performance was determined on an individual basis, while one egg/hen/wk was collected, processed, and analyzed for yolk TC, crude protein (CP), crude fat (CF), and phytosterol content. On d 28, blood samples were obtained from each hen for subsequent plasma TC analysis. There was no effect ( $P > 0.05$ ) of supplemental dietary soy sterols on 28-d weight gain, feed consumption, plasma TC, hen-day egg production, egg weights, egg component weights and percentages, and yolk TC, CP, and CF contents. Sitosterol and stigmasterol were virtually absent from all eggs tested. In contrast, eggs from both control and phytosterol-fed hens generally contained campesterol, although the average amounts were extremely small (0.3 vs. 1.0 mg/yolk, respectively). It was concluded that phytosterols are either poorly absorbed from the laying hen intestine or, if they are absorbed, that they are efficiently secreted back into the intestinal lumen, possibly via an as yet uncharacterized ATP-binding cassette transporter protein(s). Alternately, it may be necessary to feed laying hens greater amounts and/or different combinations of soy sterols in order to enrich egg yolks and possibly reduce egg yolk TC contents via sterol substitution following absorption and transport to the ovary.

**Key Words:** Phytosterols, Eggs, Laying hens

**217 Differential effects of conjugated linoleic, n-6 or n-3 polyunsaturated fatty acids on hepatic lipid characteristics and histopathology of laying hens.** Gita Cherian\* and Mary P. Goeger, *Department of Animal Sciences, Oregon State University, Corvallis, Oregon, 97331-6702.*

The effect of dietary conjugated linoleic (CLA) and polyunsaturated fatty acids (PUFA) on hepatic lipid characteristics and histopathology of laying hens were investigated. One hundred and twenty thirty-week old

Single Comb White Leghorn laying hens were distributed randomly to four treatments (3 replications of 10 birds per replication) and were fed diets containing (CLA), sunflower oil (SFO, n-6 PUFA), flax oil (FLO, n-3 PUFA) or fish oil (FO, long chain n-3 PUFA). The total lipid content of each diet was 3%. Feeding CLA resulted in an increase in hepatic total lipids ( $P < 0.05$ ). Liver triacylglycerol (TAG) content varied from 32.2, 18.7, 18.9 and 29.4 mg/g for hens fed CLA, SFO, FLO and FO diets, respectively ( $P < 0.05$ ). Serum TAG was lowest in birds fed FLO ( $P < 0.05$ ). Dietary CLA resulted in an increase in the total number of fat vacuoles and lipid infiltration in hepatocytes ( $P < 0.05$ ). The number of cells with 75% or higher lipid vacuolation was observed only in CLA-fed hens. Feeding CLA resulted in an increase in the content of c9t11 CLA isomer in the liver TAG ( $P < 0.05$ ). No difference was observed in the concentration of CLA in the hepatic phosphatidylcholine (PC) and phosphatidylethanolamine (PE) fractions. The content of docosahexaenoic acid (DHA, C22:6 n-3) was higher in the TAG, PC and PE of hens fed FLO and FO than other treatments ( $P < 0.05$ ). Feeding CLA resulted in an increase in total saturated fatty acids in the TAG and PC fractions ( $P < 0.05$ ).

**Key Words:** Conjugated linoleic acid, Polyunsaturated fatty acid, Laying hens, Histopathology

**218 The effect of various levels of conjugated linoleic acid on chicken egg yolk fatty acid content and hatchability.** R. Aydin\*, E. Ozsan, and M. E. Cook, <sup>1</sup>*Kahramanmaraş Sutcuimam University, Turkey*, <sup>2</sup>*Kahramanmaraş Sutcuimam University, Turkey*, <sup>3</sup>*University of Wisconsin Madison, USA.*

Previous studies in our laboratory showed that feeding conjugated linoleic acid (CLA) in a low-fat diet resulted in increased yolk CLA content, changed fatty acid composition of yolk and caused embryo mortality. We also showed that CLA was not directly toxic for the developing chick embryo. The objective of this study was to determine the lowest level of CLA in the diet influencing fatty acid content and hatchability. Six 24 wks old SCWL laying hens per treatment were assigned to diets containing 0 (0.5% canola oil-Group A), 0.06% (Group B), 0.12% (Group C), 0.25% (Group D) or 0.5% CLA (Group E) for 22 days. Three eggs were collected at the last day of feeding for fatty acid analysis. Laying hens were artificially inseminated weekly. Fertile eggs were collected daily, stored at 15C for 24 hours and then incubated. Embryo mortality was affected significantly by feeding Groups D and E, compared to Group A. Cis-9, trans-11 CLA (as % of fatty acids) of yolk from Groups A, B, C, D and E was 0.12, 0.27, 0.59, 0.58 and 1.25%, respectively. Trans-10, cis-12 CLA isomer (%) in Groups A, B, C, D and E was 0, 0.06, 0.16, 0.19, and 0.49%, respectively. The ratio of SAFA/UFA in eggs from Groups A, B, C, D and E was 0.64, 0.77, 0.90, 1.11, and 1.53, respectively. This study showed that 0.25% CLA is the lowest level of dietary CLA affecting hatchability by changing fatty acid composition of egg yolk.

**Key Words:** Conjugated Linoleic Acid (CLA), Chicken, Egg yolk, Fatty acid content, Hatchability

## Processing and Products - Egg Microbiology

**219 National Egg Temperature Survey: 1. Production.** P. H. Patterson\*<sup>1</sup>, K. W. Koelkebeck<sup>2</sup>, K. E. Anderson<sup>3</sup>, M. J. Darre<sup>4</sup>, J. B. Carey<sup>5</sup>, D. U. Ahn<sup>6</sup>, R. A. Ernst<sup>7</sup>, D. R. Kuney<sup>8</sup>, and D. R. Jones<sup>9</sup>, <sup>1</sup>*Penn State University, University Park, PA*, <sup>2</sup>*University of Illinois, Urbana, IL*, <sup>3</sup>*North Carolina State University, Raleigh, NC*, <sup>4</sup>*University of Connecticut, Storrs, CT*, <sup>5</sup>*Texas A&M University, College Station, TX*, <sup>6</sup>*Iowa State University, Ames, IA*, <sup>7</sup>*University of California, Davis, CA*, <sup>8</sup>*University of California, Riverside, CA*, <sup>9</sup>*USDA-ARS, Athens, GA.*

During the hearings on the Egg Safety Action Plan in Washington, DC, many questions were raised concerning the egg temperature (T) patterns used in the risk assessment model. Therefore, a national study was initiated to determine the T of eggs from oviposition through distribution. Researchers from Extension and USDA-ARS, in CA, CT, GA, IA, IL, NC TX, and PA gathered data on internal and surface egg T from commercial egg production facilities. An infrared thermometer was used to rapidly measure egg surface T, and interior T was determined by probing the egg. The main effects evaluated were; geographic region, season,

and operation type. Egg T data was recorded at specific locations in the production facilities in order to standardize the comparisons. The experimental design was a mixed model with two random effects of season and geographic region and a fixed effect component for operation type, i.e. in-line or off-line operations. Egg winter surface T in the hen house averaged 24.0C with a range of 40.0 to 10.0C. Mean summer surface T was 28.3C, from 38.0 to 21.0C, with a seasonal difference of 4.3C. Interior egg T averaged 27.3 in winter and 30.1C in summer. There was a significant correlation (0.832) between egg surface and interior T that validated further use of the infrared thermometer. Additional data were collected with the goal of building an egg T x time risk model. The T differential (dT) between internal egg T and hen house ambient T during mechanical belt gathering (90min) was 2.2C in summer and 1.4C in winter. Ambient T on the rod conveyors averaged 24.4 and 19.0C in summer and winter with an egg residence time of 29 to 43min for in-line complexes of 6 to 9 houses.

**Key Words:** Shell eggs, Production, Temperature, Risk model

**220 National Egg Temperature Survey: 2. Processing.** K. W. Koelkebeck<sup>1</sup>, P. H. Patterson<sup>2</sup>, K. E. Anderson<sup>3</sup>, M. J. Darre<sup>4</sup>, J. B. Carey<sup>5</sup>, D. U. Ahn<sup>6</sup>, R. A. Ernst<sup>7</sup>, D. R. Kunej<sup>8</sup>, and D. Jones<sup>9</sup>, <sup>1</sup>University of Illinois, <sup>2</sup>Penn State University, <sup>3</sup>North Carolina State University, <sup>4</sup>University of Connecticut, <sup>5</sup>Texas A&M University, <sup>6</sup>Iowa State University, <sup>7</sup>University of California, Davis, CA, <sup>8</sup>University of California, Riverside, CA, <sup>9</sup>USDA-ARS, Athens, GA.

During the hearings on the Egg Safety Action Plan in Washington, DC, many questions were raised concerning egg temperature patterns used in the risk assessment model. Therefore, a national study was initiated to determine the temperature sequence of eggs from oviposition through distribution. Researchers composed of Extension Specialists and USDA-ARS, in CA, CT, GA, IA, IL, NC, TX, and PA gathered data on internal and external egg temperatures from commercial egg production and processing operations. The main effects being evaluated were: geographic region, season, and operation type. Egg temperature data were recorded at specific points during processing in order to standardize the comparisons during the winter and summer months. The experimental design was a mixed model with random effects for season and geographic region, and a fixed effect for operation type (In-line or Off-line). This is a summary of data obtained in processing plants. There was a significant season by geographic interaction ( $P < 0.05$ ) for both surface and internal egg temperatures. In the winter, egg temperatures at the accumulator and post-wash were 17.6 and 22.4 C, respectively. Mean egg temperatures post-candling were 22.6 C and 24.1 C at the packer head. In the summer, egg temperatures averaged 24.5, 28.5, 28.8, and 28.7 C at the accumulator, post-wash, post-candle, and packer head phases, respectively. Thus, an average of 6.5 C was added to egg temperatures during winter processing and 4.2 C during summer. These data suggest that the season of year and geographic location can affect the temperature of eggs during processing and should be a component in future assessments of egg safety.

**Key Words:** Egg processing, Egg temperatures, Shell eggs

**221 External and internal microbial contamination of shell eggs during extended storage.** D. R. Jones\*, M. T. Musgrove, and J. K. Northcutt, *Russell Research Center, USDA-ARS, Athens, Georgia.*

The current project was conducted to determine the microbial quality of commercially processed shell eggs during extended storage. Eggs were collected from a single in-line processing operation on three consecutive days. Control eggs (CE) were collected at the accumulator before entering the processing line. Washed eggs (WE) were retrieved after placement in cartons. All eggs were stored on pulp flats at 4 C for 10 wks of storage. Twelve eggs from each treatment were rinsed on the day of collection and each week of storage. After rinsing, eggs were sterilized in ethanol and contents aseptically collected for additional analysis. Total aerobes, *Enterobacteriaceae*, pseudomonads, and yeasts and molds were enumerated for shell rinses and pooled egg contents. During storage, no differences were found between CE and WE for *Enterobacteriaceae* and pseudomonads for either shell rinses or contents. No differences were found between treatments for population levels of total aerobes or yeasts and molds in the egg contents throughout the storage period. Significant differences occurred at each week of storage for external shell contamination by total aerobes between treatments. The greatest level of CE contamination occurred at 8 wks of storage (5.34 log cfu/mL). The lowest degree of contamination occurred at 0 and 1 wks of storage (4.37 and 4.35 log cfu/mL, respectively). The highest level of shell contamination with aerobic bacteria in the WE was found at 0 wks of storage (2.47 log cfu/mL) and the lowest level occurred at 7 wks (0.99 log cfu/mL). Yeast and mold contamination levels were also significantly different during each week of storage between treatments for shell rinses. Population levels ranged from 1.32 and 2.94 log cfu/mL for CE and 0.12 and 0.71 log cfu/mL for WE. Although previous plant sanitation sampling indicated high levels of bacterial contamination, commercially washed eggs were significantly less contaminated than unwashed eggs for the populations monitored.

**Key Words:** Shell eggs, Egg processing, Storage

**222 Condition of broiler carcasses from two lighting programs.** B. M. Rathgeber\*<sup>1</sup> and J. L. MacIsaac<sup>2</sup>, <sup>1</sup>Nova Scotia Agricultural College, <sup>2</sup>Atlantic Poultry Research Institute.

Lighting programs that utilize increasing length of photoperiod can be used to reduce the incidence of metabolic disease in broiler chickens. In this investigation the impact on carcass bruising and scratches was evaluated for increasing compared to continuous photoperiod length. Two trials; each consisting of 2400 male broilers were housed in two rooms; each room was divided into two pens of 600 birds, with a light tight divider in the middle of the room so that two treatments could be conducted in each room. The continuous lighting treatment received 23 hr of light, while the increasing lighting treatment went from 6 hours to 23 hr of light over the 38-day growth period. Both treatments were exposed to 23 hr of light for the first three days. The birds were weighed on days 0, 7, 14, 24, 31, and 38. On day 39 carcass bruising and scratches to the skin were evaluated on the birds sent to slaughter. Personnel at the commercial processor scored 100 birds per rep per treatment for bruising and scratches. Increasing lighting resulted in elevated bird activity and increased the number of severe carcass scratches and cellulitis on processed carcasses. It was determined that there was a significant increase in the incidence of wing bruising for birds on continuous lighting (13.5/%) versus the increasing photoperiod length (9.8/%), ( $P < 0.05$ ). It was also noted that there was no significant difference in the growth performance of the two treatments.

**Key Words:** Lighting programs, Bruises, Scratches, Broiler

**224 Growth of Salmonella Enteritidis in shell eggs as of function vitelline membrane deterioration.** D. E. Conner\*<sup>1</sup>, L. K. Kerth<sup>1</sup>, P. A. Curtis<sup>1</sup>, D. L. Kuhlers<sup>2</sup>, K. E. Anderson<sup>3</sup>, J. B. Tharrington<sup>4</sup>, and K. M. Keener<sup>4</sup>, <sup>1</sup>Poultry Science Dept., Auburn Univ., <sup>2</sup>Animal Sciences Dept., Auburn Univ., <sup>3</sup>Poultry Science Dept., North Carolina State Univ., <sup>4</sup>Food Science Dept., North Carolina State Univ.

Current assessment models for shell egg safety correlate risk of *Salmonella enterica* Enteritidis (SE) growth to breakdown in vitelline membrane integrity, which is time-temperature dependent. However, there are little data to confirm this correlation. Thus, research was conducted to determine growth of SE in shell eggs as a function of storage temperature, and to relate temperature and vitelline membrane strength to time required for significant SE growth. Freshly packed Grade A eggs were obtained from a commercial in-line packer, then stored at 4, 10, 20 or 30C. At predetermined storage times, SE(500 cfu/egg) was inoculated into albumen of each of 40 eggs/temperature. Inoculated eggs were held at 23C for 5 d, after which SE was enumerated. Percent of eggs for each 40 egg set that permitted a >3 log increase in SE population was determined. At each storage time, additional sets of uninoculated eggs were analyzed to determine the force (g) required to rupture the vitelline membrane. The exp was replicated 3 times (Jan, April, Sept). In eggs held for 9 wk at 4 C, SE did not grow and membrane strength changed little. For eggs stored at 10, 20 or 30C, results varied by replicate, indicating flock age and other effects. SE growth occurred at 8-9 wk, 6-7 wk, and at 12-16 d in eggs stored at 10, 20 or 30C, respectively. The time at which SE growth was permitted appeared to coincide with a decline in membrane rupture force to approximately  $\leq 1.5$ g. Deterioration of the vitelline membrane is a key factor in determining risk of SE in shell eggs. Holding commercially produced shell eggs at  $\leq 10$ C for up to 7 wk does not increase risk of SE growth.

**Key Words:** Salmonella Enteritidis, Shell egg, Vitelline membrane, Risk, Temperature

**225 Effect of elevated incubation temperature (42° C) on the multiplication and rapid detection of Salmonella enteritidis in egg contents pools.** Richard K. Gast\* and Peter S. Holt, *USDA-ARS, Southeast Poultry Research Laboratory.*

Detecting internal contamination of eggs with *Salmonella enteritidis* is essential for identifying laying flocks that could threaten public health. The most common strategy for such testing is to prepare pools of the contents of 10-20 eggs and to then incubate these pools at 25-37° C to allow *S. enteritidis* multiplication before proceeding to a series of traditional bacteriological culturing steps. Supplementation with concentrated sources of nutrients can increase the rate of *S. enteritidis* growth in incubating egg pools. The present study sought to determine whether

incubation of egg pools at an elevated temperature (42° C) could further increase the rate of multiplication of *S. enteritidis* in order to allow the detection of contamination by a rapid method within a single day. Pools of 10 eggs were contaminated with approximately 10 cfu of *S. enteritidis*, supplemented with concentrated broth enrichment medium, and incubated at either 37° C or 42° C. Incubation of contaminated egg pools at 42° C resulted in significantly higher *S. enteritidis* levels after 6, 8, 10, and 12 hours. However, incubation at 42° C could only generate a mean *S. enteritidis* concentration of  $1.6 \times 10^4$  cfu/ml within a single working day (8 hours), inadequate to support efficient detection by most rapid assays. Accordingly, detection of *S. enteritidis* contamination in egg pools by a rapid lateral flow immunodiffusion test was not achieved at a high frequency until 12 hours of incubation at 42° C.

**Key Words:** Salmonella enteritidis, Eggs

**226 Multiple rinses of eggshells for recovery of aerobes and enterobacteriaceae.** M. T. Musgrove<sup>\*1</sup>, D. R. Jones<sup>1</sup>, J. K. Northcutt<sup>1</sup>, and M. A. Harrison<sup>2</sup>, <sup>1</sup>USDA-ARS, <sup>2</sup>University of Georgia.

It has been demonstrated that when broiler carcasses are rinsed repeatedly, specific bacterial species can be continuously recovered from multiple rinses. Though eggshells are less convoluted than chicken skin, they do have numerous pores that are large enough to harbor bacteria. In order to test the ability of rinsing to remove bacteria from shell surfaces, the following experiments were designed. In each of three experiments, eggs were rinsed eight times with 10 mL of phosphate buffered saline. Aliquots of the first, second, fourth, and eighth rinses were plated onto plate count agar and violet red bile agar to enumerate aerobic and *Enterobacteriaceae* populations. In each of the experiments, half the eggs (five) had been washed and the other half had not been washed (five). *Enterobacteriaceae* were only recovered from rinses of unwashed eggs with visible feces in the first experiment. All four rinses (1, 2, 4, 8) were positive though average levels (log<sub>10</sub> cfu/ml rinse) decreased from 2.8 to 1.2 from the first to the eighth rinse. In all three experiments, recovery rate for aerobic populations decreased with subsequent rinsing. Aerobic organisms were recovered from washed eggs at the following rates: 93, 47, 33, and 20 % for rinses 1, 2, 4, and 8, respectively. Unwashed egg recovery rates were 100, 87, 67 and 53 %. Average aerobic population

levels (log<sub>10</sub> cfu/ml rinse) for all 3 experiments were 1.4, 0.7, 0.9, and 0.8 for washed eggs and 4.2, 2.9, 2.5, and 2.5 for unwashed eggs. These data indicate that though larger rates of recovery and greater bacterial numbers are observed for the first rinse, subsequent rinses continue to remove organisms from egg shells. This may indicate that shell rinse methodology could be improved.

**Key Words:** Eggs, Eggshells, Aerobes, Enterobacteriaceae, Methodology

**227 Airborne microorganisms in shell egg processing facilities.** J. K. Northcutt<sup>\*</sup>, D. R. Jones, K. D. Ingram, and A. Hinton, Jr., USDA-ARS, Russell Research Center, Athens, GA.

Total aerobic bacteria, molds/yeasts, coliforms and pseudomonads were determined in the air of three shell egg processing facilities (in-line, off-line and mixed operations) using MicroBio MB2 Air Samplers. Sites were sampled from each facility on three different days (replication) during the same week. Four air samples (1000 L each) were drawn from each sampling site on a given day. Sampling sites, if applicable, included areas in or near the following locations: layer house (in-line and mixed operations), farm transition room (in-line and mixed operations), washers, dryer, packer heads, post-processing cooler, nest-run cooler (off-line and mixed operations), loading dock and dry storage. Type of facility (in-line, off-line or mixed), sampling site and the interaction between facility and site had a significant effect on the number of total aerobic bacteria, molds/yeasts, coliforms and pseudomonads recovered (P < 0.05). Highest counts for total aerobic bacteria (5.9 log<sub>10</sub> cfu/mL air), molds/yeasts (4.0 log<sub>10</sub> cfu/mL air), coliforms (2.5 log<sub>10</sub> cfu/mL air) and pseudomonads (3.2 log<sub>10</sub> cfu/mL air) were found in the layer house. Lowest counts for total aerobic bacteria (1.25 log<sub>10</sub> cfu/mL air) and molds/yeast (2.5 log<sub>10</sub> cfu/mL air) were found in the coolers and off-line coolers, respectively. Few samples in the post-processing coolers, nest-run coolers, loading docks and dry storage areas tested positive for coliforms (0/36, 2/24, 1/36, and 0/36, respectively) and pseudomonads (1/36, 2/24, 5/36, and 6/36, respectively). Data gathered during this study may be useful in identifying the sources and levels of airborne contaminants in commercial shell egg processing facilities.

**Key Words:** Airborne, Bioaerosols, Microorganisms, Shell eggs

## Avian Osteoporosis: Measurement and Ethical Considerations

**228 Welfare implications of avian osteoporosis.** A. B. Webster<sup>\*</sup>, The University of Georgia, Athens, GA.

The modern laying hen has a high demand for calcium to support egg shell formation. If dietary calcium is insufficient, structural bone may be demineralized, resulting in osteoporosis. Osteoporosis is not readily reversible while egg laying continues. The problem can be exacerbated incrementally by periods of deficient intake of calcium, phosphorous, or vitamin D due to depressed feed intake or errors in feeding management. Hens may experience some behavioral disturbance during episodes of calcium deficiency because heightened activity and stereotypic pecking have been observed in chickens fed calcium-deficient diets. Light-hybrid laying hens, having small skeletal frames, are the most prone to problems due to osteoporosis, especially if housed in cages. Osteoporosis increases risk of cage layer fatigue and bone fracture. A hen with serious cage layer fatigue cannot stand and may eventually die. Hen mortality due to cage layer fatigue appears to have become less prevalent. However, even in apparently healthy hens, folds in the sternum and at the junctions of sternal and vertebral rib segments indicating past fractures due to bone weakness are not uncommon. It is reasonable to believe that bone breakage is painful to hens. Some pain or discomfort may occur when bones such as the sternum or ribs deform due to weakness. Osteoporosis appears to have its most serious welfare implications in regard to spent hen catching and transport. In 2002, roughly 110 million spent laying hens in the U.S. were sent to processing plants. Catching of spent hens can result in high percentages of birds with broken bones, and the rate of breakage is negatively associated with bone strength. Transport for several hundred kilometers and transit times of 12-24 h are not unusual, so pain associated with vibration and jostling of an injury can last a considerable time. Many dead-on-arrival hens have at least one freshly broken bone. At present, care in husbandry is the key to minimize prob-

lems due to osteoporosis because, while the hen is in lay, the condition seems not amenable to a cure.

**Key Words:** Avian osteoporosis, Animal welfare

**229 Overview of bone biology in the egg-laying hen.** C. C. Whitehead<sup>\*</sup>, Roslin Institute, Edinburgh, Midlothian, UK.

In young pullets, long bones elongate by endochondral growth. Growth plate chondrocytes proliferate, then hypertrophy and are replaced by osteoblasts that form a network of trabecular bone. This bone is gradually resorbed by osteoclasts as the bone lengthens. Long bones widen, and flat bones are formed, by intramembranous ossification in which cortical bone formation by osteoblasts in the periosteal layer is accompanied by osteoclastic resorption at the inner endosteal surface. Growth of structural trabecular and cortical bone types continues up to the onset of sexual maturity in pullets. At this point, the large surge in oestrogen changes the function of osteoblasts to forming medullary bone rather than structural bone. Medullary bone is a woven bone that acts as a labile source of calcium for eggshell formation. It lines structural bone and also occurs as spicules within the marrow cavity. It has little inherent strength, though can contribute to fracture resistance. Osteoclasts resorb both medullary and structural bone so that during the period the hen remains in reproductive condition there is a progressive loss of structural bone throughout the skeleton characteristic of osteoporosis. The increasing fragility of the bones makes them more susceptible to fractures. The dynamics of bone loss can be affected by a number of nutritional, environmental and genetic factors. If the hen goes out of reproductive condition, oestrogen levels fall, osteoblasts resume structural bone formation and skeletal regeneration can take place.

**Key Words:** Laying hens, Bone, Osteoporosis