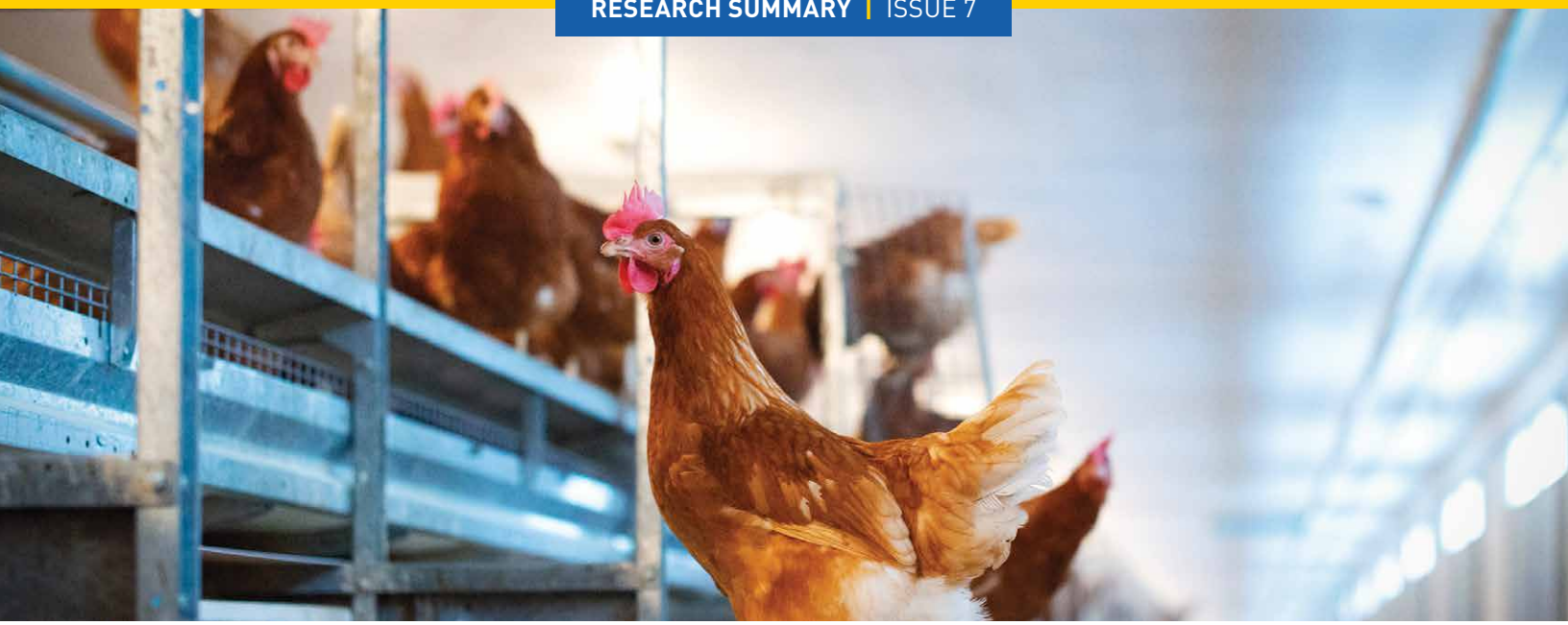


Advancing our industry through evidence-based research

Research summary overview

Our Research Grant Program actively supports research projects in a variety of fields at universities across Canada. Each research project is linked to at least one of Egg Farmers of Canada's research priorities. Below is an introduction to these research projects as well as their status.

2024 EFC GRANT PROGRAM RESEARCH SUMMARY

PROJECT NAME	STATUS	PAGE	RESEARCH PRIORITY AREA ADDRESSED								
			Animal care science	Bird nutrition and health	End of flock management	Environment and sustainability	Food safety	Human nutrition and health	Innovative uses of eggs	Public policy and economics	Research gaps identified by the Code of Practice
Determination of ideal perch space allowance for pullets	Complete	6	X								X
Determination of the metabolic triggers responsible for sexual maturation in laying hens and their relation to rearing environment and nutrition	Complete	6	X	X							X
Evaluation of hemp seed products to ameliorate fatty liver disease and reduce cannibalism in laying hens	Complete	7	X	X				X			
Egg residue depletion of oral topical formulations of fluralaner (Bravecto™) in laying hens	Complete	8	X	X			X				

PROJECT NAME	STATUS	PAGE	RESEARCH PRIORITY AREA ADDRESSED								
			Animal care science	Bird nutrition and health	End of flock management	Environment and sustainability	Food safety	Human nutrition and health	Innovative uses of eggs	Public policy and economics	Research gaps identified by the Code of Practice
Optimization of vaccination strategies for laying hens controlling egg production problems induced by currently circulating infectious bronchitis virus variants	Complete	8		X							X
Surveillance of egg yolk peritonitis (EYP) and causative *Escherichia coli (E. coli)* in Alberta egg farms	Complete	9		X							
Long-life layers: An environmental, economic, and animal welfare cost/benefit analysis	Complete	9				X				X	
Optimization of environmental and hen welfare outcomes in Canadian egg production using predictive analytics (machine learning) techniques	Complete	9				X					
A detailed characterization of particulate matter in Canadian egg farms	Complete	10	X	X		X					
Cold plasma pasteurization of liquid whole eggs	Complete	11					X				
Whole eggs for reducing inflammation and promoting muscle repair in adults with obesity	Complete	11						X			
Assessing hatchery related well-being	In progress	12	X	X						X	X
The use of pecking blocks as foraging enrichment for improvement of feather condition in enriched colonies	In progress	12	X								X
Pre-hatch sexing for chicks based on chorioallantoic membrane immune-interrogation	In progress	12	X			X					
Perching requirements for pullets and laying hens: Preferences for grasping and elevation	In progress	12	X								X
Understanding feather pecking in laying hens: The gut-microbiome-brain connection II	In progress	13	X	X							
Aggressive and severe feather pecking in brown and white feathered Leghorn pullets: Will blue light during brooding and rearing cycle improve future egg production?	In progress	13	X			X					X
Advancing poultry welfare with artifical intelligence: Integrative multimodal analysis for laying hens	In progress	13	X		X						X
Precision pullet rearing strategies for optimal reproductive body condition	In progress	14	X	X							X
Functional feedstuffs to bolster performance and immunocompetence of pullets reared at different rearing densities in enriched colony housing systems	In progress	14		X							X
Development of novel and alternative approaches using small-RNA based immune-stimulant molecules for control of avian infectious bronchitis virus	In progress	14		X							

PROJECT NAME	STATUS	PAGE	RESEARCH PRIORITY AREA ADDRESSED								
			Animal care science	Bird nutrition and health	End of flock management	Environment and sustainability	Food safety	Human nutrition and health	Innovative uses of eggs	Public policy and economics	Research gaps identified by the Code of Practice
Use of full-body imaging scans on live hens to develop a model describing the impact of body composition on sexual maturation	In progress	14		X							X
Supplementation strategies in vitamin D to protect layers from vitamin D deficiency and immunological stress	In progress	15		X				X			
Manipulation of maturity with light during incubation	In progress	15		X							
Building a usable surveillance and monitoring tool for avian influenza outbreaks in Canada	In progress	15		X							
From potential to implementation: Evaluating alternatives to antibiotics in layers through coordinated in vivo experimental studies and barn-level surveillance with industry partners	In progress	15		X							
Antimicrobial peptides: A better alternative to antibiotics on egg farms	In progress	15		X							
Functional nutrients to support calcium metabolism and egg production in a context of extending laying period in modern hens	In progress	15	X	X		X					
Evaluation of hemp seed products to ameliorate fatty liver disease and reduce cannibalism in laying hens in a modern group housing system and generation of efficacy and safety data	In progress	16	X	X				X			X
The impact of synchronizing photoperiod with body weight and metabolic thresholds to optimize sexual maturation in free run layers	In progress	16	X	X							X
Nutraceuticals for hens and humans through polyphenol enriched feeds and eggs	In progress	16		X				X			
Impact of body weight, age and strain on keel bone health and sexual maturity in layer pullets raised in commercial free run housing systems	In progress	16	X	X							X
Dietary strategies to improve calcium status in hens with extended laying cycles	In progress	16		X		X					
Valorization of end-of-lay hens for a sustainable egg industry	In progress	17			X	X					
A novel approach to end-of-flock management and biomass valorization using ambient alkaline hydrolysis	In progress	17			X	X					
Sustainable composites from waste eggshells for practical applications	In progress	17				X					
Expanding opportunities for Western Canadian fava bean *(Vicia faba)* as a feedstuff for laying hens	In progress	18		X		X					

PROJECT NAME	STATUS	PAGE	RESEARCH PRIORITY AREA ADDRESSED								
			Animal care science	Bird nutrition and health	End of flock management	Environment and sustainability	Food safety	Human nutrition and health	Innovative uses of eggs	Public policy and economics	Research gaps identified by the Code of Practice
Towards circular manufacturing strategies for the egg industry using eggshells as value-added mortar filler material for large-scale additive manufacturing	In progress	18				X			X		
Global warming: Impact of cooling strategies on the air quality inside livestock buildings and environmental emissions of gas and bioaerosols	In progress	18	X	X		X	X	X			
Modelling of alternative ventilation designs in layer houses	In progress	19				X					
Sustainable and resilient management of egg supply chains using Internet of Things	In progress	19			X	X	X	X		X	
Cleaner egg production: Conversion of manure to energy as a pathway for reduction of greenhouse gas emission and production costs	In progress	19				X					X
Canadian phytobiotics as natural alternatives to antibiotics to control Avian *E. coli*	In progress	19		X			X				
Developing a vaccine against Avian Pathogenic *E. coli*	In progress	19					X	X			
Metagenomic Assessment of Risk of *Salmonella*: Validation of a rapid diagnostic workflow to support *Salmonella* control and surveillance program in egg farming	In progress	19				X	X				
Optimizing relative humidity for superior shell cuticle to maintain egg quality and safety	In progress	20					X				
Develop new application of egg protein ovotransferrin as a functional food ingredient on bone health	In progress	20						X			
Eggs as a strategy to maintain retina health in people with diabetes	In progress	20						X			
Eggs-sactly what's required: Eggs as an appealing way to restore nutritional status after cancer treatment	In progress	20						X			
Including egg protein as part of a plant-based dietary pattern improves cardiometabolic health by ameliorating fatty liver disease	In progress	20						X			
A preliminary human study on bioavailability and efficacy of bioactive peptide IRW in egg white hydrolysate	In progress	21						X	X		
Additional daily intake of eggs for improving metabolic outcomes and choline levels in overweight and obese individuals: Phase I study	In progress	21						X			
Egg-sploring the long-term impact of a low-carbohydrate egg-based breakfast for type 2 diabetes	In progress	21						X			

PROJECT NAME	STATUS	PAGE	RESEARCH PRIORITY AREA ADDRESSED								
			Animal care science	Bird nutrition and health	End of flock management	Environment and sustainability	Food safety	Human nutrition and health	Innovative uses of eggs	Public policy and economics	Research gaps identified by the Code of Practice
Modified eggshell membrane formulations as a novel supplement to maintain gut health	In progress	21				X		X	X		
Animal implant studies with nano-textured eggshell-based constructs for bone regeneration	In progress	21						X	X		
From eggshell wastes to key components in green energy storage and conversion	In progress	21							X		
An integrated process for recovering calcium carbonate and collagen/collagen amino acids from waste shells	In progress	22				X		X	X		
Bioprinting of eggshell membrane-based biomaterials for promotion of wound healing	In progress	22				X		X	X		
Development of 3D printable self-powered biosensors for glucose monitoring from natural egg white	In progress	22							X		
Use of adeno-associated virus for production of monoclonal antibodies in eggs	In progress	22							X		
Environmentally and economically optimal lay cycle in aviaries and enriched housing systems in Canada	In progress	22				X				X	
Effects of microclimate on the airborne dust concentration in layer houses in Ontario	In progress	22									X
Phage therapy to decrease *E. coli* mortality in laying hens	Upcoming	22		X		X					
Evaluation of a novel multi-component protease to bolster dietary protein utilization for sustainable poultry production	Upcoming	23		X		X	X				
The effect of dietary omega-3 polyunsaturated fatty acids on birds' response to immune challenge induced by vaccination against avian encephalomyelitis	Upcoming	23		X							
Exploring the potential role of surface coating and ultraviolet (UV) irradiation against aerosol based highly pathogenic avian influenza (HPAI) virus transmission	Upcoming	23		X							X
Pilot scale fractionation of spent hen hydrolysate (from thermal hydrolysis) for animal feed and foliar fertilizer	Upcoming	24			X	X					
Lay facility disinfection using gaseous aqueous ozone applications	Upcoming	24	X		X	X	X				
Green approaches to enhance anticancer bioactivities of particalized eggshell membranes	Upcoming	24				X		X	X		

Completed research 2023-2024

Animal care science

Determination of ideal perch space allowance for pullets

Dr. Karen Schwean-Lardner, University of Saskatchewan

Also covers: Research gaps identified by the Code of Practice.

Objective

During the rearing stages, pullets learn to navigate their environment, including learning to perch. This study explored various perch space allowances (6, 9, 12 and 15 cm/bird) to determine the minimum perch space requirements for white and brown pullets throughout the rearing period. It also looked at the impact of perch space and genotype on growth and performance parameters, behaviour, bone strength and keel bone damage.

Results

The researchers found that a minimum of 12.5 cm (Lohmann LSL-Lite White) and 13.9 cm (Lohmann Brown-Lite) per bird was required for all pullets to perch at 18 weeks of age. While there were no differences in the percentage of pullets perching in the 12 and 15 cm/bird treatments, perch space allowances of 6 and 9 cm had fewer pullets perching. This indicates that smaller perch space allowances are not enough for all pullets to perch at the same time. Perch space allowances tested did not impact body weight, feed consumption, body width, comb damage (aggressive behaviour), stress, keel bone deviations, mortality, or bone strength.

Increasing perch space allowance increased the percent of pullets that perched in both white and brown strains. Future studies could explore the impact of different perch space allowances in a commercial environment.

Bird nutrition and health

Determination of the metabolic triggers responsible for sexual maturation in laying hens and their relation to rearing environment and nutrition

Dr. Gregoy Bedecarrats, University of Guelph

Also covers: Animal care science, research gaps identified by the Code of Practice.

Objective

This study aimed to determine the body weight and body composition responsible for initiating sexual maturation in two strains of laying hens reared in enriched colony, conventional and aviary housing environments. Body composition includes bone mineral content, total bone area, and the weight of fat, lean and total tissue. The researchers also looked at growth trajectory related to sexual maturation.

Results

For this study, pullets were separated into three groups, and either had restricted access to feed (20% under target), unlimited access to feed, or were fed based on the breeder guidelines. The researchers found restricting feed access reduced body growth and delayed sexual maturation in both white and brown pullets. Continuous access to feed accelerated body growth and sexual maturation in brown birds only, compared to the breeders' recommended guidelines. Delayed onset of lay was associated with lower body fat, bone mineral density and estrogen levels. The researchers also determined that a body fat threshold between 10-15% is required for sexual maturation to proceed. Additionally, birds housed in enriched colony systems reached sexual maturity faster compared to those reared in aviaries.

Overall, this project suggests that onset of lay is affected by rearing environment, nutrient availability, and strain.

Evaluation of hemp seed products to ameliorate fatty liver disease and reduce cannibalism in laying hens

Dr. Stephanie Collins, Dalhousie University

Also covers: Animal care science, human nutrition and health.

Objective

This study looked at the effect of feeding hempseed meal and hempseed oil to laying hens, with the goal of providing recommendations for including hemp by-products in laying hen diets. Researchers sought to assess the impact of hempseed meal and oil on hens' production, mortality rate, incidence of fatty liver disease, carry-over of cannabidiol (a natural agent found in hemp and cannabis) to egg yolks, and hen behaviour, among other things.

Results

The inclusion of hemp by-products in hens' diets contributed to an increase in alpha linolenic acid in eggs, indicating that hemp may be used to produce omega-3 eggs. The researchers also found there was no carry over of cannabidiol to the egg yolk. Hens fed diets with hemp by-products presented greater tibia strength and lower mortality. No significant effects of hemp by-products were found on the incidence of fatty liver disease or feather pecking. The findings indicate that hemp by-products are safe to use in laying hen diets, with the possibility to reduce fatty liver disease and cannibalism. Currently, the researchers are conducting a follow-up study to test the safety and efficacy of hemp by-products in enriched colony housing systems.

Egg residue depletion of oral topical formulations of fluralaner (Bravecto™) in laying hens

Dr. Patricia Dowling, University of Saskatchewan

Also covers: Animal care science, food safety.

Objective

Canadian small flocks lack affordable and convenient treatment options against one of the most significant ectoparasite pests in poultry: the red mite. A potential treatment could be found in fluralaner, a product already used for cats and dogs under a formulation called Bravecto™. This project sought to determine if Bravecto™ is safe for laying hens, with no dangerous residues transferred to any eggs laid. The researchers were particularly interested to see how Bravecto™ compared to a new poultry-specific fluralaner product, called Exholt™, which is in the process of being approved for poultry use in Canada.

Results

Bravecto™ for cats was found to be a successful way of fighting red mites in hens. The same cat formulation also led to low amounts of fluralaner residues in eggs, amounts that were below the maximum residue limits. Bravecto™ for cats is a topical application, and it could provide protection against red mites causing hen dermatitis. Bravecto™ for dogs, an oral application, led to unsafe residues of fluralaner in eggs.

In summary, the researchers found no negative effects of topical Bravecto™ for cats when applied to hens. Future studies could test the absorption of Bravecto™ for cats on poultry skin, fat, muscle and liver residues to ensure it is completely safe.

Optimization of vaccination strategies for laying hens controlling egg production problems induced by currently circulating infectious bronchitis virus (IBV) variants

Dr. Faizal Careem, University of Calgary

Also covers: Research gaps identified by the Code of Practice.

Objective

This project sought to optimize vaccination strategies against false layer syndrome, shell-less egg syndrome and other egg production abnormalities induced by select IBV variants isolated from laying hens. To do this, researchers tested different vaccination strategies, using market available infectious bronchitis vaccines against Mass and DMV1639 variants.

Results

A previous study showed IBV caused by the Mass and DMV1639 variants resulted in egg production abnormalities including shell-less egg syndrome, false-layer syndrome, and more. Administering both a live attenuated vaccine containing a weakened form of the virus between 2 and 9 weeks of age, followed by an inactivated infectious bronchitis vaccine between 14 and 16 weeks of age, enhanced the immune responses of pullets and hens. The researchers also found vaccinated hens from breeder flocks passed the antibodies to the chicks, which can provide protection against infectious bronchitis from an early age.

Based on the above results the researchers concluded that the application of this two-step vaccination protocol is an effective way to enhance the hens' immune response, reducing the incidence of IBV-related egg production abnormalities.

Surveillance of egg yolk peritonitis (EYP) and causative *Escherichia coli (E. coli)* in Alberta egg farms

Dr. Dongyan Niu, University of Calgary

Objective

This study sought to determine the incidence of egg yolk peritonitis caused by *E. coli* in Alberta pullets and laying hens. Additionally, the researchers aimed to genetically characterize *E. coli* and determine risk factors.

Results

The researchers found that the current incidence of reported egg yolk peritonitis is low in Alberta. The researchers collected 105 fecal *E. coli* samples from broilers, laying hens, and turkeys from Alberta farms. Through testing, they discovered that strains found in the different poultry species are related to each other and that some strains of fecal *E. coli* held the potential to become Avian Pathogenic *E. Coli* (APEC) if virulence genes were acquired. Finally, the testing showed that APEC has genes for antimicrobial resistance, posing an important risk and highlighting the importance of biosecurity.

Environment and sustainability

Long-life layers: An environmental, economic, and animal welfare cost/benefit analysis

Dr. Nathan Pelletier, University of British Columbia Okanagan and Dr. Maurice Doyon, Université Laval

Also covers: Public policy and economics.

Objective

This study aimed to investigate and quantify the potential environmental, animal welfare and economic effects of extending lay cycle length in Canada. The evaluation of these impacts can provide valuable information to Canadian egg farmers about the economic feasibility and sustainability implications of longer lay cycles.

Results

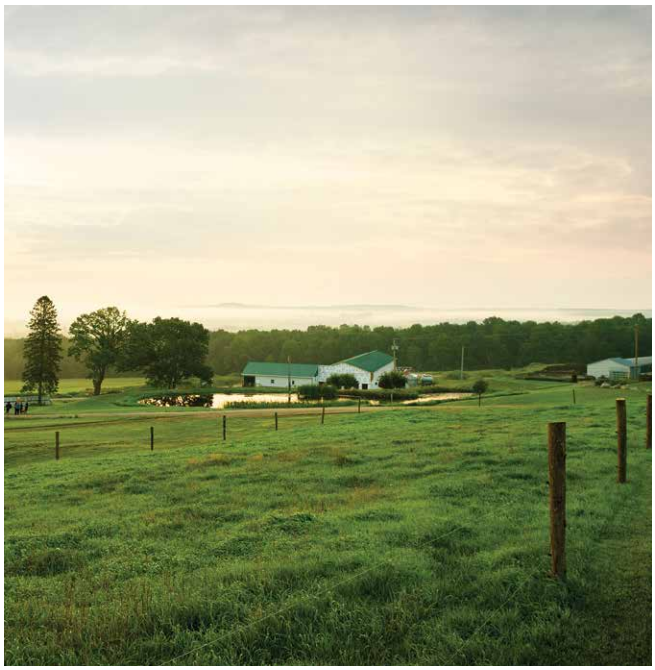
Researchers gathered pre-existing data to examine the potential impact of longer lay cycles. Variables such as egg laying rate and egg mass showed acceptable levels of performance beyond 70 weeks of age; however, variability increased beyond 80 weeks of age. According to the data, extending lay cycles beyond 52 weeks of production showed an increase in all environmental impacts per tonne of eggs produced in all housing systems. Due to the environmental, welfare and economic trade-offs of extending the lay cycle, the study found that extending lay cycles has the potential to increase profitability over time, with an economically optimal lay cycle of 71 weeks identified as the most profitable. Further research in commercial settings is required to fully understand the impact of longer lay cycles.

Optimization of environmental and hen welfare outcomes in Canadian egg production using predictive analytics (machine learning) techniques

Dr. Nathan Pelletier, University of British Columbia Okanagan

Objective

Machine learning involves programming a computer to analyze different problems, for which it then develops potential solutions. This type of computer programming



can be applied to analyze large amounts of data. Using machine learning techniques, the researchers aimed to optimize the sustainability of the Canadian egg industry by identifying animal welfare and environmental best practices. The results from this project sought to outline improvement opportunities and trade-offs to inform the ongoing housing transition in Canada.

Results

The researchers found that use efficiency of feed and pullets have the largest potential for reducing the environmental impact of the industry. This analysis showed that the egg industry had improved efficiency when compared to previous assessments, but indicates that there is still room for improvement. For example, feed formulations can be improved by using more regionally grown crops and taking into consideration housing type and genetics of a flock. The researchers also explored the development of an animal welfare life cycle impacts assessment to estimate which animal welfare risks could negatively impact sustainability. Future studies will use these findings to explore the sustainability of extending lay cycles.

A detailed characterization of particulate matter in Canadian egg farms

Dr. Ran Zhao, University of Alberta

Also covers: Animal care science, bird nutrition and health.

Objective

This study evaluated, optimized and validated the use of low-cost air quality sensors on egg farms. Additionally, the researchers looked at the trend of dust and particulate matter in the air in barns on Canadian egg farms, particularly those with enriched colony and aviary housing systems. This included identifying factors impinging on the concentration of dust and particulate matter and understanding the chemical composition and toxicological effect of particulate matter on egg farms.

Results

After some adjustments were made to the low-cost air quality sensors, the researchers found that they accurately and continually monitored the barn's environment. The sensors successfully identified trends of the hens' daily activity that can alter the chemical composition of air and particulate matter. The sensor ran for 1.5 months unattended and required routine cleaning thereafter. Pollutant levels were found to be greater in particulate matter suggesting that particulate matter could be a carrier for pollutants such as ammonia. The researchers also found an increase in particulate matter levels during the day, which was associated with an increase in bird activity levels.

Altogether, this project demonstrates that low-cost sensors can be an effective approach to monitoring air quality in barns. Future studies will investigate the reason for chemical variations distributed throughout the barn and air, providing a better understanding of how to manage on-farm pollutants.

Food safety

Cold plasma pasteurization of liquid whole eggs

Dr. Kevin Keener, University of Guelph

Objective

High voltage atmospheric cold plasma (HVACP) uses gas to target and destroy a pathogen while maintaining food quality. This project tested the effects of HVACP to pasteurize liquid whole eggs and manage *Salmonella* Enteritidis (SE). The researchers also evaluated HVACP effects on food quality like cakes and scrambled eggs to determine if protein and shelf life is affected after liquid whole egg treatment.

Results

To test the effect of HVACP, cultured SE was added to the eggs before pasteurization. Liquid whole eggs were pasteurized with either HVACP alone, or in combination with hydrogen peroxide. The combination of HVACP with hydrogen peroxide was effective at reducing SE. The food quality assessment found liquid whole eggs treated with HVACP and hydrogen peroxide were able to successfully maintain the foaming properties necessary for stability of baked goods, particularly cakes. Following baking, cakes containing liquid eggs treated with HVACP and hydrogen peroxide had increased in volume. Although slight colour changes in both the cakes and scrambled eggs were observed, the final food product retained its structure and overall taste.

Overall, the researchers found that HVACP with hydrogen peroxide treatment on liquid whole eggs is a good alternative for egg pasteurization targeting SE, and maintains the structure stability of baked goods and scrambled eggs. Future research will further explore the changes in functional properties of liquid whole eggs pasteurized with cold plasma, and how this affects baked goods containing eggs.

Human nutrition and health

Whole eggs for reducing inflammation and promoting muscle repair in adults with obesity

Dr. Michael De Lisio, University of Ottawa

Objective

Chronic inflammation and high fat accumulation around the muscles is a common characteristic of obesity and can impair muscle regeneration. This project sought to understand if a short-term increase in whole egg consumption would aid in muscle regeneration and reduce inflammation following exercise in obese adults.

Results

For this study, adults between ages 19-39 consumed either whole eggs or egg whites for 10 days. On day 7, the participants completed an exercise routine, after which the researchers measured muscle regeneration. The researchers found that short-term egg white consumption lowered inflammation. Following exercise, the egg white group had lower markers for inflammation and improved muscle adaptation, indicating egg whites promote muscle regeneration. Researchers hypothesized that the higher fat content in whole eggs could be responsible for impairing muscle regeneration in obese individuals. Given the short period of egg consumption, future work could look at the long-term effects of consuming eggs on inflammation and resistance training.

Research in progress

Animal care science

Assessing hatchery related well-being

Dr. Karen Schwean-Lardner, University of Saskatchewan

Also covers: Bird nutrition and health, public policy and economics, research gaps identified by the Code of Practice.

Objective

The researchers aim to provide evidence-based information to assist hatcheries with decision-making around equipment and transportation practices that promote chick welfare.

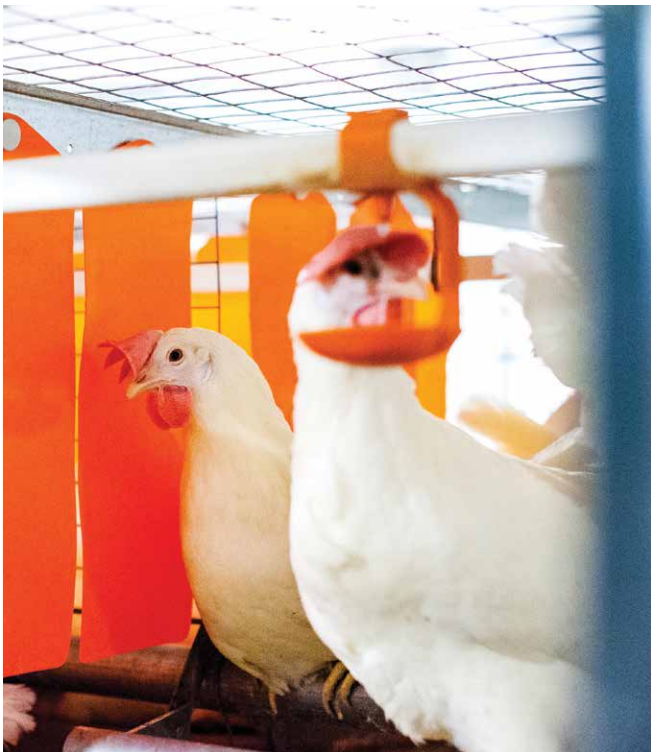
The use of pecking blocks as foraging enrichment for improvement of feather condition in enriched colonies

Dr. Tina Widowski, University of Guelph

Also covers: Research gaps identified by the Code of Practice.

Objective

This project looks to determine the effect of pecking blocks on foraging behaviour, feather pecking, feather damage and beak shape, while also identifying the most effective placement of pecking blocks within an



enriched colony housing system. The researchers will also note individual differences in frequency and duration of pecking block use among hens and will match this behaviour to health outcomes, including keel fractures, feather damage and eggshell quality. Finally, this study will establish whether the attraction to pecking blocks is related to its nutritional composition.

Pre-hatch sexing for chicks based on chorioallantoic membrane immune-interrogation

Dr. Maxwell Hincke, University of Ottawa

Also covers: Environment and sustainability.

This research project is currently underway and an update will be provided in a future research summary.

Perching requirements for pullets and laying hens: Preferences for grasping and elevation

Dr. Tina Widowski, University of Guelph

Also covers: Research gaps identified by the Code of Practice.

Objective

There are different understandings about what structures can be used as perches for laying hens, particularly in structures where hens cannot wrap their toes around the structure. To provide greater context to perching requirements, this study aims to explore hens' motivation for grasping and elevation, as well as how motivation for perching develops in pullets and if health conditions in older birds affects their roosting preferences. Additionally, the researchers will determine if strain differences affect these preferences.

Understanding feather pecking in laying hens: The gut-microbiome-brain connection II

Dr. Alexandra Harlander, University of Guelph

Also covers: Bird nutrition and health.

Objective

The researchers seek to identify a simple, practical prebiotic nutraceutical that can prevent or reduce feather pecking in laying hens on Canadian farms. To do this, they will use a galacto-oligosaccharide prebiotic and investigate its efficacy, effectiveness, and its potential mode of action.

Aggressive and severe feather pecking in brown and white feathered Leghorn pullets: Will blue light during brooding and rearing cycle improve future egg production?

Dr. Karen Schwean-Lardner, University of Saskatchewan

Also covers: Environment and sustainability, research gaps identified by the Code of Practice.

Objectives

Aggressive feather pecking and cannibalism are significant issues affecting animal welfare and production

on egg farms. This study will determine whether the use of blue light alters behaviour in brown and white feathered Leghorn pullets, resulting in reductions in aggressive pecking compared to birds reared under white light. In addition, the researchers will assess if using blue light during the brooding and rearing period close to the age of sexual maturation has a lingering effect on egg production when birds transition to white light at either 15 or 17 weeks of age.

Advancing poultry welfare with artificial intelligence: Integrative multimodal analysis for laying hens

Dr. Suresh Neethirajan, Dalhousie University

Also covers: End of flock management, research gaps identified by the Code of Practice.

This project will look at the simultaneous use of a variety of sensors (e.g. cameras, microphones, environmental sensors) to assess the welfare of hens in free run housing systems.

Bird nutrition and health

Precision pullet rearing strategies for optimal reproductive body condition

Dr. Martin Zuidhof, University of Alberta

Also covers: Animal care science, research gaps identified by the Code of Practice.

Objective

This project aims to optimize nutritional management for free run pullets and hens. The researchers will strive to understand the metabolic and physiological interactions that govern sexual maturation and lifetime egg production using precision feeding.

Functional feedstuffs to bolster performance and immunocompetence of pullets reared at different rearing densities in enriched colony housing systems

Dr. Elijah Kiarie, University of Guelph

Also covers: Research gaps identified by the Code of Practice.

Objective

This study aims to understand the impact of functional feedstuffs (e.g. omega-3 fatty acids, yeast metabolites) on pullet growth, mortality, health and *E. coli* load in enriched colony housing systems at low and high stocking densities. Additionally, this project will examine the long-term effects of functional feedstuffs on laying hen performance and livability.

Development of novel and alternative approaches using small-RNA based immune-stimulant molecules for control of avian infectious bronchitis virus

Dr. Faizal Careem, University of Calgary

This research project is currently underway and an update will be provided in a future research summary.

Use of full-body imaging scans on live hens to develop a model describing the impact of body composition on sexual maturation

Dr. Gregoy Bedecarrats, University of Guelph

Also covers: Research gaps identified by the Code of Practice.

Objective

This project seeks to develop a standard operating procedure for using full-body imaging scans on live hens and monitor body composition changes during growth of pullets with a specific focus on adipose tissue accumulation and bone characteristics. The researchers will also determine the precise relationship between changes in body composition and the onset of sexual maturation throughout the development of pullets and will generate a model describing the physiological processes governing the impact of body composition on reproductive capacity and fitness. This model will provide the tools to predict growth and maturation of pullets and proactively implement on-farm adjustments to ensure nutrition and housing requirements are met during pullet growth.

Supplementation strategies in vitamin D to protect layers from vitamin D deficiency and immunological stress

Dr. Marie-Pierre Létourneau-Montminy, Université Laval

Also covers: Human nutrition and health.

Objective

This study will test the addition of vitamin D to hen diets in a more active form, to the maximum allowed, for up to 90 weeks of laying. Researchers will specifically explore the impact of this diet on production performance, mineral levels, immune system, and bone health. With this project, the researchers look to improve the robustness of laying hens so that they can better cope with nutritional, immune, and environmental stresses in a context of longer laying cycles.

Manipulation of maturity with light during incubation

Dr. Bruce Rathgeber, Dalhousie University

Objective

The researchers will determine the impact of photoperiod length during incubation of hatching eggs on several factors, including hatch success and timing of hatch, early post-placement feed and water intake, recovery from long distance transportation, age at first egg, overall performance over a production period, egg number and egg size, and bone health in the long term. This project will provide data to further the knowledge of potential benefits of using light in incubators.

Building a usable surveillance and monitoring tool for avian influenza outbreaks in Canada

Dr. Rozita Dara, University of Guelph

This research project is currently underway and an update will be provided in a future research summary.

From potential to implementation: Evaluating alternatives to antibiotics in layers through coordinated in vivo experimental studies and barn-level surveillance with industry partners

Dr. Nicole Ricker, University of Guelph

Objectives

For this project, the researchers will identify changes in gut microbiota and short-chain fatty acid production (e.g. lactate) in response to acidification administered through either feed or water additives, as well as noting biomarkers or easy-to-measure physiological indicators that could confirm the success of the acidification treatment. The researchers will then partner with industry to observe and validate, at the barn level, the use of biomarkers and the effectiveness of water acidification and protected feed acidifier on avian pathogenic *E. coli* shedding and colonization.

Antimicrobial peptides: A better alternative to antibiotics on egg farms

Dr. Inanc Birol, Michael Smith Genome Science Centre

This research project is currently underway and an update will be provided in a future research summary.

Functional nutrients to support calcium metabolism and egg production in a context of extending laying period in modern hens

Dr. Angel René Alfonso Avila, Centre de recherche en sciences animales de Deschambault (CRSAD)

Also covers: Animal care science, environment and sustainability.

Objectives

Over the decades, the assessment of nutrients such as vitamin K and magnesium requirements has not evolved with those of amino acids or calcium. The researchers in this project look to determine the impact of functional nutrients on calcium metabolism and egg production, particularly in extended lay cycles.

Evaluation of hemp seed products to ameliorate fatty liver disease and reduce cannibalism in laying hens in a modern group housing system and generation of efficacy and safety data

Dr. Stephanie Collins, Dalhousie University

Also covers: Animal care science, human nutrition and health, research gaps identified by the Code of Practice.

Objective

This project will be the continuation of a recently completed project on the use of hemp by-products fed to laying hens housed in single tier (white hens) and conventional systems (both strains). The researchers aim to expand on the findings of feeding hemp by-products to white and brown hens housed in an enriched colony system, and brown hens housed in a free run system.

The impact of synchronizing photoperiod with body weight and metabolic thresholds to optimize sexual maturation in free run layers

Dr. Gregoy Bedecarrats, University of Guelph

Also covers: Animal care science, research gaps identified by the Code of Practice.

Objectives

The researchers want to identify the relationship between metabolic and photoperiodic (light) cues in laying hens and determine the minimum thresholds to achieve optimal entry into lay. In addition, they will establish the influence of free run environments on activity levels and its impact on body composition and bone quality as it relates to the timing of sexual maturation in laying hens.

Nutraceuticals for hens and humans through polyphenol-enriched feeds and eggs

Dr. Deborah Adewole, University of Saskatchewan

Also covers: Human nutrition and health.

Objective

Polyphenols are a natural compound commonly found in many fruits, vegetables, and cereals, with antioxidant properties that have the potential to improve hen health and production. This project will determine if feeding hens a polyphenol-rich diet can result in polyphenol-enriched eggs, and the effects on egg shelf life, egg taste, hens' health, and environmental emissions.

Impact of body weight, age and strain on keel bone health and sexual maturity in layer pullets raised in commercial free run housing systems

Dr. Gregoy Bedecarrats, University of Guelph

Also covers: Animal care science, research gaps identified by the Code of Practice.

Objectives

This project is an extension of the project titled *'The impact of synchronizing photoperiod with body weight and metabolic threshold to optimize sexual maturation in free run layers.'* In this extension, the researchers will enhance the applicability of the results by expanding the scope to include brown feathered hens and testing the results at a commercial farm.

Dietary strategies to improve calcium status in hens with extended laying cycles

Dr. Marie-Pierre Létourneau-Montminy, Université Laval

Also covers: Environment and sustainability.

Objectives

Calcium is an important mineral for bone health and eggshell formation in laying hens, and it can be paired with vitamin D_3 to better promote its absorption.

Phytogenics, plant-based natural bioactive compounds with antioxidant, anti-inflammatory and anti-bacterial properties, have also been found to improve bone metabolism. With extended lay cycles and the concurrent increase in bird age, additional calcium will be needed to support the hens' metabolism and maintain bone quality. This study aims to determine if supplementing hens' drinking water with calcium, either alone or with vitamin D_3, or the use of phytogenics will improve laying hen performance, egg quality, mineral status, and bone mineralization.

End of flock management

Valorization of end-of-lay hens for a sustainable egg industry

Dr. Jianping Wu, University of Alberta

Also covers: Environment and sustainability.

Objective

This project seeks to develop an industry-viable approach of valorizing end-of-lay hens with demonstrated financial feasibility and environmental sustainability. While a single product is normally extracted from an end-of-lay hen, this project will focus on developing a methodology to extract fat, muscle protein and collagen from a single end-of-lay hen and evaluate the characteristics of the resulting products.

A novel approach to end-of-flock management and biomass valorization using ambient alkaline hydrolysis

Dr. Brandon Gilroyed, University of Guelph

Also covers: Environment and sustainability.

Alkaline hydrolysis involves using an alkaline solution (pH greater than 7) at ambient temperature and pressure to break down end-of-lay hens into nutrient-rich by products. This research project is currently underway and an update will be provided in a future research summary.

Environment and sustainability

Sustainable composites from waste eggshells for practical applications

Dr. Duncan Cree, University of Saskatchewan

This research project is currently underway and an update will be provided in a future research summary.

Expanding opportunities for Western Canadian fava bean *(Vicia faba)* as a feedstuff for laying hens

Dr. Doug Korver, University of Alberta

Also covers: Bird nutrition and health.

Objective

This project seeks to understand the nutritional characteristics of Canadian fava beans and incorporate them into feeding programs for laying hens in a way that minimizes impacts on productivity and bird health.

Towards circular manufacturing strategies for the egg industry using eggshells as value-added mortar filler material for large-scale additive manufacturing

Dr. Lucas Hof, École de technologie supérieure

Also covers: Innovative uses of eggs.

This research project is currently underway and an update will be provided in a future research summary.

Global warming: Impact of cooling strategies on the air quality inside livestock buildings and environmental emissions of gas and bioaerosols

Dr. Stéphane Godbout, Research and Development institute for the agri-environment (IRDA)

Also covers: Animal care science, bird nutrition and health, food safety, human nutrition and health.

Objectives

Global warming and the increasing frequency of heat waves might promote the use of water-based cooling systems. However, little is known about the potential health risks associated with their use. This study will investigate the effects on air quality of an experimental evaporative cooling pad system, with a focus on gas and bioaerosols emissions, and on water condition and biofilms presence in the cooling pad.

Modelling of alternative ventilation designs in layer houses

Dr. Syeda Tasnim, University of Guelph

Objective

This project aims to develop and implement simulation mathematical models to evaluate the performance of conventional and alternative ventilation designs for layer houses in Ontario.

Sustainable and resilient management of egg supply chains using Internet of Things

Dr. Armin Jabbarzadeh, École de technologie supérieure

Also covers: End of flock management, food safety, human nutrition and health, public policy and economics.

This research project is currently underway and an update will be provided in a future research summary.

Cleaner egg production: Conversion of manure to energy as a pathway for reduction of greenhouse gas emission and production costs

Dr. Khaled Benis, Dalhousie University

Also covers: Research gaps identified by the Code of Practice.

Objective

This research project is currently underway and an update will be provided in a future research summary.

Food safety

Canadian phytobiotics as natural alternatives to antibiotics to control Avian *E. coli*

Dr. Sophie Kernéis-Golsteyn, Lethbridge College

Also covers: Bird nutrition and health.

This research project is currently underway and an update will be provided in a future research summary.

Developing a vaccine against Avian Pathogenic *E. coli*

Dr. Aaron White, VIDO, University of Saskatchewan

Also covers: Human nutrition and health.

This research project is currently underway and an update will be provided in a future research summary.

Metagenomic Assessment of Risk of *Salmonella*: Validation of a rapid diagnostic workflow to support *Salmonella* control and surveillance program in egg farming

Dr. Musangu Ngeleka, Prairie Diagnostic Services, University of Saskatchewan

Also covers: Environment and sustainability.

Objective

This project seeks to develop and validate a rapid metagenomics-based workflow, based on gene sequencing technologies, to support *Salmonella* detection, characterization, risk profiling, and surveillance in egg production systems.

Optimizing relative humidity for superior shell cuticle to maintain egg quality and safety

Dr. Bruce Rathgeber, Dalhousie University

Objective

The eggshell cuticle prevents loss of moisture and protects a freshly laid egg from bacterial infection. Barn environment and hens' metabolic conditions could affect eggshell cuticle quality and reduce the success of suction cups used by egg transfer equipment. This study will look at the impact of relative humidity and bird stress levels on cuticle structure and deposition, both in the bird environment and during storage. In addition, researchers will assess the effects of barn and egg storage conditions on cuticle structure and how this impacts its interactions with transfer equipment.

Human nutrition and health

Develop new application of egg protein ovotransferrin as a functional food ingredient for bone health

Dr. Jianping Wu, University of Alberta

This research project is currently underway and an update will be provided in a future research summary.

Eggs as a strategy to maintain retina health in people with diabetes

Dr. Miyoung Suh, University of Manitoba

Objective

This project will investigate the effects of consuming lutein, a carotenoid naturally present in eggs involved in retina health, and omega-3 DHA-enriched eggs on retina health in people with diabetes. The results of this study will contribute to the development of prevention strategies for eye health in diabetic individuals.

Eggs-actly what's required: Eggs as an appealing way to restore nutritional status after cancer treatment

Dr. Vera Mazurak, University of Alberta

Objective

Chemotherapy treatment challenges a patient's ability to consume adequate amounts of dietary protein. This project will use an egg-based diet to promote adequate intake of high-quality protein, maintain weight and muscle mass, enhance immune function and improve food related quality of life for people who have received chemotherapy treatment.

Including egg protein as part of a plant-based dietary pattern improves cardiometabolic health by ameliorating fatty liver disease

Dr. Carla Taylor, University of Manitoba

Objective

People with excessive accumulation of fat in liver cells frequently develop type 2 diabetes, cardiovascular disease and liver cancer. The researchers will use several high protein diets containing whole egg protein

or egg white protein, individually or in combination with plant-based protein, and compare the effects of these to a plant-based protein diet alone. They will examine the effects of these diets on liver fat accumulation, adipose tissue, insulin resistance, blood pressure and gut microbiome of a rodent model of fatty liver and cardiometabolic disease.

A preliminary human study on bioavailability and efficacy of bioactive peptide IRW in egg white hydrolysate

Dr. Jianping Wu, University of Alberta

Also covers: Innovative uses of eggs.

Objectives

IRW is a bioactive peptide present in eggs that has shown potential health effects against hypertension, type 2 diabetes, insulin resistance, oxidation, and inflammation. However, its bioavailability and efficacy in humans has yet to be studied. Here, the researchers seek to perform a preliminary human study to test the bioavailability and efficacy of IRW in egg white hydrolysate in lowering blood pressure and blood glucose.

Additional daily intake of eggs for improving metabolic outcomes and choline levels in overweight and obese individuals: Phase I study

Dr. Clara Cho, University of Guelph

Objectives

This study aspires to determine the effect of additional daily intake of eggs on a variety of metabolic indices (e.g. liver, fat, glucose levels, body mass, etc.) and choline and related metabolites, including markers of disease, in overweight and obese individuals.

Egg-sploring the long-term impact of a low-carbohydrate egg-based breakfast for type 2 diabetes

Dr. Jonathan Little, University of British Columbia

Objective

This project is a follow-up study which will determine if a low carbohydrate egg-based breakfast will improve glycemic controls and lower blood sugar, body weight, hunger, and daily caloric consumption in patients with type 2 diabetes when consumed over a 12-month period.

Innovative uses of eggs

Modified eggshell membrane formulations as a novel supplement to maintain gut health

Dr. Maxwell Hincke, University of Ottawa

Also covers: Environment and sustainability, human nutrition and health.

This research project is currently underway and an update will be provided in a future research summary.

Animal implant studies with nano-textured eggshell-based constructs for bone regeneration

Dr. Maxwell Hincke, University of Ottawa

Also covers: Human nutrition and health.

This research project is currently underway and an update will be provided in a future research summary.

From eggshell wastes to key components in green energy storage and conversion

Dr. Zhi Li, University of Alberta

This research project is currently underway and an update will be provided in a future research summary.

An integrated process for recovering calcium carbonate and collagen/collagen amino acids from waste shells

Dr. Duncan Cree, University of Saskatchewan

Also covers: Environment and sustainability, human nutrition and health.

This research project is currently underway and an update will be provided in a future research summary.

Bioprinting of eggshell membrane-based biomaterials for promotion of wound healing

Dr. Maxwell Hincke, University of Ottawa

Also covers: Environment and sustainability, human nutrition and health.

This research project is currently underway and an update will be provided in a future research summary.

Development of 3D printable self-powered biosensors for glucose monitoring from natural egg white

Dr. Wen Zhong, University of Manitoba

This research project is currently underway and an update will be provided in a future research summary.

Use of adeno-associated virus for production of monoclonal antibodies in eggs

Dr. Leonardo Susta, University of Guelph

Objective

Adeno-associated virus is a virus with no pathogenic potential, currently used for gene therapy in patients. This study will look at the efficacy of injecting pullets at the start of lay with adeno-associated virus to produce Palivizumab (PVZ), an antibody used for treating respiratory infections in humans, in eggs. The characteristics of PVZ produced from eggs will be compared to commercially available PVZ. The results of the project will provide an alternative, cost-effective method to obtaining PVZ antibodies through eggs, compared to the traditional methods of obtaining them from mammals.

Public policy and economics

Environmentally and economically optimal lay cycle in aviaries and enriched housing systems in Canada

Dr. Maurice Doyon, Université Laval

Also covers: Environment and sustainability.

This research project is currently underway and an update will be provided in a future research summary.

Research gaps identified by the Code of Practice

Effects of microclimate on the airborne dust concentration in layer houses in Ontario

Dr. Syeda Tasnim, University of Guelph

Objective

This project will characterize the microclimate of layer barns in Ontario, with an emphasis on understanding its effect on the concentration of airborne dust.

Upcoming research projects

Bird nutrition and health

Phage therapy to decrease *E. coli* mortality in laying hens

Dr. Martine Boulianne, Université de Montréal

Also covers: Environment and sustainability.

This research project is currently underway and an update will be provided in a future research summary.

Evaluation of a novel multi-component protease to bolster dietary protein utilization for sustainable poultry production

Dr. Elijah Kiarie, University of Guelph

Also covers: Environment and sustainability, food safety.

This research project is currently underway and an update will be provided in a future research summary.

The effect of dietary omega-3 polyunsaturated fatty acids on birds' response to immune challenge induced by vaccination against avian encephalomyelitis

Dr. Anna Rogiewicz, Dr. Chengbo Yang, Dr. Heather Blewett, University of Manitoba

This research project is currently underway and an update will be provided in a future research summary.

Exploring the potential role of surface coating and ultraviolet (UV) irradiation against aerosol based highly pathogenic avian influenza (HPAI) virus transmission

Dr. Faizal Careem, University of Calgary

Also covers: Research gaps identified by the Code of Practice.

Objectives

This experiment will determine if the avian influenza virus, including HPAI, will become inactive when applying UV irradiation alone or in combination with surface coatings containing titanium dioxide, in a simulated barn environment. The results of this project aim to benefit the Canadian poultry industry by tackling challenges around reducing the incidence of HPAI.

End of flock management

Pilot scale fractionation of spent hen hydrolysate (from thermal hydrolysis) for animal feed and foliar fertilizer

Dr. Philip Soladoye, Agriculture and Agri-Food Canada

Also covers: Environment and sustainability.

This research project is currently underway and an update will be provided in a future research summary.

Food safety

Lay facility disinfection using gaseous aqueous ozone applications

Mr. Trevor Carlson, Geosyntec Consultants

Also covers: Animal care science, end of flock management, environment and sustainability.

Objective

This project will determine the effectiveness of ozone application as a disinfectant in poultry barns for reducing infectious pathogens such as avian influenza, *Salmonella*, coccidia oocysts, and intestinal roundworms. The experiment will be completed in both a laboratory setting and on-farm to establish the dosage level and duration of application.

Innovative use of eggs

Green approaches to enhance anticancer bioactivities of particalized eggshell membranes

Dr. Maxwell Hincke, University of Ottawa

Also covers: Environment and sustainability, human nutrition and health.

This research project is currently underway and an update will be provided in a future research summary.

Visit **eggfarmers.ca** or contact us at **research@eggs.ca** for more information about Egg Farmers of Canada or our research program.

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