NEWSLETTER ARTICLES 2023

ADVANCING KNOWLEDGE

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ADVANCING THE CANADIAN POULTRY ENTERPRISE

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

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

This booklet compiles articles published in PIP`s newsletter in 2023. We hope these articles can inform you and help you better manage your birds.

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THE MYSTERY OF FIBER IN LAYING HENS DIETS – PART 2

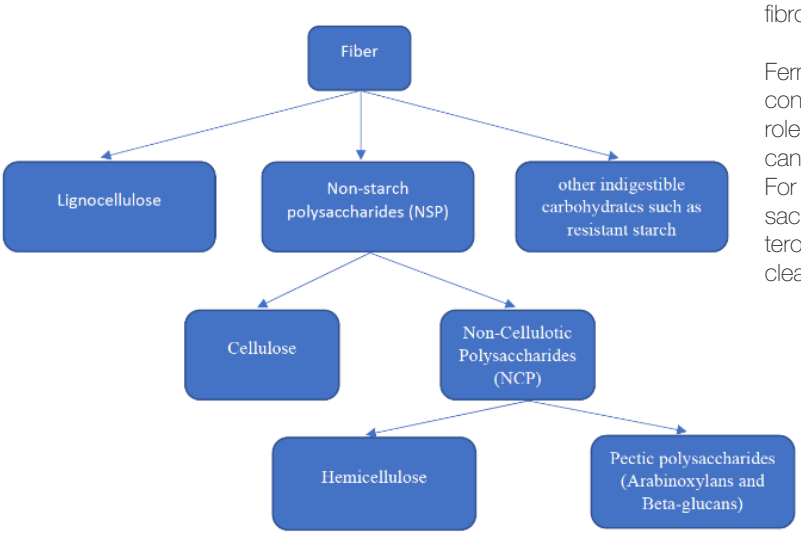
By Dr. Mohammad Afrouziyeh, January 2023

In our previous article, we discussed the definition of fiber, its sources, types, and strategies to overcome technical problems associated with increased dietary fiber. In this article, the digestion kinetics of various fiber types will be discussed to touch on the effects of fiber on nutrient utilization, gut microflora, and immunity.

Fiber digestion kinetics

Kinetics in physics refers to the study of forces acting on mechanisms, and in chemistry, it refers to the rates of chemical or biochemical reactions. Digestion kinetics explains the complex interactions between feed, digestive enzymes, microbial population, and digesta passage rate occurring within the lumen of the digestive tract. The kinetics of digestion affects the metabolic fate of nutrients after absorption. From the structural standpoint, fiber can be categorized into three main sections. Non-starch polysaccharides (NSP), lignocellulose, and other indigestible plant-based carbohydrates such as resistant starch. The NSP part can be further divided into two main parts: cellulose and non-cellulotic polysaccharides (NCP). The NCP encompasses the pectic polysaccharides (including Arabinoxylans in wheat and beta-glucans in barley) and hemicellulose.

Keeping the different parts of dietary fiber in mind, let's dive into the fiber digestion kinetics in poultry.



The function of fiber and its digestion kinetics in the gut should be investigated from the following perspectives.

1. Solubility
2. Viscosity and gelation
3. Water-holding capacity
4. Fermentation
5. Fiber particle size
6. Passage rate of solid and liquid components of digesta

From the solubility perspective, dietary fiber can be categorized into soluble and insoluble fractions. Viscosity is defined as the property of liquid to resist flow due to internal friction. A historical view has always blamed the soluble NSP for its adverse effects on increasing digesta viscosity and, subsequently, decreasing nutrient absorption. However, recent data show that those negative effects can be managed and turned into opportunities using proper nutritional management. For instance, feed processing or enzyme supplementation can break down NSP into small fermentable pieces, which can be used by the gut microbiome. We will discuss processing and enzyme supplementation in our next article (part 3). Although inulin and wheat dextrin are categorized as soluble NSP, they do not adversely affect digestion; these fiber components can be used as fuel by the beneficial bacteria in the poultry gut (prebiotic effect). The most common fiber products with prebiotic effects are inulin, raffinose, resistant starch, and small fragments of carbohydrates such as oligosaccharides of fructose, xylose, mannose, and galactose. The ability of these oligosaccharides to improve the microbiota is dose-dependent, and oligosaccharides with lower polymerization degrees (short chain oligosaccharides) can get more thoroughly broken down through the fermentation process.

These products stimulate commensal and beneficial microbes that are natural habitants in the gut; this ensures supporting the natural beneficial gut microbiota, whereas some supplemented beneficial microbes (commercial probiotics) that cannot establish colonies in the gut for a long time need to be supplemented continuously through the diet. Using natural fiber compounds that have prebiotic effects can increase the utilization of soluble NSP, supporting the beneficial microbes and managing digesta viscosity in birds fed with fibrous diets.

Fermentability of dietary fiber is an important factor that should be considered in formulating high-fiber diets. In addition to the prebiotic role and stimulating the immune system, some fermentable fibers can bind to pathogens and facilitate their exclusion from the gut. For example, mannan-oligosaccharides (MOS) and galacto-oligosaccharides (GOS) can prevent the adhesion of Salmonella and enteropathogenic Escherichia Coli, respectively, in the intestinal cells, cleaning the gut from these pathogens.

Fiber particle size plays an important role in the regulation of intestinal motility which affects nutrient utilization. Feeding insoluble fiber with coarse particles, in some cases, can help improve growth performance by decreasing the digesta passage rate, increasing the retention time in the upper digestive tract (gizzard), and harmonizing intestinal functionality. The recommended standard values for particle size are available in the "Feed sieve shaker" tool article.

Effects of dietary fiber on gut microbiome and nutrient utilization

The poultry gut microbiome consists of 900 species of bacteria, protozoa, fungi, yeast, and viruses located from the crop all the way to the colon, with the vast majority residing in the cecum and colon. The microhabitats of these microbes are the gut lumen, mucus, and mucosal linings.

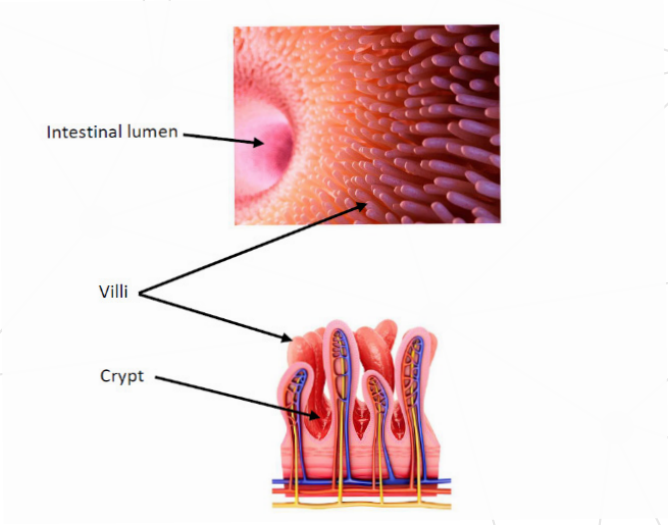
Dietary fiber or its degraded segments are fermented by gut microbes. The beneficial gut microbes play an important role in gut health and animals' immune systems by producing short chain fatty acids (SCFA); mainly acetate, butyrate, and propionate. Butyrate increases intestinal villi height to crypt depth ratio. This increases absorptive capacity and mucus secretion, which supports creating a barrier against pathogens. It has been shown that fermentation of xylans in wheat-based diets can produce butyrate and increase the mRNA expression of the tight junction proteins gene in the ileum, preventing the leaky gut issue in chickens. The SCFAs are the extracted energy from undigested nutrients (fiber) and improve the intestinal health of poultry by the following means:

1. Increase gut motility (movement through the gut)
2. Increase minerals absorption (for example sodium and chloride)
3. Increase cecal crypt proliferation
4. Support the growth of villi
5. Suppress the invasion of intestinal epithelial cells by pathogens
6. Reduce colonization of pathogens such as Salmonella
7. Decrease ammonia absorption through ionization due to intestinal pH drop

Notice that the lower gut's normal microbiome is the host's (bird) best friend that performs the following actions:

1. Utilizes the residual feed and converts it to microbial protein and useful fermentation products such as SCFA
2. Extracting energy from undigested feed for the host through fermentation, providing up to 5 to 15% of the daily metabolizable energy requirements for maintenance (MEm)
3. Preventing colonization of pathogenic and putrefactive bacteria (decay causing)
4. Promotion of gut maturation and integrity
5. Regulation of the immune responses

Gut microbiome composition can be affected by the inoculum passed from breeders (parents) to chicks, surrounding environmental conditions during the hatch, age, diet type, and intestinal environment. It is vital to support our birds' best friends (their microbiome) through proper nutrition. In this context, gut microbes need two main sources (energy and nitrogen) to grow and survive. Fermentable soluble NSP is used as an energy source (fuel), and undigested protein or amino acids as a nitrogen source for the microbiome. Lack of fermentable NSP shifts the microbial fermentation from saccharolytic (carbohydrate degradation) to proteolytic (protein degradation), producing odorous sulfur compounds, ammonia, and harmful metabolites such as amines, phenols, indols, biogenic



amines, hydrogen sulfide, and nitric oxide in the lower gut. More specifically, escaped protein and amino acids from enzymatic digestion will reach the lower gut, be fermented by the gut microflora, and turned into harmful fermentation products. These fermentation products are excreted and can affect the litter quality negatively and cause foot problems in layer pullets. Providing sufficient fermentable carbohydrates for the gut microbial population through dietary fiber is necessary to optimize gut microbial fermentation.

Dietary fiber plays an important role in colonizing gut microbiota by providing them with the substrate (foundation to live on). Lack of fiber decreases microbial diversity and thickness of the mucus layer. If bacteria in your birds' gut are "hungry" they will use glycoproteins of the mucus layer as an energy source. This will cause leaky gut disorder, malabsorption of nutrients, wet litter, feather pecking, and cannibalism.

Effects of dietary fiber on the immune system

Research has shown that including Beta-glucan NSP from dried distillers grains (DDGS) and yeast can increase immunoglobulin levels (IgA and IgG). IgA is found in the lining of the respiratory tract and digestive system. IgG is the most common antibody in blood and other body fluids and protects against bacterial and viral infections. In addition, as was previously discussed, some NSPs can be used as fuel for beneficial bacteria (prebiotic effect); these bacteria and their components activate immune cells of GALT (Gut-Associated Lymphoid Tissue). GALT is a component of the mucosa-associated lymphoid tissue, which works in the immune system to protect the body from invasion in the gut.

In conclusion, dietary fiber type, inclusion level, and particle size are worth considering in feed formulation as these factors affect the functionality of the fibrous feed components. Stay tuned for our next article, where the effects of dietary fiber on laying hens' performance, stress, and feather pecking will be discussed.

References

Hong T. N., et al. 2022. Animals. 12, 547.
Lázaro, R., et al. 2003. British Poultry Science 44 (2): 256–265.
Rajesh J. and P. Mishra. 2021. Journal of Animal Science and Biotechnology. 12:51
Tejeda, O. J. and W. K. Kim. 2021. Poultry Science. 100:101397.

THE MYSTERY OF FIBER IN LAYING HENS DIETS – PART 3

By Dr. Mohammad Afrouziyeh, February 2023

In our previous article, we discussed the digestion kinetics of various fiber types, the effects of fiber on nutrient utilization, gut microflora, and immunity. This article discusses the effects of dietary fiber on laying hens' performance, stress, and feather pecking.

Effects of dietary fiber on stress

The welfare aspect of nutritional programs can be assessed through physiological indices of stress such as elevated blood heterophil:lymphocyte ratio, corticosterone levels in plasma, cecal content, colon content, feathers, and behavioral changes such as stereotypic object pecking, over-drinking, and hyperactivity. Stress compromises gut health affecting gut integrity, permeability, and the immune system. Feeding appropriate types and levels of fiber can minimize the stress effects, supporting gut health. Feeding fermentable non-starch polysaccharides (NSP), especially fermentable oligosaccharides, has alleviated stress levels in chicken. The reduction in stress level was confirmed by reduction in the counts of heterophils in the blood as a physiological index of stress.

Effect of fiber on laying hen performance

Pelleted alfalfa was used in a study at different levels as a fiber source on Lohman Brown hybrid pullets from 9 to 16 weeks of age (Panaite et al., 2016). The results showed that using 8% pelleted alfalfa in the diet significantly increased pullet body weight by 6.73% higher than the Lohman Brown management guide. This might be because of the improvement in gizzard development as a result of using fiber in the diet. In another study, using lignocellulose at 1 kg per ton of feed increased body weight, feed intake, egg production, eggshell quality, egg yolk index percentage, and feed efficiency compared to the control group (Sozcu and Ipek, 2020).

Kocer et al. (2021) investigated the effects of supplementing laying hen diets with 3%, 4%, or 5% fiber using high-fiber sunflower meal from 21 weeks of age onward. They reported that by increasing the dietary fiber, body weight, egg production rate, and eggshell quality were increased, and the percentage of shell-less eggs and cracked eggs were reduced. Eggshell quality improved because providing fermentable fiber in laying hens diet can decrease intestinal pH and improve solubility and absorption of calcium and other minerals.

Effects of fiber on feather pecking and cannibalism

Abnormal behaviors such as feather pecking, and cannibalism can cause serious welfare, health, and financial damage to the egg industry. Insoluble fiber and coarse fiber ingredients can increase the eating time and reduce feather pecking and cannibalism in poultry. It has been shown that fiber source matters when it comes to such abnormal behavior. For instance, oat and barley are more beneficial than wheat in reducing cannibalistic behavior (Abrahamsson et al., 1996; Wahlstrom et al., 1998). Feed form also plays an essential role in fibrous diets. High-fiber diets were more effective in reducing feather pecking when the feed was provided in mash form compared to the pellet form. This might be because birds have to spend more time ingesting mash diets, satisfying their grazing behavior.

Changing the fate of fiber in the gut

As discussed in our previous article, soluble NSP can compromise poultry digesta viscosity and gut function if not appropriately managed. It is recommended to use targeted fiber components (various isolated forms of fiber), proper processing techniques, and exogenous enzymes in the feed to overcome these challenges. Feed processing and enzyme supplementation can change the fate of the dietary fiber in the gut, increasing fiber digestibility and other nutrients to produce fermentable resources for the gut microbiome. These fermentable resources serve as prebiotics, enhancing the population of beneficial bacteria. This subsequently improves the immune system and gut health.

Effects of NSP-degrading enzyme supplementation on fibrous diets

In one of our previous articles, it was mentioned that the poultry industry in different countries is moving away from using Antibiotic Growth Promoters (AGP) by replacing them with some potential alternatives. In the absence of AGP, more attention should be paid to feeding the beneficial gut microbiota; this can be done by providing a substrate for the microbiota using NSP-degrading enzymes and prebiotics. The NSP-degrading enzymes can provide fermentable oligosaccharides as a substrate for the beneficial bacteria (prebiotic effect), degrading the soluble and/or insoluble NSP.

To get the most benefit out of NSP-degrading enzymes, some multienzymes have been designed as a "cocktail enzyme", which contain several NSP degrading enzymes such as xylanase, amylase, glucanase, cellulase, mannase, and pectinase. Cocktail enzymes break down plant cell-wall matrix, particularly the insoluble components. These enzymes subsequently can release encapsulated nutrients, increasing the accessibility of digestive enzymes and nutrient absorption. Otherwise, unabsorbed nutrients (sugars) in the gut can cause osmosis of water into the gut lumen, increasing water excretion through excreta.

The main NSP-degrading enzyme is xylanase. In all NSP-degrading enzymes, xylanase is used either alone or in combination with other carbohydrase enzymes. The latter form, as mentioned, is a cocktail form. Xylanase degrades the internal glycosidic linkages in xylan and arabinoxylan and turns them into short-chain XOS (Xylan oligosaccharides) and AXOS (Arabinoxylan oligosaccharides), respectively. Intestinal bacteria ferment the latter products to produce short-chain fatty acids (SCFA), which are used as an energy source for the bird.

The efficacy of NSP-degrading enzymes depends on bird age, NSP type (grain type), the dose of NSP-degrading enzyme, and the effects of other enzymes in multienzyme products. The type of microbiota can affect the utilization of NSP. NSP-degrading enzymes help establish NSP-degrading bacteria in the gut; the better utilization of NSP, the fewer issues related to digesta viscosity, water consumption, and retention. NSP-degrading enzymes are more effective

during early life when the microbiome has not been established completely. If xylanase is fed in the starter phase, more xylan-degrading bacteria will be established in the microbiota of young chicks, enabling them to utilize dietary NSP in the subsequent phases.

Processing the dietary fiber

Feed processing techniques such as chemical, enzymatic, irradiation, milling, pelleting, etc., can affect fiber behavior in the gut, reducing adverse effects and increasing the most beneficial effects of fiber. Processing fibrous feed by hammer and roller milling increases the solubility and digestibility of NSP fraction. Adding NSP degrading enzymes to ingredients subjected to hydrothermal processing increases fiber digestibility by 1.5 to 6 times. Pelleting and micronizing can promote pentosanase action (a 5-carbon carbohydrate degrading enzyme) on fiber.

Enhanced lignocellulose (OptiCell or eubiotic lignocellulose) is a processed form of fiber that contains fermentable fiber. This product can reach its potential, exerting beneficial effects of fiber at as low as 0.5 to 1% of the diet without diluting dietary energy. This low dietary inclusion rate will guarantee the benefits of fiber without compromising dietary energy levels and feed intake.

In conclusion, animal nutritionists can change fiber "threats" to healthy flock opportunities using proper nutritional strategies. Fiber can then be used as a stress-reducing, immune-boosting, and performance-enhancing feed component in laying hens diets. Further research is warranted to define what type and levels of fiber can be used to reveal the potential benefits of this mysterious feed component.

References

Abrahamsson, P., R. Tauson, K. Elwinger. 1996. Effects on production, health and egg quality of varying proportions of wheat and barley in diets for two hybrids of laying hens kept in different housing systems. Acta Agriculturae Scandinavica, Section A – Animal Science 46(3): 173–182.

Desbruslais, A., Wealleans, A., Gonzalez-Sanchez, D., and M. di Benedetto. 2021. Dietary fibre in laying hens: a review of effects on performance, gut health and feather pecking. World's Poultry Science Journal, 77:4, 797-823.

Kocer, B., M. Bozkurt, G. Ege, A. E. Tuzun. 2021. Effects of sunflower meal supplementation in the diet on productive performance, egg quality and gastrointestinal tract traits of laying hens. British Poultry Science. 62(1): 101–109.

Sozcu, A., and A. Ipek. 2020. The effects of lignocellulose supplementation on laying performance, egg quality parameters, aerobic bacterial load of eggshell, serum biochemical parameters, and jejunal histomorphological traits of laying hens. Poultry Science. 99 (6): 3179–3187.

Wahlström, A., R. Tauson, and K. Elwinger. 1998. Effects on plumage condition, health and mortality of dietary oats/wheat ratios to three hybrids of laying hens different housing system. Acta Agriculturae Scandinavica 48: 250–259.

FABA BEAN AS AN ALTERNATIVE PROTEIN SOURCE FOR BROILERS

By Thania Moraes, March 2023

Researchers and producers are always on the lookout for an economical, nutrient rich and local feed ingredient that can increase productivity and decrease ever-rising feed costs. The faba bean fulfills many of those requirements and, despite a few drawbacks, there is great potential for its use in Alberta.

Faba bean is a grain legume rich in digestible protein and starch (1). It contains between 26.7-29.2% crude protein, 2,839 kcal/kg apparent metabolizable energy corrected to zero-nitrogen retention, and 7.5% crude fiber with variations depending on the cultivar (2). Faba bean is a pulse crop that can be cultivated locally in Alberta, and it is a great alternative that can partially replace the soybean meal in the diet, allowing poultry producers to reduce their feed costs (3).

Faba beans contain some antinutritional factors (tannin, vicine and convicine) which can reduce nutrient digestibility and cause undesirable physiological effects such as intestinal damage or growth depression (4). However, some antinutritional factors can have their negative effects removed by heating the beans (5), while heat-stable antinutritional factors can be reduced with soaking, dehulling, extrusion, pelleting, or fermentation (6, 7).

Faba Beans for Broiler Diets

Several studies have been performed to evaluate the effect of feeding faba beans to broilers. However, there is disagreement in the research findings from different authors. The difference in results can be due to differences in age and genotype of the birds (8) as well as the percentage of faba bean added, the cultivar, the treatment the seeds were submitted to prior to feeding, and the feed form.

It was observed that male broilers fed 30% of one of 5 tannin-free faba bean cultivars (from 7 to 21 d) had a higher weight gain and better feed conversion ratio than birds fed the control corn-soybean meal diet. Tannin-free faba bean also did not negatively affect performance or carcass weight (2).

In contrast, a different study (9) found no difference in weight gain and feed intake when comparing broilers fed a control soybean meal diet or with 20% replacement with low tannin faba beans from 1 to 21 days. However, the authors found that broilers fed faba beans had better excreta quality scores.

A different study also found no difference in broiler performance or carcass yield when broilers from 14 to 49 days were fed either a control soybean meal diet or a diet containing 31% dehulled-micronized faba beans (10).

Tomaszewska et al. (2018) fed broilers a control diet with soybean meal, a diet containing high-tannin faba bean in different concentrations (8/15% starter/grower diet or 16/22% starter/grower.) The diet did not influence broiler weight or feed conversion ratio during the experiment. It was also observed that the birds fed faba beans had increased villus length and thickness, therefore improving their gut absorptive capacity, maybe to counteract the negative effect of the antinutritional factors present in the diet (8).

Not only the inclusion level but also the feed form can influence the performance of broilers fed faba beans. When broilers (7-21 days of age) were fed different faba bean inclusions (0, 5, 10, 15, 20, or 25%) it was observed that in mash diets broiler growth rate decreased with the increase in faba bean inclusion, whereas in pelleted diets there was no difference in performance amongst the broilers fed different inclusions of faba bean (11). The author believes that the pelleting process generated enough heat to destroy the antinutritional factors that were detrimental to broiler performance.

A similar effect of feed form was found when 20% of faba bean was included in a pelleted broiler diet. No negative effect on performance was observed when compared to the control group (6). However, 20% inclusion on mash diets decreased feed intake and body weight (6).

Broiler body weight decreased linearly with the increase in the inclusion of faba bean in cold pellet diets (0, 8, 16, or 24%) with no negative effect on broiler health (12). However, the decrease in performance was only minor for diets with 16% or less faba bean inclusion.

When faba bean was fed to broilers (17-19 days) as the main protein source in pelleted or extruded diets, it was observed that the birds had a lower feed intake and, consequently lower body weight gain when compared to the control group. Longer retention of the faba bean diet on the upper gut and decreased palatability of the faba beans diets are believed to be responsible for the reduced feed intake observed in this experiment (13).

In general, most studies showed that faba bean did not negatively impact broiler body weight when they were from a cultivar low in antinutritional factors, fed in a treated form (pelleted) and in a lower inclusion (20% or less).

Economic Advantage of Faba Beans

Other than the economy of buying a local feed ingredient, immature or frost-damaged faba beans, which would be cheaper and undesirable for human consumption, can be fed to broilers without any negative effect on digestibility (14) or broiler performance (15). Surprisingly, low-quality faba beans had higher gross energy (7%) than high-quality seeds (15). It was also observed that faba beans (Fabelle, Snowdrop and Snowbird cultivars) that were planted later (therefore more prone to frost) had reduced antinutritional factors

and better digestibility (14).

Conclusions

Several studies have shown that faba beans can be a suitable partial substitute for soybean meal in poultry diets. However, insecurity about faba bean availability hinders its adoption as a local poultry feedstuff. Better communication between pulse growers and the poultry industry might increase the use of sustainable and locally produced faba beans in poultry diets.

References

1. Crépon, K., P. Marget, C. Peyronnet, et al.,. 2010. Nutritional value of faba bean (Vicia faba L.) seeds for feed and food. Field Crops Res. 115(3): 329-339. https://doi.org/10.1016/j.fcr.2009.09.016.

2. Usayran, N.N., H. Sha'ar, G.W. Barbour, et al. 2014. Nutritional value, performance, carcass quality, visceral organ size, and blood clinical chemistry of broiler chicks fed 30% tannin-free fava bean diets. Poult Sci. 93(8):2018-2027. https://doi.org/10.3382/ps.2014-03872

3. Tewatia, B.S., Jyotsana, A. S., Meetu, et al. 2022. Effect of dietary replacement of soybean meal with faba beans (Vicia faba L.) on the performance of broilers. Indian J. Anim. Nutr. 39(1): 81-87. https://doi.org/10.5958/2231-6744.2022.00011.1

4. Muzquiz, M., A. Varela, C. Burbano, et al. 2012. Bioactive compounds in legumes: pronutritive and antinutritive actions. Implications for nutrition and health. Phytochem Rev 11: 227–244. https://doi.org/10.1007/s11101-012-9233-9

5. Cardador-Martínez, A., K. Maya-Ocaña, A. Ortiz-Moreno, et al. 2012. Effect of Roasting and Boiling on the Content of Vicine, Convicine and L-3,4-dihydroxyphenylalanine in Vicia faba L. J. Food Qual. 35(6): 419-428. https://doi.org/10.1111/jfq.12006

6. Ivarsson, E., and H. Wall. 2017. Effects of toasting, inclusion levels and different enzyme supplementations of faba beans on growth performance of broiler chickens. J. Appl. Poult. Res. 26(4):467-475. https://doi.org/10.3382/japr/pfx016

7. Omar, A. E,. H.S. Al-Khalaifah, T.A. Ismail, et al. 2021. Performance, Serum Biochemical and Immunological Parameters, and Digestive Enzyme and Intestinal Barrier-Related Gene Expression of Broiler Chickens Fed Fermented Fava Bean By-Products as a Substitute for Conventional Feed. Front Vet Sci. 8:1-15. https://doi.org/10.3389/fvets.2021.696841

8. Tomaszewska, E., S. Muszyński, P. Dobrowolski, et al. 2018. The influence of dietary replacement of soybean meal with high-tannin faba beans on gut-bone axis and metabolic response in broiler chickens. Ann. Anim. Sci. 18(3): 801-824. https://doi.org/10.2478/aoas-2018-0019

9. Nalle, C.L., V. Ravindran, and G. Ravindran. 2010. Nutritional value of faba beans (Vicia faba L.) for broilers: Apparent metabolisable energy, ileal amino acid digestibility and production performance. Anim. Feed Sci. Technol. 156(3–4):104-111. https://doi.org/10.1016/j.anifeedsci.2010.01.010.

10. Laudadio, V., E. Ceci, and V. Tufarelli. 2011. Productive traits and meat fatty acid profile of broiler chickens fed diets containing micronized fava beans (Vicia faba L. var. minor) as the main protein source. J. Appl. Poult. Res. 20(1):12-20. https://doi.org/10.3382/japr.2010-00173.

11. Gous, R.M. 2011. Evaluation of faba bean (Vicia faba cv. Fiord) as a protein source for broilers. S. Afr. J. Anim. Sci. 41(2): 71-78. https://doi.org/10.4314/sajas.v41i2.71009

12. Koivunen, E., P. Tuunainen, L. Rossow, and J. Valaja. 2014. Digestibility and utilization of faba bean (Vicia faba L.) diets in broilers. Acta Agric. Scand. – A: Anim. Sci. 64(4): 217-225. https://doi.org/10.1080/09064702.2015.1020857

13. Itani, K., J. Ø. Hansen, B. Kierończyk, et al. 2022. Air-classified faba bean protein fraction as a substitute to soybean meal in pelleted and extruded broiler diets. Br. Poult. Sci. 63(1): 62-72. https://doi.org/10.1080/00071668.2021.1960949

14. Smit, M.N., R. F. Ketelaar, L. He, and E. Beltranena. 2021a. Ileal digestibility of energy and amino acids in three faba bean cultivars (Vicia faba L.) planted and harvested early or late in broiler chickens. Poult. Sci. 100(9):1-10. https://doi.org/10.1016/j.psj.2021.101332.

15. Smit, M.N., L. He, and E. Beltranena. 2021b. Feeding different cultivars and quality levels of faba bean to broiler chickens. Transl. Anim. Sci. 5(3): 1-18. https://doi.org/10.1093/tas/txab094

IRON IN WATER CAN AFFECT BIRD HEALTH!

By Dr. Mohammad Afrouziyeh, April 2023

Poultry producers understand that good quality water containing acceptable levels of mineral contaminants supports poultry flock health and livability. Productivity improves while the use of therapeutic treatments is reduced, equipment problems are prevented, and the sustainability of commercial poultry production is improved. High levels of iron in drinking water do not impose any direct health concerns for poultry, but systems with high iron may exhibit increased biofilm formation in water lines and also lead to water equipment malfunction. It is important to test water samples for iron levels regularly and treat the water accordingly.

Iron occurs naturally in water, usually at less than 1 mg/litre, but up to 100 mg/liter in groundwater. Any iron levels less than 0.2 mg/litre fall into the best practice level; between 0.2 and 0.3 mg/litre are acceptable, and any values above 0.3 mg/litre are above the acceptable level. Birds can tolerate iron. A study conducted by Fairchild et. al. at the University of Georgia suggested that broiler tolerance for iron in drinking water was up to 600 ppm. That being said, high iron concentration in water promotes the growth of pathogens and other farm challenges. Iron particles feed bacteria (like Pseudomonas, Salmonella, and E. coli), so if your water has excessive levels of iron, the water is prone to contamination. In addition, high levels of iron cause water system scaling, which may result in the malfunctioning of watering equipment and lead to water deprivation. Iron oxide precipitant can get into the nipple drinker mechanism and result in leaky nipples. This results in poor litter conditions, increasing ammonia levels and compromising birds' performance.

Water and equipment observational tests

On-farm observational tests on your drinking water can help identify a problem with levels of high iron. The fist step is to collect water samples from the water source, water after treatment, and the end of the water line. Each water sample should be taken in two glasses. You will need to run some tests on the fresh water sample and some tests on a water sample after sitting for a minimum of 4 hours in a glass.

Below are four examples of problematic iron levels after testing. If you come up with the following results, you should check the water iron level by sending a water sample to a lab for iron analysis or using an on-farm water iron meter tool. A detailed explanation of the standard operating procedure of the water iron meter can be found in our previous tool of the month article.

If you have high iron levels in your water you might observe the following:

1. The appearance of your fresh drinking water sample is gray, brown, or black.
2. If you let the water sit for a minimum of 4 hours in a glass, the color of the water changes to yellow, brown, or reddish-brown.
3. The odor or taste of the fresh water sample is metallic or bitter.
4. Any equipment in contact with water, such as water filters, water lines, fogging nozzles, and evaporative cooling systems, should also be monitored for any signs that might suggest a problem. Test the water for iron if it leaves behind any brown or reddish-brown residue (stains, film, or scale) on the surfaces.

Treatment of high iron in drinking water

Iron removal is probably the most practical approach to effectively dealing with high iron content in water. The following methods can be taken to manage the issue.

*Coagulation is a method to remove fine particles, iron, arsenic, and manganese. The coagulation chemicals, such as aluminum sulfate, neutralize the charge on the particles and cause particles to coalesce into floc (a loosely clumped mass of fine particles) that can be removed by filtration or settling. The removal of particles prior to chlorination makes disinfection much more effective.
*Some filters, such as manganese greensand filters, slow sand filters, nano-filters, or reverse-osmosis membranes, may be effective in reducing iron in drinking water.
*Oxidation with chlorine, chlorine dioxide, or ozone and then filtration removal with proper-sized mechanical filtration.
*Biologically activated carbon with pre-oxidation: Biological Activated Carbon (BAC) is a water purification process that combines physical adsorption onto granular activated carbon and pollutants/organics biodegradation through biofilms. More information about the BAC system is available at Wageningen University and Research website.
*Shock chlorination of well water is recommended to eliminate bacterial contamination and to reduce iron-fixing bacteria and hydrogen sulfide-producing bacteria in the water source. Shock chlorination can be done using household liquid bleach or chlorine tablets / coated calcium hypochlorite tablets. The goal is to achieve 100-200 part-per-million (ppm) chlorine in the system for optimal shock chlorination. To reach these levels of chlorine, use approximately 3 pints (about 1.5 liters) of liquid bleach per 100 gallons (about 378 liters) of water. Notice that these levels of chlorine are not safe for human and animal consumption, so this method should be done only between flocks when there are no birds in the barn. Remove any activated carbon filters that might be in the system to prevent filter damage.

In conclusion, iron in water is an important factor to consider in poultry production. Ramifications of high levels of iron in water can compromise bird health and increase the water system maintenance cost. Regularly testing water samples for iron levels and taking steps to manage high levels can help ensure the health and productivity of your flock.

References

Fairchild, B. D., A. B. Batal, C. W. Ritz, and P. F. Vendrell. 2006. Effect of drinking water iron concentration on broiler performance. J. Appl. Poult. Res. 15:511–517.

Harry Bruning. 2019. Potential of an innovative ultrapure water production plant with biological activated carbon filters. Wageningen University and Research.

The Extension Poultry Housing program of Auburn University. 2000. Key Water Factors for Broiler Production. Auburn University Poultry Ventilation and Housing Newsletter No. 7. Page 65-69.

Watkins, S. 2008. Water: Identifying and Correcting Challenges. AVIAN Advice. Avian Advice. University of Arkansas Cooperative Extension Service, Fayetteville, AR. Vol. 10, No. 3. Pages 10 – 15.

Watkins, S. 2015. Optimizing Water Quality for Organic Bird Production. Midwest Poultry.

FEED MIXING UNIFORMITY TEST – PART 1

By Dr. Mohammad Afrouziyeh, May 2023

When formulating a diet, the ultimate goal of nutritionists is to match nutrient supply with the nutrient requirements of animals. This will ensure that an animal receives all of the nutrients in the right proportion on a daily basis. To achieve the goal, proper feed manufacturing steps should be practiced carefully. Producing high-quality feed starts with receiving, grinding, mixing, and batching of ingredients. A proper mixing procedure should be followed to produce a homogenous mixture where nutrients and medications are uniformly distributed. Having a uniform final mixture is important for optimal animal health and performance and to minimize food safety hazards related to nutrient toxicity. Furthermore, if the feed is to be further processed (to make a pellet or crumble form), an excellent mixture uniformity is necessary. The homogeneity of the final product is assessed using a procedure called the feed mixing uniformity test.

Feed uniformity testing is an important aspect of feed manufacturing that assesses the level of one or more tracers (nutrients) in a pre-established number of feed samples in a batch of feed to determine the feed homogeneity. Although there are some variations between samples of a batch, an ideal mixture is one with minimal variation in the composition of its samples. The feed uniformity test can help ensure the quality of the feed, reduce waste, increase efficiency, and ensure regulatory compliance. By assessing the uniformity of the feed, producers can determine if the ingredients are being mixed properly and if there are any variations that could affect the nutritional value of the feed. Consistent uniformity is essential for animal health, growth, and performance. Feeding a uniform feed ensures animals receive a balanced amount of nutrients to minimize the environmental footprint. Many regulatory bodies also require feed uniformity testing to ensure that the feed produced meets specific standards. By conducting regular testing, producers can ensure that their feed meets the required standards, avoiding regulatory issues and associated costs.

Mixing uniformity test procedure

The feed mixing uniformity test evaluates the degree of uniformity in the feed mix. To perform this test, samples of feed mix are collected from various parts within the mixer and analyzed for nutrient uniformity. The test result is expressed as a coefficient of variation (CV), which indicates the degree of variation in the mix. The following steps should be followed to evaluate a feed mixture uniformity.

1. Sampling procedure

The sampling method depends on the mixer type (vertical and horizontal mixer). To take feed samples from a vertical mixer, take 10 equally sized samples (between 100 and 500 grams for dry feeds) from a single batch and have it analyzed for tracer(s) content. The sampling spots should represent the full batch. While the system is running, take the samples at even and predetermined time intervals (for example, every 10 seconds) at or as close to the mixer discharge as possible. Horizontal mixers are usually accessible from the top. To take feed samples from a horizontal mixer, use a grain probe to take samples from 10 different locations in the mixer. Read the Tool of the Month article in this newsletter to learn more about using grain probes!

2. Choosing tracer(s)

To choose the right tracer, consider the following criteria.

a. The selected tracer(s) should come from a single ingredient source to avoid masking non-uniformity.
b. The method to determine the level of the tracer should be highly reproducible with a low variation. The analytical variability for lab methods should be less than the target CV for the mixer.
c. The tracer also should have sufficient particles per gram to ensure the marker can be detected when the sample is obtained from the mixer.

Salt (sodium and/or chloride), synthetic amino acids (lysine, methionine), and trace minerals (zinc, copper, manganese) are suitable tracers for conducting the test.

3. Analyzing the samples for tracer(s)

The feed samples should be sent to a feed analysis lab and analyzed for the tracer content. Alternatively, an on-farm test can be conducted to quantify the tracer (for example, chloride) concentrations in feed samples. I will introduce an on-farm test method in our next newsletter issue.

4. Calculating the Coefficient of Variation

Homogeneity is obtained by calculating the CV of the tracer content in the samples using the following formulas shown on the next page.

Interpretation of results

Mixer tests are interpreted based on CV ranges for the tracer content in feed samples. Herrman and Behnke (1994) categorized a CV of less than 10% as excellent, 10 to 15% as good, 15 to 20% as fair, and greater than 20% as poor. Guide to Feed Mixing protocol from the University of California, Davis suggests a 5% CV as the industry standard for most ingredients. A CV = 5% means that the distribution of the nutrient (tracer) is between plus or minus 10% of the average intended dose. If the average intended dose of a nutrient (chloride level in the previous example) is 0.20 % and the CV is 5% then standard deviation (SD) of the nutrient is 0.01. Based on the Gauss curve (normal distribution rule), the nutrient dose of 95% of the mass of the batch falls within 2 SD (in this example 2 SD is 2 × 0.01 = 0.02) of the average dose. In the previous example, this would be 0.20±0.02, which creates a range from 0.18 to 0.22% of dietary chloride level. In plain language, an animal receives at least 95% of its formulated dietary allowances between 0.18 to 0.22% of the nutrient. The following standards are based on the Guidance Document Repository (GDR) of the Government of Canada.

Product	Target CV (%) for the mixing uniformity
Dilute drug premixes*	Less than 5%
Micro or macro premixes and supplements	Less than 10%
Complete feeds and total mixed rations	Less than 15%

*Dilute drug premix means a drug for veterinary use that results from mixing a drug premix (drug identification number (DIN) product) with feed ingredients so that the final product has an inclusion rate of at least 10 kg per ton (1%) of complete feed when used at the lowest approved dosage level of the drug.

In conclusion, a validation test for mixer performance should be periodically performed to ensure homogeneity is achieved. If not, corrective actions should be implemented, and their efficacy should be assessed. Stay tuned for the corrective actions in our next article!

References

Fahrenholz, A. C. 2019. Best practices: Mixing and sampling. Animal Feed Science and Technology. 250 51–52.

Herrman, T. 2001. Sampling: Procedures for Feed. MF-2036. Kansas State University Agricultural Experiment Station and Cooperative Extension Service Bulletin

Herrman, T. and K. Behnke. 1994. Testing mixer performance. MF1172. Kansas State University Agricultural Experiment Station and Cooperative Extension Service Bulletin, Manhattan, KS: Kansas State University

Stark, Ch., and Saensukjaroenphon M. 2017. Testing Mixer Performance. Kansas State University.

Zinn, R. A. 2020. A Guide to Feed Mixing. University of California, Davis.

a. Calculate the mean value of tracer content in feed samples:

$$Mean\ value\ of\ tracer\ content = \frac{Sum\ of\ tracer\ content\ in\ feed\ samples}{number\ of\ feed\ samples}$$

b. Calculate the standard deviation (SD) of tracer content in feed samples:

$$SD = \sqrt{\frac{Sum\ of\ (each\ sample's\ tracer\ content - mean\ value\ of\ tracer\ in\ samples)^2}{number\ of\ feed\ samples}}$$

c. Calculate the coefficient of variation (CV) of the feed samples:

$$CV = \frac{SD\ of\ tracer\ content}{Mean\ value\ of\ tracer\ content} \times 100$$

Let's try the formulas in an example. Imagine a tracer (chloride) concentration in 10 feed samples as follows: 0.21, 0.20, 0.22, 0.19, 0.19, 0.21, 0.20, 0.18, 0.21, 0.20. To find the tracer's CV follow the following steps:

$$Mean\ value\ of\ tracer\ content = \frac{0.21+0.20+0.22+0.19+0.19+0.21+0.20+0.18+0.21+0.20}{10} = 0.20$$

$$SD = \sqrt{\frac{(0.21-0.20)^2+(0.20-0.20)^2+(0.22-0.20)^2+(0.19-0.20)^2+(0.19-0.20)^2+(0.21-0.20)^2+(0.20-0.20)^2+(0.18-0.20)^2+(0.21-0.20)^2+(0.20-0.20)^2}{10}}$$

$$SD = 0.01$$

$$CV = \frac{0.01}{0.20} \times 100 = 5\%$$

FEED MIXING UNIFORMITY TEST – PART 2

By Dr. Mohammad Afrouziyeh, July 2023

In our previous article, the importance of testing feed mixing uniformity was introduced and the reader was taken through the test procedure, from sampling the feed all the way to interpreting the results. If the feed mixing process is not monitored, measured, and evaluated correctly, bird performance and the return on investment of the feeding practices may be substantially compromised. After recognizing the importance of the feed mixing uniformity test, the following questions come to mind. What should be done if the test results are not satisfactory? What actions should be taken to correct the feed uniformity issue? Answers to these questions and more will be explored in this article.

Feed additives such as vitamin premix, synthetic amino acids, and supplements are provided as a powder. There is a science behind powder technology and it is important to understand the behavior of powder in a mixture to optimize feed mixture uniformity. For example, segregation of a powder blend can compromise mixture uniformity if proper corrective actions are not in place. Powder technology plays such an important role in feed and pharmaceutical manufacturing that numerous scientific journals such as Powder Technology Journal publish the science behind this technology! If you are interested in this topic, you may consider reading more articles in the respective scientific journals to learn the fundamentals of mixing technologies.

Corrective actions for improper mixing uniformity

The corrective actions should be planned based on the factors affecting the mixing uniformity. Several factors, such as mixing time, mixer type, mixer loading, ingredient quality, mixer maintenance, and the sequence of ingredient addition, can affect the uniformity of the mix. Common corrective actions for mixing uniformity issues include increasing the mixing time, looking for worn equipment, mixer loading, and considering the sequence of ingredient addition.

Weighing process

Always try to monitor, measure, and analyze the weighing process to optimize feed mixing uniformity. Weighing accuracy can be compromised due to personnel factors, equipment calibration errors, and ingredient dry matter, which can negatively affect the feed mix uniformity. To minimize the personnel effect, try to make one person responsible for the weighing process and calibration checking. Ingredient moisture content can vary from batch to batch due to the origin of ingredients and transportation conditions, which can subsequently affect dry matter content. Thus, try to measure the moisture content and adjust the ingredient weight before weighing.

Mixing time

Mixing time is the duration for which the ingredients are blended together in the mixer. A proper mixing time depends upon the mixer type, manufacturer's guidelines and ingredients. Different mixers have different mixing mechanisms and can handle different types of ingredients. Vertical mixers have two mixing zones (one at the top and one at the bottom of the center screw). In contrast, twin ribbon/paddle mixers create multiple mixing zones from the opposing direction of the ribbons as they rotate. As a result, vertical mixers take a longer mixing time than horizontal mixers to achieve comparable outcomes. It is recommended to allocate at least 15 minutes for mixing in a vertical mixer, 7 minutes for a horizontal paddle mixer, and 4 minutes for a horizontal ribbon mixer. In addition, a proper mixing time depends on the ingredient particle size. A batch of feed consisting of ingredients with consistent particle size requires less mixing time than a batch with inconsistent particle size. Remember that if the mixing time is too short, the ingredients may not be mixed thoroughly, resulting in poor mixing uniformity. On the other hand, if the mixing time is too long, it can cause over-mixing and result in a loss of ingredient quality.

Ingredient order

The order in which ingredients are added to the mixer can also affect uniformity. Optimal results are obtained by initially loading the mixer with a portion of the major ingredients (grains, soybean meal, or other energy and protein sources), followed by the minor ingredients and additives (vitamins, minerals, synthetic amino acids, and other additives), and finally, the remaining portion of the major ingredients. It is essential to add liquids (such as oil) only after thoroughly mixing all the dry ingredients. This can help ensure that all ingredients are evenly distributed and mixed thoroughly.

Mixer loading

Overloading or underloading the mixer can also affect feed mixing uniformity. Overloading the mixer can result in uneven mixing due to the creation of dead spots above the top of the ribbons/paddles and insufficient space for ingredients to move around. Underloading can lead to overmixing and the loss of ingredient quality. An optimal level of loading also depends on the mixer type. Horizontal mixer designs are constantly evolving and improving. In recent years, the twin-shaft ribbon/paddle combination has become the preferred choice, replacing the traditional single-shaft double ribbon used in many feed mills. The twin shaft design offers several advantages, including a shorter mixing cycle due to the multi-directional flow of ingredients in the mixing zone and the ability to handle a greater range of batch sizes. When using twin ribbon/single shaft mixers, keeping them at least 50 percent full during operation is recommended. However, twin-shaft ribbon/paddle mixers can operate effectively at just 25 percent of their rated capacity without compromising the uniformity of the feed mixture.

Ingredient quality

The quality of the ingredients used in feed mixing can also affect uniformity. Ingredients that vary in size, electrostatic charge, shape, or density can result in uneven mixing. One of the most important analyses is checking the ingredient moisture content, which can vary from batch to batch. The moisture content of the ingredients can affect mixing uniformity, as ingredients with different moisture levels can clump together and not mix properly.

Mixer maintenance
The condition of the mixer can also affect feed mixing uniformity. Worn or damaged parts can compromise the mixing process and lead to uneven mixing. Regular maintenance, including cleaning, adjustment of mixer ribbons to reduce the space between the ribbons and the mixer shell, and replacing worn parts, can help ensure that the mixer is functioning properly and producing uniform mixtures.

In summary, feed mixing uniformity can be affected by several factors, including mixing time, mixer type, mixer loading, ingredient quality, mixer maintenance, and ingredient order. Understanding these factors and implementing best practices can help ensure that feed mixing is consistent and uniform, resulting in optimal animal nutrition and health.

References
Mavromichalis, I. 2014. Mixing uniformity affects piglet and broiler performance. Feed Strategy digital magazine.

Purkhiser, E. D. and P. D. Bloome. 1984. Calibrating Meter-Type Feed Mills. Pork Industry Handbook.

Stark, Ch., and Saensukjaroenphon M. 2017. Testing Mixer Performance. Kansas State University.

BRIDGING THE INTERNET DIVIDE

By Thania Moraes and Brenda Reimer, August 2023

Accessing the internet is a powerful tool to help you communicate with other people, search for information and learn. There are many tools that you can use to monitor your farm's conditions in real-time - but you need a solid internet connection! Recognizing this need, the Government of Canada has committed $7.6 billion to ensure that 98% of Canadians will have access to a high-speed, dependable internet service by 2026, with 100% planned for 2030. There are several options for high speed internet access out there - read on to learn more and explore solutions for high-speed internet access on your farm.

Important Considerations

When thinking about getting internet access on your farm, there is a lot to consider. You'll need to think about what's available to you, what you want out of your internet service, how much you're willing to pay and so on. When choosing the right internet for you, here are some factors you need to consider:

1. Availability

Perhaps your location is remote, you live in a valley or lower area, or you have a lot of trees on your property. Each of these factors can affect the type of internet service available to you. If you're looking for a new provider, checking with your neighbors is a great place to start. The Government of Canada maintains a National Broadband Internet Service Availability Map where you can see the providers available to you in your area by the type of service provided (more types of services later). If you're in Alberta, you can use the Internet Service Coverage Search provided by the Government of Alberta. https://www.servicealberta.ca/WISP_Search.cfm

2. What are your requirements?

Internet speeds are reported in Mbps or megabits per second – this refers to the amount of data that is being transferred per second. Download speed refers to how quickly you receive data from the internet to your device; Upload speed refers to how quickly you can transmit data from your device to the internet.

The number of devices and activity on each device will help you determine your minimum requirements. If you have several devices or several users on your farm you'll need faster download and upload speeds. For more details on how download and upload speeds you can view this resource from Hello Tech: https://www.hellotech.com/blog/wp-content/uploads/2020/07/What_is_a_Good_WiFi_Speed-Infographic.pdf

3. Contract and terms of service

Some internet services require a contract to access lower fees or free installation – but be aware that cancelling early will likely result in cancellation fees. Some plans have discounted values for the first couple of months, so make sure you are ok with the value you will have to pay after the initial discount period is over. Also, be aware of the terms of your service, some plans have a specific amount of data you can access per month. If you go over your limit you may have to pay extra or have slower internet for the remainder of the month.

4. Customer service

Even the best internet might go through some problems. Make sure you know how to contact your provider and get technical support when you need it.

Internet Service Types

As we mentioned earlier, the National Broadband Internet Service Availability Map will show you what services are available in your area (the list may not be complete, but it is a good place to start). The Availability Map shares providers by the type of service provided in a given area. Below is a description of the most popular kinds of internet.

1. Dial-up: This is likely the way most of us started accessing the internet. It is an old way of connecting to the internet. It is usually very inexpensive, but it requires a landline to work. You cannot make a call while using dial-up internet. Dialup connection has slow internet speed, because of that, video and audio chats are not possible. This type of connection is likely available in some locations but is obsolete. However, for some types of data monitoring on your farm, this may be an option!

2. DSL (Digital subscriber line): DSL provides internet access through a telephone landline but internet and phone can be used at the same time. It is faster than a dialup connection. DSL is reliable, affordable, and often available in areas that do not have access to cable or fiber internet.

3. Cable: Cable internet is typically only available in urban areas. It uses a modem that connects the internet through the same cable that provides TV services. Its speed is comparable to DSL and it is usually available at a wide range of prices. Reliability is a concern with cable internet because the coaxial cables used by this type of connection are susceptible to network congestion during peak usage times. You will likely pay a higher monthly feed to access higher speeds on this type of service.

4. Fixed Point Wireless: Fixed Point Wireless Internet has likely been the most common method for rural customers to connect to the internet until fairly recently. This connection uses line-of-sight radio towers to transmit data to a receiver antenna on your property. Since the antenna needs a direct line of sight with the hub, if there are hills, trees, buildings, or other obstacles nearby, the connection might not work effectively. Some customers have installed their antennas on a tower, or on top of a taller outbuilding to receive a good signal. You will likely pay a higher monthly feed to access higher speeds on this type of service.

5. Fiber optic: As the name says, it uses fiber-optic cables to transmit large amounts of information quickly. It is very fast and reliable but not available in many rural areas due to the limitations and costs of creating the network infrastructure.

6. High Earth Orbit Satellite: This type requires a special dish to connect to geostationary satellites orbiting the Earth (approximately 35,000 kilometers above earth). For this type of satellite you only need a clear view of the sky towards the satellite. Due to the distance that the signal must travel, there is a delayed connection or lag. Satellite providers may limit the amount of data you can use per month. Basic satellite internet is not very fast and plans with higher speeds or more data are often expensive but it may be the only type available in remote areas.

7. Low Earth Orbit Satellite: In the past couple of years another type of satellite internet has become available. Low Earth Orbit satellite internet has lower lag because the satellites are closer to Earth (approximately 550 kilometers). LEO satellite can also provide higher speeds. The antenna requires a fully unobstructed view of the sky. Some plans allow you to take your satellite antenna with you as you travel (for an additional fee).

8. Cellular or Mobile: All major mobile phone companies have a mobile internet option that uses the same network as your mobile phone. Depending on the company, this type may be called a rocket or smart hub and may also provide home phone service using the same device. This type can be useful if you are travelling and want to take your service with you. Speed will be limited by the cellular network in your area. The major drawback to this type of service is the cost of data – some provider plans start at only 5GB of data for the month while others offer up to 500 GB of data per month.

Making the Most of your Connection

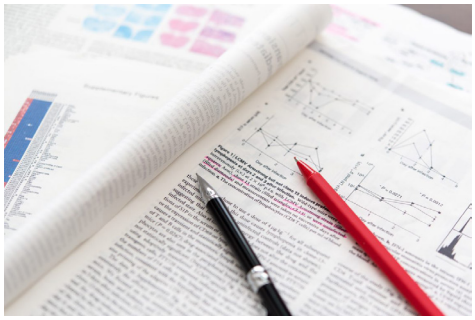
Did you know that you can beam your internet service from your house to your barn or wherever you need it? Wireless Bridge technology utilizes two small antennas to beam a signal from the house to the barn. Have multiple places you'd like to have an internet connection, perhaps a grain drying shack? Not a problem! Just add another dish. You do require line-of-sight to make this technology work and an installer familiar with the technology. In the experience of the author, we are able to beam a signal from the home office to the farm shop a mile down the road. It works so well we are able to use a cloud-based security camera system to monitor the farm 24/7.

There are other technologies out there that specialize in connecting your farm – some even allow you to connect grids miles wide so you can be connected when you're out in the field (a mesh type system).

If you have more questions, do not hesitate to contact us at poultryinnovationpartnership.ca

CONTINUOUS IMPROVEMENT IN POULTRY OPERATIONS

By Dr. Mohammad Afrouziyeh, September 2023



Continuous improvement in poultry management refers to the ongoing process of enhancing and optimizing various aspects of poultry farming operations to achieve better results. These results include production efficiency, bird health, and overall farm profitability. A Process Behavior Chart, also known as a performance measurement chart or control chart, can be used as a robust tool to implement and manage continuous improvement processes effectively.

A Process Behavior Chart is a statistical method used in quality management and process improvement to monitor and assess the stability and performance of a particular process. The chart displays changes in the output of a particular process over a period of time. In the context of poultry farms, performance measurement charts provide a visual representation of key performance indicators (KPIs) related to various aspects of poultry production, such as egg production, feed consumption, growth rate, and mortality rate. It allows tracking of these metrics over time and identifies trends, patterns, and areas where improvements can be made. By establishing control limits on the charts, farm managers can quickly spot deviations from the expected performance range and take corrective actions promptly. In this regard, they can compare their farm's performance against industry benchmarks and standards and use this information to set goals and targets for improvement. For instance, consider egg production on a poultry farm. By using a process behavior chart, farm managers can plot the number of eggs produced per day or egg weight over a period of time. The chart would include upper and lower control limits, which represent the acceptable range of egg production. If the data points consistently fall within these limits, it indicates stable and predictable production. However, if data points breach these limits, it alerts managers to potential issues that need investigation and correction, such as disease outbreaks, suboptimal feeding practices, or environmental stressors. Furthermore, process behavior charts facilitate making data-driven and informed decisions. Instead of relying solely on intuition or subjective assessments, producers can base their decisions on quantifiable data trends. This leads to more informed choices regarding adjustments to feed formulations, environmental conditions, health management protocols, and other factors that impact poultry production. Last but not least, process behavior charts serve as a reliable tool to evaluate the impact of an improvement action you intend to implement. They can also assist in addressing queries such as: Have the changes you have made produced any noticeable effects on the process? Have they resulted in improvements or setbacks?

Follow the following steps to run a continuous performance evaluation procedure using the Process Behavior Chart. Refer to the Tool of the Month article for guidance on utilizing an Excel spreadsheet to execute a Process Behavior Chart.

Data collection and analysis
Start by collecting and maintaining detailed records of various farm parameters, such as feed consumption, performance data (e.g., growth and egg production), feed conversion ratio, and mortality rates across your flocks.

Data preparation
Organize the collected data into a time-ordered sequence. This sequence is essential to observe any patterns or trends in the process behavior over time.

Calculate central line (CL) and control limits
The central line represents the mean performance over time. It is calculated by finding the average of the data points. Control limits are calculated to determine the natural variation in the process. There are typically Upper Control Limits (UCL) and Lower Control Limits (LCL) derived from the data's standard deviation.

Plot the data
Create a graph where the x-axis represents time or consecutive data points, and the y-axis represents the measured values. Plot the CL, UCL, and LCL on the chart. These lines help you visualize the expected variation in the process.

Interpretation
Continuously monitor the data points as they are added to the chart. Look for patterns, trends, or data points that fall outside the control limits (outliers.) Common patterns include shifts (sudden changes in the process mean) and trends (gradual changes in the process mean.) Outliers or data points beyond the control limits may indicate special causes of variation that require investigation and corrective action. Please refer to the Tool of the Month article for instructions on identifying unusual variations and signals within the data.

If you observe any unusual patterns or data points outside the control limits, it is essential to delve into the root causes and implement corrective measures to restore process stability. Regularly update and maintain the Process Behavior Chart to ensure continuous monitoring and improvement of the measured process.

The key benefits of using process behavior charts for continuous performance evaluation are:

1. Early detection of process deviations or issues.
2. Improved process stability and consistency.
3. Data-driven decision-making for process improvements.
4. Reduced variation in the process, leading to better product or service quality.

In conclusion, continuous improvement in poultry management is an essential practice for staying competitive in the poultry industry. By regularly assessing and refining various aspects of your operations, you can optimize production, enhance animal welfare, and achieve long-term success in poultry farming. The application of performance measurement charts in the continuous improvement of poultry farms empowers managers to closely monitor key performance metrics, maintain consistent production quality, and swiftly address deviations from optimal performance.

This data-driven approach ultimately leads to improved efficiency, better resource allocation, and healthier poultry stocks.

References

Kriss Nelson, 2023. Implement a continuous improvement process for your farm. Iowa Soybean Association.

Laura Candelotto, Klara J. Grethen, Camille M. Montalcini, Michael J. Toscano, and Yamenah Gómez. 2022. Tracking performance in poultry is affected by data cleaning method and housing system. Applied Animal Behaviour Science. Volume 249, April 2022, 105597

Luca Willington. Process Behaviour Charts – An Introduction. Deming Alliance.

MANAGING RISK IN POULTRY OPERATIONS

By Thania Moraes, October 2023

A farmer's life is stressful. The unpredictability of the Ag sector, as well as the workload pressures, can take a toll on farmers' well-being. With climate change causing more frequent and intense weather patterns, farmers are facing an even greater level of uncertainty. Droughts, floods, hailstorms, and heatwaves can all wreak havoc and have devastating consequences for farmers and their families. These, and other disasters, such as disease outbreaks, power outages, and gas leaks, can be mitigated with a risk management plan.

This article will give some tips on how to prepare for emergency events. Developing a risk management strategy should be done in collaboration with experts who have knowledge of your farm's specific situation (e.g. accountants, veterinarians, nutritionists, and business advisors).

A risk management strategy helps to plan for when unexpected situations occur, restores some sense of certainty, control, and confidence and can assist with reducing stress and burnout.

Creating a risk management plan

The key steps of implementing a risk management plan are:

Identify all possible risks, evaluate them, and rank them based on their likelihood of happening. The plan should assess risk severity, which is how much damage (such as profit loss, duration of lost production, health and safety of employees, reputational damage) each situation would cause if it happened.
Start with your highest priority risks and identify best practices or actions to implement to increase preparedness through preventative or mitigating measures.
Describe the task, person(s) responsible and create a timeline.
Meet with your farm team to review and revise, if necessary, and incorporate it into your business plan.
Implement and monitor your progress and adjust as circumstances change.

A risk management plan should consider:
People: occupational health and safety, personal well-being, hired labour, family, advisors
Finance: financial planning, cash flow, access to credit, debt, investiments
Markets: sourcing, selling, trade
Business Management: strategic planning, business structure, performance measurement, innovation, transition planning, operations
Business Environment: politics, policy, public trust
Production: animal health and welfare, nutrient management, pest management, environment and climate

Difference between risk mitigation and risk management

Risk mitigation means to prevent the risk. It requires a higher level of thinking, such as the development of a business plan, which can prevent something from happening or lessen the hardship if it happens.

There are always 'sunk costs' when focusing on mitigation and business planning – sometimes, investing more in something upfront can end up costing less in the long run. For example, if you need to shower in and shower out for biosecurity, this will be easier when you initially build the barn than renovating it afterward.

Risk management is a response to something that is already happening. It requires a more detailed level of thinking with the development of an operational plan. It aims to find the best way to deal with the undesirable situation that is already happening.

Common risks

Each farmer should assess and rank their risks. In this article, we will give two examples of common risks and how to address them.

Wildfire management

The 2023 wildfire season has seen the most burned area in Canada's history. Even if you aren't near a heavily forested area, it is important to remember that grass fires can be severe and spread fast.

In addition, the fallout of smoke from wildfires far away can impact you and your birds. Veterinarians report that poultry smoke inhalation can cause higher mortality during shipping from one barn to another or to the processing plant.

Ways to prepare

Avoid grassy areas, whenever possible keep the yard gravel, clear brush, and trees.
During high-risk periods such as hot and dry weather with strong winds, keep critical areas wet.
Research what resources and equipment are available in your area. Do the neighbors or county have something you can use to put out the fire? Do you have their contact information? Can you pre plan to help each other?
Develop a plan for a case of mandatory evacuation. What are you going to do with your birds? Is it possible to ship to the processing plant earlier? Will you depopulate your barn?

Drought Management

The likelihood of drought happening will vary according to the location of the farm and the weather conditions.

It is important to look ahead and forecast water availability versus need. Think about the financial implications of a drought and prepare for it accordingly.

You can assess the likelihood of drought by using historical data to inform the future. For example, in South Africa, they looked at historical data, knew what was coming, and invested in water-efficient equipment and monitoring their water use. They combined this with sealed on-farm storage so it couldn't evaporate.

Ways to prepare

Check provincial maps to find the location of old wells and springs. It can be found online. Sometimes, these wells can be reactivated if needed.

Policies can change. Consider what you would do if you were assigned less for irrigation or in your water license.

Consider using an underground storage tank. They are not affected by extreme weather. However, they can be expensive to install, and you may also need to install a pump if you need quick access.

As a last resort, you can truck in water, but you should have plans for that. Investigate your options, know if the supply would be limited in a long-term drought, and understand the costs and the impact on your business.

Want to learn more? Access resources at Farm Management Canada and Poultry Industry Council websites. Alberta Poultry Producers can find the Producer Emergency Response Plan for diseases at the APIEMT website.

Information obtained from PIP and EFA's Risk Management Flock Talk with participation from Farm Management Canada.

Thanks to Jenna Griffin (Egg Farmers of Alberta) and Heather Watson (Farm Management Canada) for the content that helped create this newsletter article.

POULTRY VACCINATION TIPS AND TRICKS

By Thania Moraes, November 2023

Proper vaccination is essential to prevent diseases and improve poultry performance.

To better understand vaccination methods and ideal vaccine storage, we have to consider the composition of the vaccines.

Live vaccines contain a virus or bacteria that is alive but modified to stimulate immunity without causing disease. Live vaccines provide short-term protection and can be delivered through spray, drinking water, or wing web injection.

Killed vaccines contain an inactivated virus or bacteria with an oil carrier (adjuvant). The carrier helps optimize the immune response of the killed vaccines. These vaccines generate a long-term immune response and are injectable.

This newsletter article will focus on tips and tricks for effective vaccination in poultry. A workshop that focused on layers and pullets inspired most of the recommendations in this article, however some aspects of vaccine conservation and use are common for all poultry.

Vaccine Storage

According to poultry veterinarian Dr. Teryn Girard, poor vaccine storage is the number one reason for vaccination failure.

Live vaccines must be kept at cold temperatures and can be killed by poor storage. Thermometers or a RH/Temp Data Logger in the fridge can track and prevent this. Measuring and recording minimum and maximum temperatures in the fridge daily is useful for troubleshooting vaccine storage problems.

When storing vaccines, it is important to consider the location of the vaccine in the fridge, how full the fridge is, and how fridge temperature measurements are done.

Ideally, vaccines should be stored in the middle of the fridge. Do not store vaccines in the fridge door because temperature variations are easier to occur at that location.

A full fridge can have unequal temperature and vaccine quality can be reduced in warmer spots inside the fridge.

Producers should record the fridge temperature at the same time every day to create a routine and avoid forgetting. Measuring at the same time of day also takes into account the temperature variations that might happen during the day.

Mixing live vaccines

Live vaccines usually come as lyophilized (freeze-dried) powder, and they have to be mixed with water before use. Some factors have to be considered when mixing vaccines:

• The water temperature of the stock solution is critical. It should be around fridge temperature (2-6°C).

• The water used should ideally be distilled water or demineralized water.

• Avoid using water with any sanitizers or contamination.

• Use a stabilizer such as a Vacc Safe tab.

• The final vaccine volume is variable. For example, for vaccines in water, it will depend on how much water the birds are consuming. For spray vaccines, it will depend on how much water your sprayer uses, how many cages and birds you have in the barn, and the length of each aisle or barn section.

Make sure all the vaccine is out of the vial by gently rinsing it in your stock solution multiple times and don't forget to wear gloves.

Mix the vaccine in a clean stock bucket. That bucket shouldn't be used for any other products or chores and should not have residue cleaning material in it.

Using ice to reduce water temperature before mixing vaccines is not recommended. Ice can have chlorine (some producers use Vacc Safe to make their own ice to alleviate this). Even if you use distilled water for ice, you will get uneven temperatures. If you plan to use ice, ensure it is fully stirred and melted so that you don't have pockets of colder and warmer water. It is recommended to use refrigerated water.

Spray (aerosol) vaccination

Spray vaccination is a common delivery method for respiratory diseases like Bronchitis. The goal of spray vaccination is to get droplets on the eyes and upper airways of the birds to develop immunity.

For the vaccine to be effective, the droplet/nozzle size should be greater than 100 microns. However, it can decrease to 80-100 microns after the first two spray vaccines for that same disease. Smaller droplets can be carried away with the air movement and not reach the birds.

Equipment pressure will also influence vaccine distribution. Therefore, it should be between 65-75 PSI (4.5-5 Bars).

TIP: To test your droplet size, spray a piece of paper at the same distance as the birds will be and measure what you see for droplets. It is also good to test over time to ensure your sprayer nozzle isn't clogged because that will decrease your droplet size.

When spraying, producers should walk and spray with plain water first to see how far into the barn 1L goes and develop the stock solution accordingly.

When spraying, use the solution within 1 hour of mixing.

Lower lighting can help keep the birds calm during vaccination. However, birds should not be sleeping when spraying. They should be alert and looking at the spray.

Ventilation is important if you are spraying. Ideally, producers should turn ventilation off while vaccinating and leave it off for 15 minutes after vaccinating so the droplets have time to settle on the birds.

However, in some circumstances, the barn may get too hot with the ventilation off. Vaccinating early in the morning can help prevent this challenge. Producers can do a section at a time to allow for ventilation between each group. If possible, turn emergency ventilation on so it will come on if it gets too hot. Watch the top layer of cages; panting behavior is a bird's last resort for coping with heat. If panting is observed, the ventilation should be turned back on regardless of the vaccination process. Another option if it is too hot: minimum ventilation can be running, but another vaccination should be done later to compensate for the reduced effect due to the ventilation.

For caged pullets, ensure the pressure makes the spray reach the back of the cages. The nozzle should be around 20cm from the front of the cage. The spray should be at bird head height, and ideally, the birds should be looking at the spray. It is helpful to dim the lights in your barn and then add a red or green light to the front of your sprayer, to gain the attention of the birds.

Water vaccination

Drinking water quality is essential in water vaccination. Producers should shut off all acidifiers, sanitizers, antibiotics, and other water products 72 hours before and after water vaccination.

At a concentration designed to kill viruses and bacteria at drinking water levels, peroxide and chlorine are dangerous to vaccines. In an ideal world, producers should shut off all sanitizers 72 hours before and after water vaccination. However, we need to be mindful that some producers might be bringing untreated water (ex., if dugout water is used, producers may not want the water sanitation off for any period of time). If the water is coming into the barn with peroxide already that can't be shut off, the first thing to do would be to measure the antibody titers in your flock – if blood titers are ok, carry on! If it is a problem, cisterns or stock solutions may be options. If you use peroxide and leave it in a tank, the peroxide will evaporate, but this does not work for chloramines. Charcoal filters may work to some degree.

The vaccine should have a stabilizer with dye to make it possible to see where the vaccine is in the waterline. Producers should charge the lines until the dye with the vaccine appears at the end of the lines.

With drinking water delivery, we want it to be in the water long enough that all birds drink. The range of 2-3 hours should be enough time for most birds to drink. A short period of water deprivation before vaccination might help birds to consume the vaccine faster.

Consider using the PIP Poultry Water App. This is a great tool that is available for free to all Albertan Poultry Producers. This app contains information that will allow you to delve deeper into understanding water sanitizers and managing water during vaccination procedures involving water.

Injectable vaccines

Killed vaccines on-farm are injected intramuscularly. Infectious bronchitis, Newcastle disease, and salmonella can be injected into the muscle on-farm between 14-18 weeks of age.

During on-farm vaccination, the vaccine must be warmed to room temperature in a warm water bath.

Since injectable vaccines are individual for each bird, producers should double-check the ideal dose volume for each vaccine.

Needle gauge and length should also be considered for vaccine effectiveness and to avoid bird injury. For manual injection, the needle gauge should be 18G and length ¼ inch. If machines are used, the needle gauge should be 18G, but the length should be 1 inch.

The injection needle should be changed at least every 500 birds to reduce the chance of injury to the bird and possible needle contamination. Injecting with a dull needle is painful – check it and change it when needed (including if bent or barbed) regardless of the number of birds.

Intramuscular vaccines are best in the breast muscle. If the needle is too short, it will not get fully into the breast muscle, and it can cause bacterial contamination. If you choose to provide intramuscular vaccines into the leg of the bird, ensure proper training and handling is utilized or your birds can be severely injured.

For more effective immunity, it is important to reduce bird stress during injectable vaccination. Producers can have the birds slightly above body weight target and give a vitamin B supplementation 2-3 days before and after vaccination to help minimize the impact of the vaccine on the birds.

If possible, producers should avoid vaccinating when there are other stressful moments such as diet or barn change. It is also important to handle the birds properly during vaccine application.

If producers have questions about their vaccination method, schedule, or titers, they should consult their poultry vet.

Information obtained from PIP and EFA's Risk Management Flock Talk. Thanks to Jenna Griffin (Egg Farmers of Alberta), Dr. Teryn Girard, Dr. Hollyn Maloney and Dr. Hayley Bowling (Prairie Livestock Veterinarians) for their help with this newsletter article.

SUSPENDED DUST IN POULTRY FACILITIES

By Mst Rowshon Afroz and Dr. Ran Zhao, December 2023

Indoor air quality (IAQ) in poultry facilities is a critical factor for maintaining optimal conditions for poultry production and safeguarding the health of birds and producers. However, these facilities often face challenges related to indoor air pollution. The modern poultry industry has adopted intensive and free-run bird farming practices, resulting in increased emissions of contaminants such as dust particles. Dust can be generated from various sources like floor bedding, feed, feathers, manure, dander, bird skin, and microorganisms.(1) These dust particulate matter (PM) exhibit distinct size distributions compared to other indoor and outdoor air, with concentrations generally 10 to 100 times higher.(2) In poultry facilities, inorganic ions, volatile organic compounds, heavy metal ions, and antibiotics can be absorbed on the surface of PM.(3) Additionally, PM could also serve as a vector for disease transmission.(4) PM with diameters equal to or less than 2.5μm (PM2.5) and 10μm (PM10) is of particular concern in air quality studies. These fine particles can be inhaled and accumulate in the respiratory system, penetrating deep into the lungs and causing various health issues for both producers and chickens.(5,6) Moreover, pollutants released from poultry farms can have negative consequences in different environmental compartments.(7) Proper monitoring of air quality could help to reduce the health impact and environmental footprint while supporting food production.

Methods of investigating air quality and affecting parameters

IAQ data in Canadian farms is particularly scarce, especially considering that poultry facilities are mostly indoors due to the harsh winter weather outside. Continuous air quality monitoring is challenging due to the cost of expensive research-grade instruments and highly dusty air inside poultry facilities. The use of low-cost sensors (LCS) can potentially address this issue. An ongoing study led by PhD student Rowshon Afroz and PI Ran Zhao, at the University of Alberta, aimed to assess the field performance of a custom-built LCS network in indoor poultry facilities. The performance of the sensor was tested in a commercial table egg farm near Edmonton, AB during winter. These sensors were specifically designed for dusty poultry facilities and successfully monitored the concentration of particulate matter (PM2.5 and PM10), carbon dioxide (CO_2), relative humidity (RH), and temperature in real time. Despite the challenging environment, these sensors operated continuously for several months, showing their potential to serve as an affordable solution for continuous real-time environmental monitoring in intensive food production facilities.

In this comprehensive study, several crucial findings have come to light, shedding new insights into the IAQ within poultry housing. The study revealed elevated levels of PM in the laying house, with PM10 at 5.5×104 and PM2.5 at 6.3×103 μg/m3 along with increased levels of CO_2. For comparison, the Canadian outdoor PM2.5 guideline is 27 μg/m3 for a 24-hour average, which is almost a thousand times lower than what we observed in the housing. The concentration levels and trends were found mostly influenced by the chicken activity and light regime. Moreover, indoor PM and CO_2 levels, temperature, and relative humidity exhibited a complex intercorrelation with each other, as well as influenced by the outdoor temperature and the building ventilation rate. In addition, the study also observed the impact of housing pollutants infiltration on areas where producers work regularly without personnel protective equipment (PPE).

Practice for maintaining healthy IAQ in the poultry housing and protecting producers from harmful air pollutants

(a) Real-time indoor environment monitoring is essential for maintaining better IAQ in chicken housing. By implementing an IAQ monitoring program, producers can identify sources and levels of indoor air pollution, as well as specific times when air pollutants peak, and take appropriate action to improve IAQ levels or mitigate risks. Based on our findings, it is recommended to track dust levels both inside the barn and in surrounding facilities where producers do not normally wear PPE. We hope that the sensor we developed and tested in this study serves as a pioneering effort toward achieving this goal.

(b) As expected, ventilation plays a pivotal role in controlling IAQ and dust concentrations. We found a general trend that the ventilation rate is reduced when outdoor temperatures reach low. The balance between ventilation and energy efficiency of the farm will continue to be a challenge for the Canadian poultry industry. Through our study, we wanted to raise awareness that a reduced ventilation rate reduces energy consumption during cold weather, but the benefit of which may be compromised by risks associated with elevated indoor air pollutants. This is particularly important during daytime, when the birds are active and lead to more suspended dust.

(c) It is extremely crucial for chicken farm workers to wear proper PPE to avoid exposure to harmful contaminants and prevent health risks. We recommend masks that can filter out both particles and toxic gases (e.g., ammonia). As our study has shown that dust can infiltrate from the barn to its exterior through openings, effort should be made to make the barn as air airtight as possible, which also serves to reduce both the energy cost and the environmental footprint of the farm.

Overall, a proactive and integrated approach that combines efficient ventilation, stringent hygiene practices, and continuous monitoring is essential to maintaining healthy IAQ in chicken farms, ensuring the well-being of both humans and animals, as well as the productivity of the farm, while also contributing to environmental sustainability.

References

1. Ahaduzzaman M, Milan L, Morton CL, Gerber PF, Walkden-Brown SW. Characterization of poultry house dust using chemometrics and scanning electron microscopy imaging. Poultry Science. 2021;100:101188.

2. Cambra-López M, Winkel A, Mosquera J, Ogink NWM, Aarnink AJA. Comparison between light scattering and gravimetric samplers

for PM10 mass concentration in poultry and pig houses. Atmospheric Environment. 2015;111:20–27.

3. Li Q-F, Wang-Li L, Liu Z, Jayanty RKM, Shah SB, Bloomfield P. Major ionic compositions of fine particulate matter in an animal feeding operation facility and its vicinity. Journal of the Air & Waste Management Association. 2014;64:1279–1287.

4. Wei J, Zhou J, Cheng K, et al. Assessing the risk of downwind spread of avian influenza virus via airborne particles from an urban wholesale poultry market. Building and Environment. 2018;127:120–126.

5. Viegas S, Faísca VM, Dias H, Clérigo A, Carolino E, Viegas C. Occupational Exposure to Poultry Dust and Effects on the Respiratory System in Workers. Journal of Toxicology and Environmental Health, Part A. 2013;76:230–239.

6. US EPA O. Particulate Matter (PM) Basics. April 19, 2016. https://www.epa.gov/pm-pollution/particulate-matter-pm-basics. Accessed August 28, 2023.

7. Gržinić G, Piotrowicz-Cieślak A, Klimkowicz-Pawlas A, et al. Intensive poultry farming: A review of the impact on the environment and human health. Science of The Total Environment. 2023;858:160014.

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