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EU–Mercosur Agreement: Opportunities and Threats for the Turkey Meat Market

Felipe Bugueño
Hybrid Turkeys

Abstract

After more than two decades of negotiations, the EU and Mercosur reached a political breakthrough in December 2024 and, in 2025, the European Commission transmitted the legal texts for signature and conclusion—though by the end of 2025, full ratification remains pending. The agreement would phase-in tariff reductions and establish quotas for sensitive agri-foods while reaffirming EU sanitary, animal welfare and sustainability rules. For turkey meat, competitive dynamics will hinge on how poultry quotas are allocated and enforced, how SPS compliance is managed, and how emergent regulations (notably the EU Deforestation Regulation) interact with the agreement's "rebalancing" and safeguard clauses. This paper assesses market opportunities (new channels for genetics, technology, diversification and; supply-chain resilience, including raw materials) and threats (price pressure from lower-cost producers, compliance costs, animal health shocks), and proposes mitigation strategies for integrators, processors, and breeders on both sides of the Atlantic.

1. Introduction: Status of the agreement and its importance

Negotiations began in 1999 and led to a political agreement in 2019, with a renewal of the language on sustainability agreed in December 2024. In September 2025, the Commission presented the legal texts (*EU-Mercosur Association Agreement* and an interim trade agreement) for adoption, paving the way for signature, approval by the European Parliament, and national ratifications. Although interest in reaching an agreement intensified at the end of 2025, the reality is that ratification could now be delayed until 2026.

In the case of agri-food products, the texts combine tariff elimination schedules with tariff rate quotas (TRQs) for the most sensitive products/industries (e.g., beef and poultry) and incorporate sanitary, phytosanitary, and sustainability disciplines that keep EU standards intact.

2. The Baseline: Poultry and Turkey Market Context in the EU and Mercosur

EU market. Poultry is ~14 million tonnes in the EU, with broilers dominating; turkeys typically account for ~12% (1.700.000 tonnes) of poultry output and have faced pressure from AI outbreaks and cost volatility. 2024–2025 data show production recovery and resilient trade, but disease events continue to disrupt segments.

Mercosur profile. Brazil is a structural poultry export powerhouse; its turkey segment is smaller and volatile, with 2024 turkey exports down ~8% YoY to ~64k tonnes, reflecting market and health-system disruptions but with optimism for renewed flows to Europe and the Middle East. More broadly, Mercosur's external trade remains commodity-heavy, with Brazil the dominant player.

Sanitary and Phytosanitary: EU audits report significant improvements in Brazil's poultry public-health controls compared to the post-2017 period, relevant to any incremental access under TRQs. Nonetheless, market access depends on compliance with stringent EU import conditions.

3. What the Agreement Says for Poultry — and What It Implies for Turkey

Although the agreement's headline TRQs publicly emphasized beef and poultry, the Commission's schedules point to a poultry TRQ of 180,000 t (CWE) duty-free phased in over five years, split between bone-in and boneless/preparations. Turkey products (HS 0207 24–27) are part of the poultry chapter in customs nomenclature; in practice, the commercial impact on turkey will depend on how import licenses are allocated among HS subheadings, how importers arbitrage relative prices, and how swiftly exporters certify to EU SPS.

Two design features shape outcomes:

- **Standards do not soften.** The agreement does not lower EU SPS/food-safety thresholds nor animal-welfare conditions; EU retains precautionary powers, audits, and border checks under Reg. 853/2004 and associated guidance (guidance on hygiene requirements for food of animal origin). 71516
- **Quota management and safeguards.** The EU has tightened poultry quota management rules (post-Ukraine ATMs) and preserves bilateral safeguard clauses to respond if imports harm or threaten harm. These tools influence how fast poultry inflows materialize into sub-markets like turkey. 1714

Although chicken cuts initially absorb most of the tariff quota value, conditions for turkey meat may arise through mixed shipments, processing uses, and seasonal demand, if exporters comply with certification, residue control, and animal welfare equivalence requirements.

4. Opportunities

4.1 Market Access & Portfolio Plays

Tariff-free access within the poultry tariff quota improves the landed cost position of Mercosur products relative to MFN tariffs, enabling portfolio strategies: chicken cuts as volume anchors and turkey as margin enhancers for seasonal or specialized EU channels (e.g., delicatessen, ready-to-eat products). EU processors, in turn, can diversify sourcing and hedge against AI or feed cost crises.

4.2 Technology, genetics and services

The deal promises broader two-way trade in equipment, genetics, vaccines, and services under reduced industrial tariffs and simpler customs—benefiting EU suppliers into Mercosur's integrated poultry chains and supporting productivity upgrades (FCR, welfare, processing yields) in the region.

4.3 Compliance as a differentiator

Improved controls and acceptance of digital certification of origin in Brazil increase the predictability of regulatory compliance, opening the door to premium, fully compliant turkey offerings that meet EU buyer requirements (e.g., responsible antibiotic use, certified welfare).

5. Threats and frictions

5.1 Price pressure and resilience of EU producers

Cheaper imports under tariff rate quotas may put pressure on EU prices in certain segments. Industry bodies point to differences in competitiveness due to varying input costs and regulatory bases; models suggest small average declines in EU poultry production (≤1.5%), but with pressure concentrated in sensitive regions.

5.2 Regulatory complexity

All poultry must comply with EU sanitary and phytosanitary standards (health marks, authorized establishments, veterinary certification, residue plans). At the same time, the EU Deforestation Regulation (EUDR), which is scheduled to be phased in from December 30, 2025, raises traceability expectations for covered commodities (not poultry itself), but may indirectly affect feed supply chains (e.g., soybeans).

5.3 Animal health shocks and market access

Avian influenza and third-country restrictions can suddenly disrupt trade and affect turkey plants more severely than broiler plants due to their smaller geographical coverage. Acceptance of regionalization and vigilant biosecurity remain essential.

6. Strategic implications for the turkey meat value chain

For EU producers and processors

- Differentiate on welfare, sustainability (deforestation-free feed sourcing), and provenance storytelling; lock in retail programs that valorize EU standards.
- Use safeguards: monitor quota fill-rates and price signals; coordinate with associations to activate clause(s) if injury risks emerge.
- Resilience planning: dual-sourcing for raw materials; invest biosecurity and compartmentalization.

For Mercosur exporters (turkey and mixed poultry)

- SPS-first market entry: prioritize listing/approvals, residue monitoring plans, digital origin documentation, and third-party certifications valued by EU buyers.
- Product mix: target boneless/prepared lines aligned with TRQ sub-windows and EU deli/foodservice formats where turkey carries a premium.
- Feed & ESG (Environmental, Social, Governance): prepare EUDR-ready soy traceability to de-risk reputational and policy exposure with EU customers.

For integrators and other suppliers (both sides)

- Services and tech linked to welfare, precision nutrition, and carcass quality will see increased tradability under the agreement's industrial tariff cuts and procurement access. Co innovation programs (health, AMR stewardship) can open doors in government and retail tenders.

7. Conclusions

When it enters into force, the agreement between the EU and Mercosur will reshape poultry trade conditions through quota-based access, without changing EU sanitary and phytosanitary standards. In the case of turkey meat, there is room for improvement, but this will not happen automatically: it will depend on quota allocation, sanitary and phytosanitary readiness, disease stability, and alignment with evolving sustainability frameworks, particularly the EUDR. Stakeholders who invest early in compliance, differentiation, and risk management will be able to capture the agreement's benefits while buffering its shocks.

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From droppings to data: Urofecal Glucocorticoid Metabolites as an Indicator of Stress in Turkeys

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Background:

In poultry production, stress assessment is frequently based on blood-derived corticosterone measurements. However, blood sampling is invasive, requires restraint and handling, and can itself activate the hypothalamic–pituitary–adrenal (HPA) axis, thereby confounding interpretation. Non-invasive monitoring of glucocorticoid metabolites in avian droppings offers an attractive alternative, enabling repeated sampling without additional stress for the animals. In broiler chickens, Wolf et al. (2024) validated urofecal glucocorticoid metabolites (ufGCM) as a practical welfare-related biomarker: ufGCM concentrations showed no significant diurnal pattern under the tested conditions and remained largely stable for several hours after defecation—specifically, within the first 4 hours the variation was minimal (~±5%), while later time points showed marked increases (e.g., after 8 hours). This provides an operational sampling window for field conditions and reduces the need for strict timing of collections.

Objective:

The present work aimed to transfer this non-invasive ufGCM approach from broilers to turkeys and to explore whether ufGCM profiles reflect potentially stressful events, phases or management procedures at the hatchery and during on-farm rearing.

Animals, Materials and Methods:

Two different flocks of male turkeys (BUT6), hatched at two different hatcheries, were reared at two separate sites under conventional housing conditions. Fecal samples were collected according to the same sampling scheme starting at day 0 in the hatchery till the age of 5 weeks.

On day 0 (morning), immediately before take-off from the hatch trays (all poults hatched and dried), meconium samples were taken by gently pressing the poults vents. Sampled poults were color-marked to avoid repeated sampling.

Remaining poults were assigned to three groups: Group A (standard processing: sexing, beak treatment, injection of non-steroidal anti-inflammatory drug*), Group B (sexing only; injection depending on hatchery), and Group C (untreated control: no sexing, no beak-treatment, no injection; placed directly into transport cartons and moved to the chick holding room at 27 °C and 55 % relative humidity). Groups A and B underwent the procedures described above and were subsequently held in the same chick holding room for approximately 5 hours. After this short holding period, all three groups were re-sampled (pooled meconium samples).

**According to a decree from the Ministry of Agriculture of Lower Saxony from November 23rd, 2021, a non-steroidal anti-inflammatory drug has to be administered in conjunction with or right after infrared beak treatment (IRBT) at day one in poults hatched at hatcheries in Lower Saxony.*

Injection procedures differed slightly between the two hatcheries: At hatchery 2, poults in Group A received two injections containing Ketoprofen and a vaccine, whereas poults in Group B (no beak-treatment) received the vaccine only. At hatchery 1, only Group A received an injection (Ketoprofen only; no vaccine).

Poults hatched at hatchery 1 were then loaded and shipped to the rearing farm using a climate-controlled truck. The journey took approx. 5 hours. Poults were then placed into two identically structured compartments (100 birds per compartment). First sampling started approx. 5 hours after placement.

Poults hatched at hatchery 2 were transported in a climate-controlled truck on the morning of the next day. Loading and transport took approximately 30 minutes. Poults were then placed into two identically structured compartments (81 birds per compartment). First sampling started approx. 4 hours after placement.

The no treatment control groups of both hatches remained at the hatchery and were not sampled further.

During poult rearing on both farms, sampling of droppings was conducted daily at midday for the first 14 days, followed by weekly sampling thereafter until day 35. For fecal sample collection, designated "fecal boxes" were used similar as described by Wolf et al. (2024). On day 1, on farm 2 droppings were still obtained by gentle expression; on farm 1 by scraping freshly voided droppings from pan liner covering the fecal boxes. From day 2 onwards, freshly voided droppings from at least 5 poults were transferred with a spoon into urine cups or blood tubes and immediately frozen. All samples were stored at −20°C until further processing. Relevant on-farm management procedures were performed 3 – 5 hours prior to sampling.

Frozen samples were shipped to the Department of Behavioural Biology, Osnabrück University, Germany for further processing. Urofecal glucocorticoid metabolite (ufGCM) concentrations were determined using an enzyme immunoassay as previously established and validated for chicken droppings (Rettenbacher et al. 2004; Wolf et al. 2024).

Results

Starting with high but variable concentrations of ufGCM in all groups right after hatching, values of both treatment groups A and B declined significantly, continuously and coherently for two days after hatching, reaching baseline values at approx. day 3-4 (Figure 1). In addition to the individual data points across the rearing period from both hatcheries/farms, Figure 1 also displays ufGCM concentrations of group A and B as mean from both flocks (hatchery 1 and hatchery 2) with line of best fit.

Both flocks showed a comparable pattern with similar values, with flock 2 exhibiting slightly higher ufGCM concentrations across the study period. Across the rearing period, ufGCM concentrations remained relatively stable at baseline levels. UfGCM concentrations did not increase during the beak-tip-sloughing-off period (days 7–14). On-farm management procedures, such as individual weighing, plumage and footpad score assessments, blood sampling or vaccination by injection did not lead to an obvious or lasting increase in ufGCM concentrations.

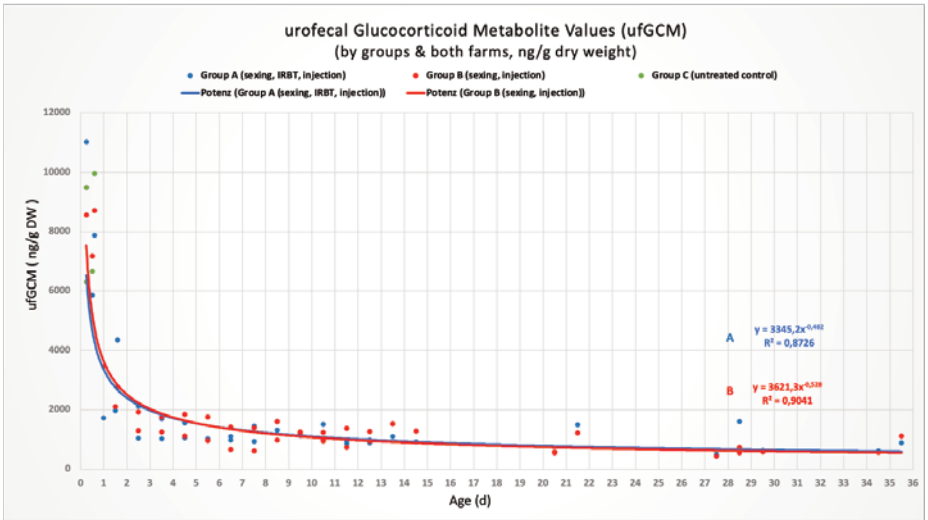

Figure 1: *Urofecal glucocorticoid metabolite (ufGCM) concentrations (ng/g dry weight, DW) over time. Day 0 samples were collected in the hatchery; from day 1 onwards, samples were collected on the farm.*

Discussion/Conclusion

The measurement of ufGCM in droppings shows potential for the repeated, non-invasive monitoring of HPA axis stress hormones in turkeys. The observed pattern of high ufGCM values right after hatching followed by a significant and constant decline to baseline levels within a few days is comparable to patterns observed for broiler chickens (Vossler et al., in preparation). No consistent differences were observed between treatment groups A and B, indicating no elevated nor long-lasting increased stress levels in beak-treated turkey poults. Interestingly, turkey baseline ufGCM values were generally higher than published concentrations for broiler chickens reported by Wolf et al. (2024). The observed pattern of higher and more variable values in the hatchery compared to the on-farm values highlights hatching and the first days of life as a key phase for further targeted investigations. Since the present study was planned as a first benchmark project, possible impact factors, explanations and conclusions remain open to more detailed follow-up studies. The absence of marked differences in ufGCM concentrations despite the differential treatment (Group A, B and C) during and after hatchery-related processing steps indicates that the hatching per se and immediate post-hatching conditions may represent a stronger physiological stress load than the subsequent routine processing steps, such as vaccination and beak treatment. Moreover, events such as beak-tip sloughing represent management-related challenges that are usually regarded as stressful for turkeys. However, under the conditions of the present study, possible endocrine responses of beak-treated birds of group A compared to non-beak-treated birds of group B (sexed only) appeared to be small, short-lived, or not detectable with the applied sampling design. Method validation data, which were also part of the project, showing significantly elevated ufGCM levels in droppings of injured birds, indicative for stress and pain, will be published elsewhere.

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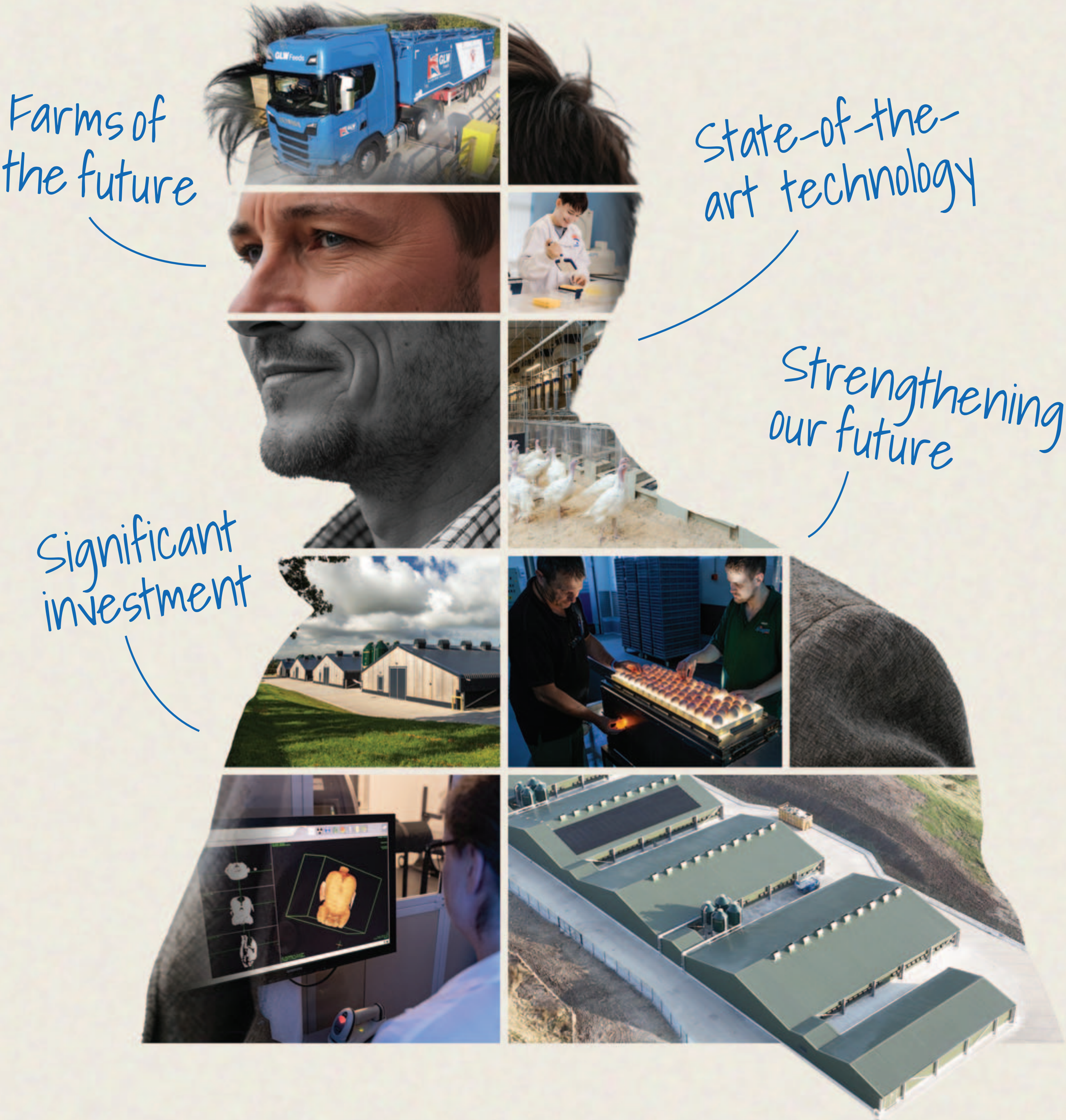
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The Turkey Market.
Where we are at the moment: February 2026

Clay Burrows
Managing Director, Aviagen Turkeys Ltd

Current Price Environment

US turkey breast meat prices have peaked twice in the last four years at record highs not seen in the past 15 years. Prices are currently at an all-time high, exceeding €14/kg for breast meat. Dark meat has followed a similar trend, with thigh meat now exceeding €6/kg, also at record levels.

As always, supply and demand dynamics are driving these elevated prices. However, the current market situation is the result of several structural and disease-related factors, rather than short-term volatility.

Structural Changes in the US Turkey Industry

Historically, the US turkey industry has operated in a classic boom-and-bust cycle. When prices increased, producers placed more poults, leading to oversupply and subsequent price crashes.

Over the past six years, however, further industry consolidation has changed this behaviour. Producers have deliberately maintained more disciplined poult placement levels, aiming to move turkey away from its historical position as a cheap, low-cost commodity.

This strategy has coincided with:

- Repeated Avian Influenza (AI) outbreaks. Losses of turkeys and other poultry.
- The emergence of metapneumovirus (aMPV) virus over the past two years, which has significantly reduced the availability of commercial eggs for setting, until recently when the vaccine was finally made available.

Together, these factors have resulted in a persistent shortage of turkey meat, compounded by shortages across other poultry proteins.

European Union Market Overview

Turkey prices across the EU have followed the same upward trend:

- **Poland:** Breast meat prices have recently averaged €7.50/kg, over 70% higher than early 2024. Thigh meat peaked at €4/kg.
- **Germany:** Breast meat prices have exceeded €8/kg, approximately 25% higher than the lowest price recorded in the last five years (December 2023).
- **Italy:** Breast meat prices are also above €8/kg, effectively doubling over the past 15 years.

Avian Influenza: Ongoing Market Disruption

Avian Influenza has had a profound impact on global turkey and poultry supply over the last five years and remains a major ongoing threat.

- More than 6,000 commercial poultry units have been reported with AI globally in the last five years.
- In the Northern Hemisphere:
    - December 2022: Over 350 positive cases in a single month.
    - November 2023: Peaked at approximately 180 cases.
    - 2025: Total cases [data not yet confirmed/unavailable].

AI has reduced production through:

- Mandatory culling of infected flocks.
- Loss of breeding stock and commercial eggs.
- Temporary placement bans in high-risk regions. (Examples Italy and Germany).

Poult Placements and Production Capacity

Estimated annual poult placements since 2017 show a slight but consistent downward trend.

The reasons include:

- Loss of breeder flocks due to AI.
- Regional placement restrictions to proactively reduce disease spread (e.g. Italy in 2022).
- A growing shortage of suitable poultry farming facilities.

Country Examples:

- **Germany**
    - Around 7% of production is now placed at up to 20% lower stocking densities
    - Marketed as "Tier 3" production
    - While welfare standards improve, total bird numbers processed still required as the same as before the downstocking. Leading to a shortage of birds.
- **France**
    - Estimated requirement of 40 new poultry farms per year for the next five years.
    - Shortages driven by underinvestment, farmer retirements, and AI-related farm closures.
- **United Kingdom**
    - The broiler industry reduced stocking densities by 20% across 85% of production during 2025.
    - Density reduced from 38kg/m^2 to 30kg/m^2
    - This has created a requirement for an additional 1.2 million m^2 of poultry housing to maintain volumes.
    - The UK is now importing more chicken from the EU, due to the shortage of broilers in the UK.,
    - All Poultry housing is now at a £ premium.

Regional Growth Markets

Despite overall declines, some regions continue to expand:

- **Spain** – stable to increasing placements.
- **Russia** – consistent year-on-year growth and a continuing increase in consumption.
- **North Africa (Morocco, Algeria, Tunisia)** – strong growth in placements and consumption.
- **Poland** – continued expansion and investment.

Processing Trends and Bird Weights

Although poult placements have declined, average live weights have increased, helping to offset some of the volume losses.

- Processed turkey meat volumes in the EU and US have remained largely flat.
- Declines have generally occurred only when bird availability was severely restricted.
- Larger birds are increasingly demanded to meet market needs.
- In the US, live male turkeys are now typically processed at over 22kg, on a routine weekly basis.

Turkey vs Other Proteins

Over the past six years, the price gap between chicken and turkey has widened.

- Chicken production has increased by 1–2% annually, driven by:
  - Lower feed cost per kg of meat produced
  - Superior production efficiency
- Turkey production costs at farm-gate level are roughly double those of broilers
- Turkey processing costs are lower than broilers, narrowing the gap slightly post-farm
- Compared to pork:
  - Turkey has slightly higher farm-gate costs
  - Becomes more competitive after processing

Consumption Trends

Reliable turkey consumption data remains limited. However, comparisons between 2020 data and estimated 2025 figures suggest:

- Declining consumption in established markets:
  - UK, France, United States and Germany as examples.
- Increasing consumption in:
  - Spain, Russia and North Africa.

Contributing factors to declining consumption include:

- Limited supermarket shelf space allocated to turkey.
- Minimal representation of turkey products in food service.

A UK survey conducted in 2018 by Aviagen Turkeys using MCA Research illustrates this clearly: 150 sampled UK restaurant menus:

- Over 1,000 beef dishes.
- Just under 1,000 chicken dishes.
- Only 6 turkey dishes.

Summary and Outlook

Summary:

- The turkey and wider poultry protein market remains in structural deficit, with freezer stocks extremely low.
- Avian Influenza continues to disrupt production across multiple regions.
- Processing volumes have declined slightly, primarily due to bird shortages, despite increased bird weights.
- A lack of modern farming infrastructure is a long-term constraint requiring significant capital investment.
- Consumption is gradually declining in mature markets but growing in emerging regions such as Russia, North Africa, and parts of Southern Europe.
- Innovation and marketing of further-processed turkey products are supporting growth in these regions.

Outlook:

- Demand for turkey and poultry meat will continue in the coming years, I believe. High price levels are likely to persist for the foreseeable future, driven by structural supply limitations, disease risk, and insufficient production.

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Critical control points of turkey embryos during the exothermic phase

Simona Gheorghitoiu, DVM
Petersime, Belgium

The exothermic phase in turkey embryo development begins around mid-incubation, day 10-11, and continues until hatch. This presentation will emphasize the critical control points of turkey embryo development from day 10-11 until day 24-25, when it is considered, the hatch starts.

Whereas during the endothermic phase the egg needs external heat to maintain temperature, in the exothermic phase the embryo's metabolic heat increases rapidly and it needs to be cooled off by the environment. The transition between the two phases is a critical stage.

A turkey embryo is not fully formed by day 11 of incubation, but it has developed many key features, and major organs have begun to form. By day 11, the embryo is entering a phase of rapid growth but is not yet a miniature version of a hatched poult.

Developmental milestones by day 11:

- The embryo is becoming more bird-like in appearance
- The allantois (which handles respiration and waste) reaches its maximum size and the yolk sack begins to shrink
- Legs have developed scales and the toes are beginning to curl
- Tail feathers are starting to become apparent
- The main blood vessel, the aorta, is visible along the neck
- The intestine begins to push into the yolk sack in preparation for the eventual absorption of the yolk

The remainder of the incubation period is primary for the growth and maturation of these organs, in addition to position itself for hatching. The embryo enters a period of significant growth and starts to produce its own metabolic heat, requiring careful temperature management of the incubator.

The primary consideration – the most important critical control point - for the exothermic phase of turkey embryo development is the substantial amount of metabolic heat generated by the growing embryo. The embryo's temperature, not the incubator's temperature, is the critical factor for healthy development: the embryo's body heat is higher than the surrounding air, so a device like an infrared thermometer is used to read and control, in standard practice, for accurate management of the eggshell temperature.

The risk of running the eggshell temperature on too high or too low temperature set points is to disturb the metabolic balance between catabolic and anabolic activity.

Too low set points will slow down the metabolism, will reduce the rate of growth of the CAM membrane, gas exchanges with the environment will slow down, the absorption of the albumen – a reservoir of proteins and water- will be delayed. Consequently, the embryos will be delayed in hatch or might not make it at all.

Too high set points of the eggshell temperature will tilt the balance in the favor of catabolic activity: burning more of the glycogen in the muscles without the time to rest, to take from the yolk sack the fuel needed to rebuild the energy reserves. As a result, the development will be advanced, but the body of the embryos will be smaller, the moisture loss will be advanced, they will be exhausted metabolically. We will send tired embryos to perform the labor of hatch, and some will fail.

However, we chose our eggshell temperature set points, depending on the hybrid, age of the flocks, SPIDES or no SPIDES treatment, we have to make sure, just as in the endothermic phase, that the readings of the infra-red sensor are, as much as possible, steady on set point. A steady eggshell temperature graph is the proof of a balanced incubator, and that is what the embryos need also in the exothermic phase. Deviations of max +/-+0.2 F are acceptable, just like the exothermic phase, and depend on the generation of machine.

The second most important critical aspect that we must make sure we drive the embryos towards, is the weight loss of minimum 11-12% at transfer, in day 24-25.
Achieving the proper weight loss makes the difference between hatching the number of 1st quality poults specified by the technical specification of the hybrid or anything less than that.

Why is weight loss so important?

- 11-12% weight loss automatically means that the size of the air cell is the proper one, meaning 1/3 of the longitudinal diameter of the egg. Having this achieved, it will be very easy for the embryos to internally pip when the times comes to transition from chorioallantois respiration to lung respiration. When %WL is below 11%, a layer of fluid and residual albumen between the embryo and the air cell membrane will make it more difficult for the embryos to get into the air cell. Some of them will not make it and drown.

- The volume of the yolk sack will be reduced to a proper size, and it will be easier to retract it into the abdomen. The umbilicus muscle will have an easier task working with a lighter weight of the yolk sack. There will be less chances of delays in the retraction of the yolk sack and less % of second quality and culls.

- The embryos body will be the proper one, not too heavy, which will ensure they will be proper “athletes” to run the “marathon of hatch”. A heavy embryo will perform all the tasks of the hatch with delays, the dynamic of its hatch will not match the steps of the hatch program, and it can end up hatching in the wrong step, having high chances of hatching into a second quality or cull. This aspect of hatching in the proper step is very important for turkey embryos but will be detailed on another edition of TSPC.

Of course, how easy it is to get the weight loss depends on the hybrid, age of the flock, SPIDES or no SPIDES, the environment the hatchery is located. From these perspectives, it is totally insufficient to have just one incubation program to comfort all the categories of eggs.

What tools do we have at our disposal to drive our turkey eggs to the proper weight loss?

Finding the right ventilation program is the main tool to use. The first days of the transition phase we have to open ventilation on low rates and gradually, continuing with the mid days of development when ventilation rates are increasing towards the transfer day.

Ideally, an air cell that takes up one third of the longitudinal diameter of the egg must be achieved in day 24: 12 hours.

Fine tuning the ventilation program is also beneficial for the proper development of the chorioallantois membrane, that serves as breathing apparatus until the embryo internally pips. Directly, if the weight loss is too low, CAM does not stretch fully.

The development of the CAM starts in day 5-6, merging from the allantois and chorion. From that moment onward, it will gradually expand under the shell, covering more until completion, the inner surface of the shell.

The CAM is responsible for:

- Gas exchange (Oxygen in / CO_2 out)
- Calcium absorption from the eggshell
- Waste handling
- Blood vessel development that supports embryo growth

If the CAM does not fully expand and fuse to the inner membrane of the shell membrane, the embryo loses critical surface area for respiration and mineral transfer.

Small or poorly developed CAM will result in:

- Poor oxygen supply, this leads to slow growth, weakness or late embryonic mortality. For turkeys is it even more critical, as they have high metabolic heat and oxygen demands. It is one of the causes of higher late mortality in turkey embryos.
- Reduce calcium mobilization: bones remain softer, leg deformities may increase, the embryo may not be able to pip properly
- Pore waste exchange: increase of metabolic stress due to accumulation of metabolic waste
- Lower hatchability and weaker poults cause by late dead, high % pore quality poults

Just like in the endothermic phase, turning remains highly beneficial during the exothermic phase, for several reasons that go far beyond just the early albumen mixing function.

In the exothermic phase, heat production increases very fast and this changes embryo's needs. Turning still plays several important roles during this period.

- Turning improves heat distribution and prevents hot spots: the embryos generate heat unevenly and turning redistributes heat, keeping the internal temperature more uniform.
- Turning maintains proper CAM function: even once the CAM is fully developed, turning still matters as it helps CAM thicken, vascularize and keeps it in gentle rhythmic tension. Blood flow and gas exchange will be improved which will help the embryo better manage its metabolic heat.
- Turning prevents the embryo from adhering to membranes late: sticking doesn't happen only early in the development but can also occur in late development. The embryo grows rapidly, fluids move, compressed areas become sticky, membranes shift as albumen decreases.

Without turning, the embryo may adhere to the inner shell membrane, the amniotic sac or even the CAM itself. All these will lead to malposition, pore air cell development, increase late mortalities.

- Turning improves yolk utilization: during the exothermic phase, rapid growth requires massive nutrient flow. Turning will help maintain the yolk's central position, it prevents the yolk from flattening on one side, supports better absorption.

By the time a turkey embryo is 24days:12 hours, it looks like a fully developed poult.

Optimizing the eggshell temperature program, the ventilation program and the turning are essential for every embryo the conditions it needs to reach its full genetic potential. Consistency in these basics is what separates average results from excellence hatchery performance.


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Looking back, feeding forward: The future of turkey nutrition

Alex Wealleans
Premier Nutrition, UK

Where we've come from

Despite rumours and names to the contrary, the bird known as the turkey is neither from Türkiye nor Northern America. Though a similar bird was also domesticated in the Southwest of the United States – the only case of Native American domestication north of Mexico (Lipe et al., 2016) – the forerunner of the modern turkey was domesticated in Mesoamerica, by the ancestors of the Aztecs.

There are seven subspecies of wild turkey, distinguished by differences in geographic range and plumage. Of these, the Mexican wild turkey (*Melagris gallopavo*) was the first ancestor of the turkeys brought to Europe. The birds were likely raised for their feathers as well as their meat and were widely used in sacrificial practices across the region. They were approximately half the size of their wild relatives, but domestication had encouraged a wider variety of colour variants (Schorger, 1966). By 1519, when Cortes and the Spanish arrived, it is estimated that the royal court of Moctezuma II was slaughtering more than one thousand turkeys a day in order to feed both the people of the court and their menagerie of exotic animals (Davis, 2001). Little record exists of what these turkeys would have eaten, though the archaeological record suggests that they were kept in pens and fed grains – largely maize, which formed a substantial part of the Aztecs' own diet – as well as being allowed to selectively free-range.

The first records of turkeys arriving in Europe date from 1511, when the Bishop of Valencia received ten turkeys for breeding (Crawford, 1992). Diffusion through the rest of Europe was rapid, replacing consumption of wild birds like swan, heron and pheasant. Cortes was gifted 1500 live turkeys by Moctezuma in 1520, and the pace of spread suggests subsequent large shipments of birds must have followed. Turkeys were first recorded in England in 1523-4, with similar dates recorded in Germany (~1530), Italy (1520), France (1538), Czech Republic (1578) and Scandinavia (1550s) (Kyseley and Meduna, 2019). In the 1620s the Pilgrims took turkeys with them across the Atlantic, where they hybridised with the Eastern Wild Turkey (*M. g. silvestris*), becoming larger and taking on their bronze plumage of the wild bird.

By the later sixteenth century references to turkeys are more frequent in agricultural literature across Europe. Many writers refer to turkeys as difficult birds to keep compared to other domestic birds – they suffered from a high mortality rate, had to be kept separate from other poultry, and required large amounts of feed to grow (Maltin and Jakobsson, 2023). In this timeframe, concern was growing about possible transmission of disease and ill-humour from animals to humans. Domestic poultry was therefore fed "*good corne, such as men themselves eate*", and physicians also advised on the benefits of free-range husbandry: such birds offered "*better nourishment then such as be cram'd in a coop or little house: for as prisoners*" (Moffett, 1620).

This method of feeding endured for more than two hundred years, until the early development of compound feeds in the 1840-1860s. The use of oilseed cake for livestock rations doubled in England between 1854 and 1915 (Poornan and Godley, 2025), as farmers rapidly saw the benefits of balanced rations and the addition of protein meals to animal diets. Diets at this time would have been complex, created to a fixed formulation of ingredients rather than nutrients (which were still not well understood), and fed alongside the traditional single grains and free-ranging. These early compound feeds were "*made for the purpose of feeding rapidly, composed of linseed, wheat, maize, peas, beans and locust beans in proper proportions ... a small quantity of spices ... a tonic ... so that users could at all times rely upon the proportions being the same*" (Poornan and Godley, 2025).

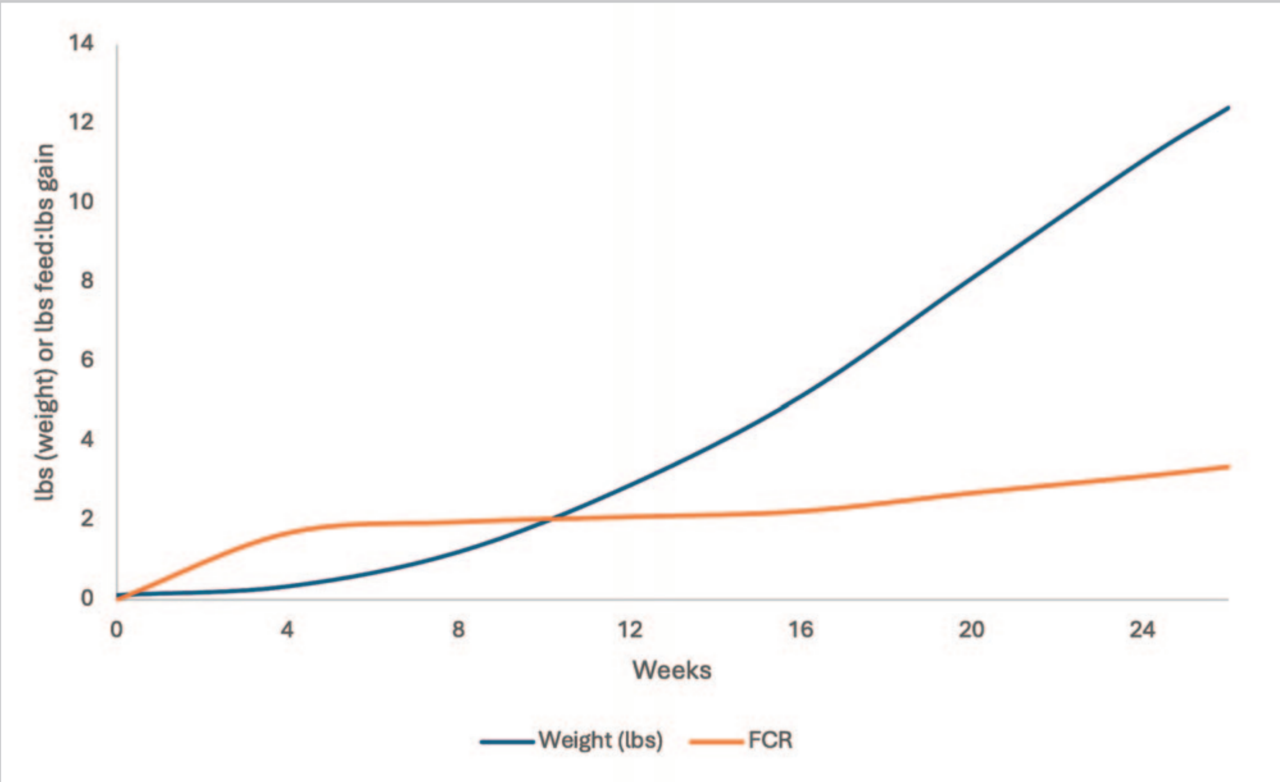
While feeding experiments and first compound feeds feed focused on cattle and pigs, there is little doubt that similar compound, or "condimental" feeds, would have also been given to the farmers' poultry. In the 1920s Brooks (1927) reported the following purely cereal-based turkey formulation:

- 6 lbs cracked yellow corn
- 4 lbs cracked wheat

- 2 lbs steel cut oats
- 2 lbs wheat bran
- 2 lbs wheat middlings

Assuming book nutrient values, this indicates a diet with 10.58% crude protein, 5% crude fibre, 11.52 MJ/kg AME and 0.29% dLys. Amino acid ratios were, of course, unbalanced and minerals including calcium, sodium and chloride are present in trace amounts. Brooks goes on to say that buttermilk, ground bone and oyster shell were all available *ad libitum*, and young chicks were supplemented with boiled eggs, bread and "scratch grain". Birds fed this diet reached a liveweight of 5.64 kg in 26 weeks with an FCR of 3.35, as shown in Figure 1. By contrast, the latest BUT6 performance objectives (Aviagen, 2025) would expect a modern stag to reach this weight in less than nine weeks and hens in less than 10 weeks; both would expect an FCR below 2.0.

Figure 1. *Growth and FCR rates of turkeys fed grain-based diets* (Brooks, 1927)



From here, the development of feed formulations into those we recognise today was consistent and rapid. Comparison of reported experimental diets demonstrates this nicely, as shown in Table 1. These diets are pulled from published experimental reports of diets for "young turkeys" and demonstrate clear step changes in raw material use across the years.

Use of animal by-products – including meat scrap, milk powders, and fish meal – falls out of favour by the 1970s, as does the use of high-fibre ingredients including oats and alfalfa. Other ingredients come into favour over time: soybean meal was used in all formulations from 1947 onwards, though initially at a 44% CP. Once 48% CP soybeans were introduced, they were never left out of formulations. Similarly, the introduction of single amino acids in the 1991 diet began with lysine and methionine, expanding in the later diets to include single additions of threonine, valine and arginine. The first paper in this range to report the nutrient levels of the diets was Summers *et al.* (1968).

Table 1. *Raw materials used in experimental turkey diets, 1935-2011*

Ingredient	1935	1947	1958	1961	1968	1971	1988	1991	1994	1997	2008	2011	2021
Maize	33.5	25	49.37	42.95	36.75	42.75	39.56	40.37	44.75	41.97	56.68	44.16	46.84
Meat scrap/liver meal/ meat meal/feather meal	17	0	0	4	2	0	0	0	5	0	6	0	0
Wheat midlings or bran	25	10	0	0	0	0	0	0	0	0	0	0	0
Whey/dried milk powders	12	1	3	2.5	2	0	0	0	0	0	0	0	0
Oats	5	10	0	0	0	0	0	0	0	0	0	0	0
Alfalfa	5	5	5	5	2	0	0	0	2	0	0	0	0
Limestone	2	2	2	3	0.75	1.25	1.42	1.45	1.12	1.2	1.06	2.5	1.3
Salt	0.5	1	0.5	0.3	0.25	0.25	0.3	0.37	0	0.4	0.36	0.35	0.47
Soybean meal, 44%	0	35	22	12.5	0	0	0	0	0	0	0	0	0
Soybean meal, 48%	0	0	0	0	49.5	49.75	52.23	49	42.1	48.66	31	48.75	41.4
Wheat	0	10	10	0	0	0	0	0	0	0	0	0	0
Fish meal	0	0	5	2.5	0	0	0	0	0	0	0	0	0
Fish oil	0	1	0	0	0	0	0	0	0	0	0	0	0
DCP	0	0	3	0	2	3	2.09	3.55	1.62	2.04	1.56	1	3.57
Animal fat	0	0	0	0	1	2	3.71	4.44	2.64	4.82	0	0	0
Premix	0	0	0.2	0.28	0.75	1	0.5	0.5	0.65	0.6	0.45	0.5	1.3
L-Lysine HCl	0	0	0	0	0	0	0.05	0.07	0	0.1	0.29	0.3	0.517
DL-Methionine	0	0	0	0	0	0	0.14	0.28	0.12	0	0.22	0.44	0.42
L-threonine	0	0	0	0	0	0	0	0	0	0	0.08	0	0.116
L-valine	0	0	0	0	0	0	0	0	0	0	0	0	0.155
L-arginine	0	0	0	0	0	0	0	0	0	0	0	0	0.138
Barley	0	0	0	27	0	0	0	0	0	0	0	0	0
Vegetable oil	0	0	0	0	0	0	0	0	0	0	2.3	2	0.7
Corn gluten	0	0	0	0	0	0	0	0	0	0	0	0	3

Where we are today

Looking at the data from a set of commercial turkey diets that are reformulated every month to account for changes in nutrient levels and price can reveal a number of insights about current feed formulation practices. Across a more than two-year period, soybean meal declined from a high of £563.63 per tonne in March 2023 to £298.00 in June 2025. Similar trends have been seen across raw materials, with wheat prices declining by nearly 30% and sunflower by 35% over the same time period.

However, when formulating to defined specifications, the price of the raw materials has little correlation to the amount included in the diet. As shown in Figure 2, the inclusion of soybean meal varies relatively little over time, even with substantial swings in price. This is largely due to other month-to-month changes in QC nutrient levels; as the diets are balanced to amino acid and energy levels, changes in the raw materials will be reflected in the diet composition. This balancing is shown very clearly in Figure 3 - when wheat protein is high or SBM protein is low, the raw materials shift in opposite directions. For example, in April and May 2024 the inclusion of SBM increased by 2.39% compared to March, while the inclusion of wheat dropped by a corresponding 3.25%.

Figure 2. *Correlation (or lack thereof) between SBM price and dietary inclusion in a range of commercial turkey diets*

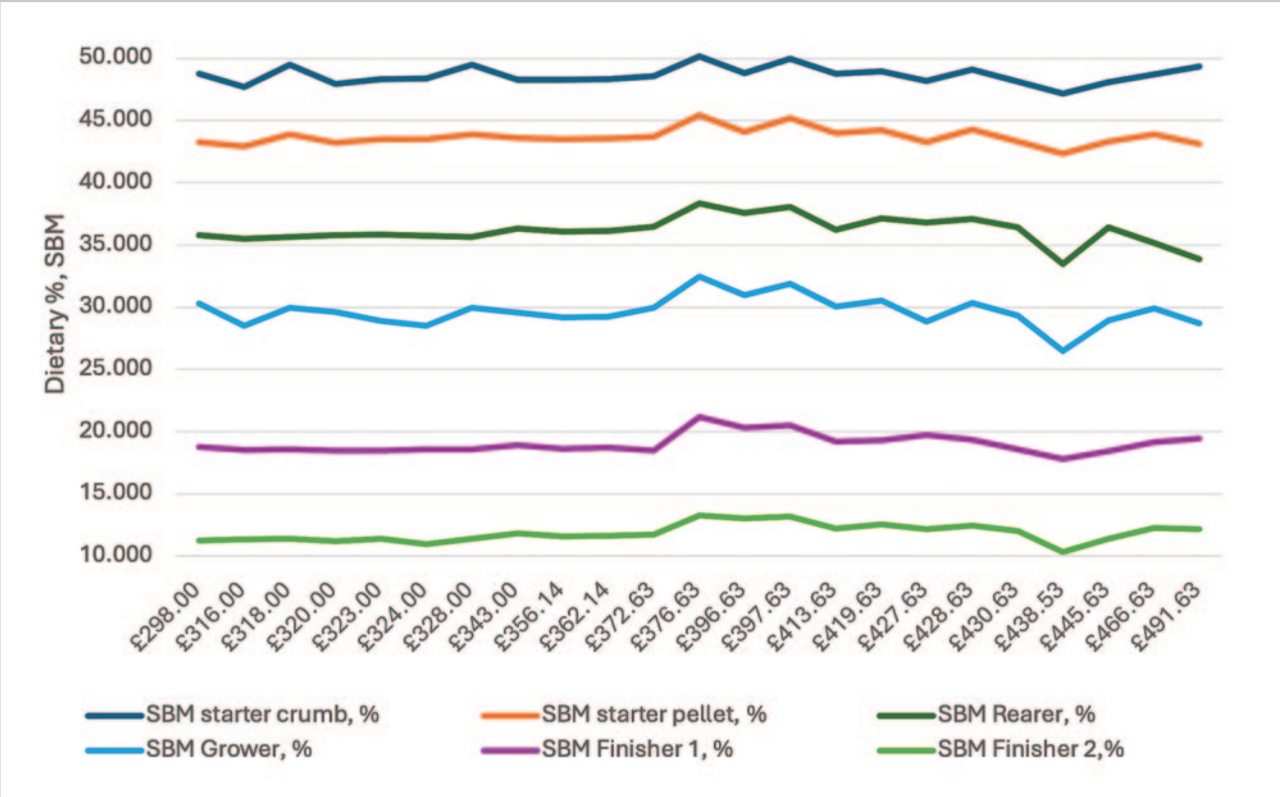
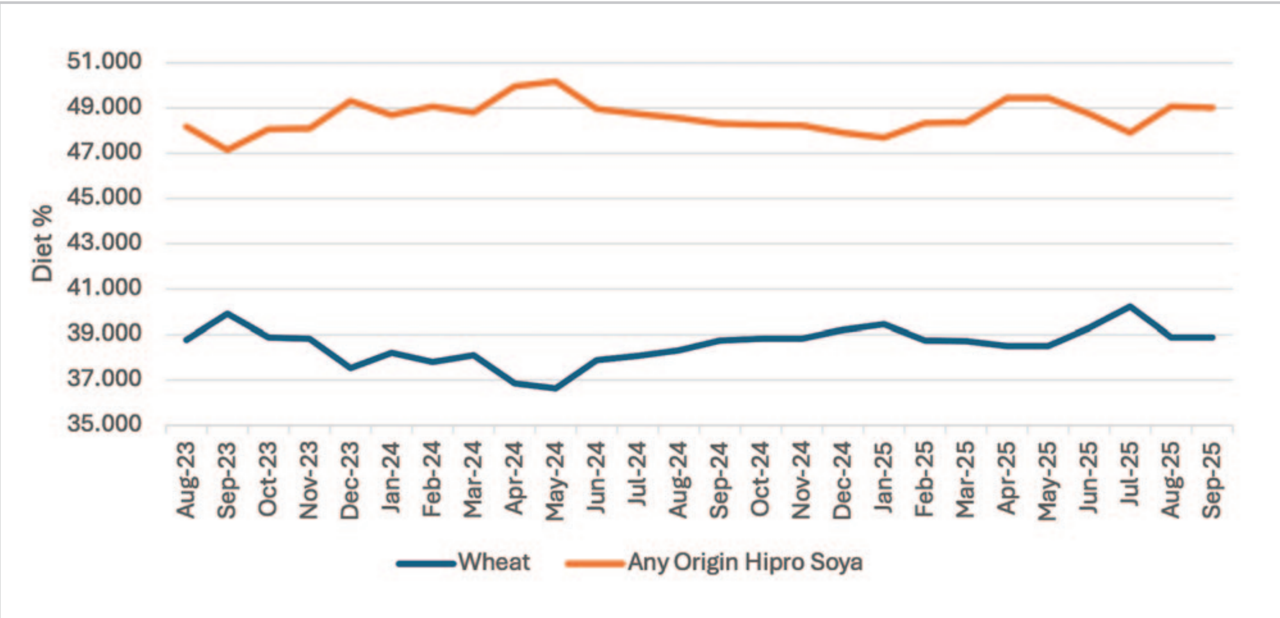


Figure 3. *Inclusion of wheat and soybean in a monthly-reformulated turkey starter diet over time*



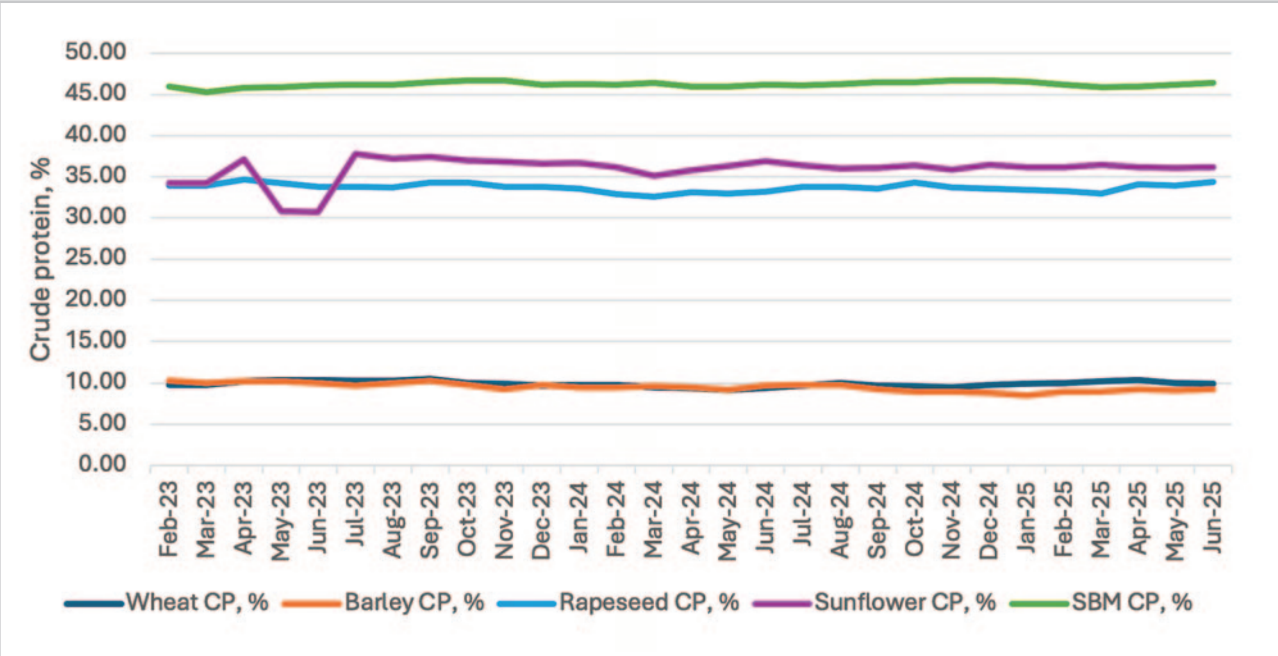
Taken together, the data highlights that modern nutrition, unlike the fixed formulations of the past, relies on raw material nutrient levels rather than costs, and that price influences formulation only as far as it interacts with nutrient supply. This means that nutritionists and mill managers need to pay close attention to raw material QC and frequently reformulate.

Figure 5 reports the crude protein QC data for the raw materials used in those commercial turkey diets. Clearly, raw materials can and do have substantial changes month to month – for example sunflower dropped from 37.10% in April 2023 to 30.80 in May, stayed at a low level until July when they returned to the previous level (37.80%). This likely reflects a change in sourcing or origin of the sunflowers in these months, perhaps due to availability issues with the higher-grade product.

However, many shifts in raw materials look less dramatic on the graph but will regularly swing by 0.5% month to month. Cereals are often relatively consistent throughout a harvest year, and then change as the new crop arrives, but protein meals vary throughout the year. For example, in the first six months of this chart, SBM went from 46.00 in February 2023 to 45.30, 45.80, 45.90, 46.10, and back to 46.20 in July 2023. In the starter ration, for example, this change would have meant a drop in overall crude protein of 0.35% - potentially enough to have an impact on bird performance that would not necessarily be picked up until the birds cleared many weeks later.

Month-to-month variation in raw material protein content also changes the supply of individual amino acids - particularly those for which we are not correcting with the inclusion of single amino acids. As diets become increasingly optimised on cost and sustainability, this places greater emphasis on maintaining ratios relative to lysine for a wider range of amino acids.

Figure 4. *Reported crude protein values for feed raw materials over time*



A similar pattern is evident for dietary energy. Despite large fluctuations in ingredient prices, formulated energy density remains tightly constrained. This masks substantial variation in the source and digestibility of that energy, particularly as fibre fractions and NSP profiles shift with ingredient quality. As a result, maintaining target AME values increasingly depends on ingredient characterisation, enzyme use, and QC, rather than reliance on static table values.

Modern turkey formulation can therefore be viewed as an exercise in constraint stacking: amino acid ratios, energy density, ingredient availability, cost, sustainability targets, and welfare outcomes are all held within increasingly narrow bounds. The apparent stability of finished diets conceals a high degree of internal adjustment, with formulation margins becoming progressively tighter. One consequence of this approach is that subclinical nutritional imbalances may not be immediately visible in traditional performance metrics. Intake regulation, flock uniformity, feathering, gut health, and resilience under challenge may respond to subtle shifts in amino acid balance or energy utilisation long before growth rate or feed conversion are affected. In this context, "where we are today" is characterised by diets that appear remarkably stable on paper yet are underpinned by continuous reformulation and tight nutritional control.

Where we're going

As our review of current formulations reveals, the challenge for turkey nutrition is no longer one of meeting requirements, but of preserving balance and robustness as ingredient quality, price, and sustainability pressures continue to shift. In nutritional terms, a large proportion of recent scientific work in turkeys has focused on the balancing of amino acid ratios in lower protein diets. For well characterized AAs like methionine, work is often focusing on non-growth-related parameters. For example, Mroz *et al.* (2022) reported that increasing methionine levels (from 30 to 45% of lysine) promoted better feather cover in 16-week-old turkeys, while differential arginine levels had no effect. This is slightly higher than current Aviagen recommendations (37-44%) for methionine. Similar work, looking at a high Lys:Met:Arg diet, found that increasing absolute lysine levels (from 1.6 to 1.8%) and Met/Arg ratios (from 90/30% respectively to 110/45%) improved performance, as well as supporting gut integrity under *C. perfringens* challenge (Konieczka *et al.*, 2022).

Branched-chain amino acids (valine, isoleucine, leucine) have also been looked at extensively. Leucine is rarely limiting, especially in diets with high levels of maize or corn co-products and can in fact be regularly over-supplied. At the cellular level, leucine plays a regulatory role in the mTOR signalling pathway, which coordinates protein synthesis and nutrient sensing (Estanich *et al.*, 2024). While leucine stimulation of mTOR is necessary for muscle accretion, excessive leucine in the context of insufficient valine or isoleucine leads to dysregulated signalling. This imbalance contributes to appetite suppression and inefficient protein utilisation, explaining why high-leucine diets seem to reduce growth despite adequate or excessive total amino acid supply (Rehman *et al.*, 2023).

Table 2. *Indicative digestible AA ratios relative to dLysine in turkey diets, as suggested by research papers*

	% of Lys	Sensitivity to imbalance	Risk when imbalanced
M+C	70-75	Moderate	Poor plumage, feather pecking, oxidative stress
Arg	105-110	Context-dependent	Increased variability, poor challenge resilience
Leu	105-115	High (excess)	Intake suppression, antagonism
Val	75-80	High	Reduced intake, poor FCR
Ile	65-70	Moderate-high	Growth suppression under low CP

Across recent turkey studies, optimal performance in reduced-protein and maize-based diets is generally achieved when digestible valine and isoleucine are maintained at approximately 75–80% and 65–70% of digestible lysine, respectively, while digestible leucine is constrained to below ~110–115% of lysine. Exceeding this leucine range consistently increases the risk of BCAA antagonism. This means, in practice, that leucine constraints and levels within the diet should be actively monitored and when leucine exceeds 115% of lysine, valine and isoleucine levels should also be increased, as shown in Table 3. Interestingly, while the latest nutritional recommendations for turkeys specify valine (67-74%) and isoleucine (61-65%) ratios, no guidance is given for leucine – broiler guidance suggests a ratio of 110% of dLysine.

Table 3. *Suggested amino acid ratios to avoid functional deficiency in high-leucine diets*

	Low risk	High- Leu, maize heavy	Corrected high-Leu diet
Lys	100	100	100
Leu	107	120	118
Val	78	75	82
Ile	68	68	72

Another topic that is often addressed in talks and thought-leadership pieces is the reduction in the industry's reliance on soybeans and the use of alternative proteins, and this is also reflected in the scientific literature. Pirgozliev *et al.* (2023) focused on the use of different varieties of field beans (*Vicia faba*) at 20% inclusion levels, looking at performance compared to non-bean diets, and variation in the energy content of beans. Beans had some variation in energy content (7.72 to 9.87 MJ/kg DM AMEn), largely linked to soluble NSP content of the cultivar. As well as fibre content, energy value could be correlated to the colour of the beans: lighter beans were positively correlated with higher observed AMEn values. This is likely due to lower condensed tannin levels in lighter beans, as previously reported in a range of feed pulses (Abdulla *et al.*, 2017; Oomah *et al.*, 2011; Igbasan *et al.*, 1997).

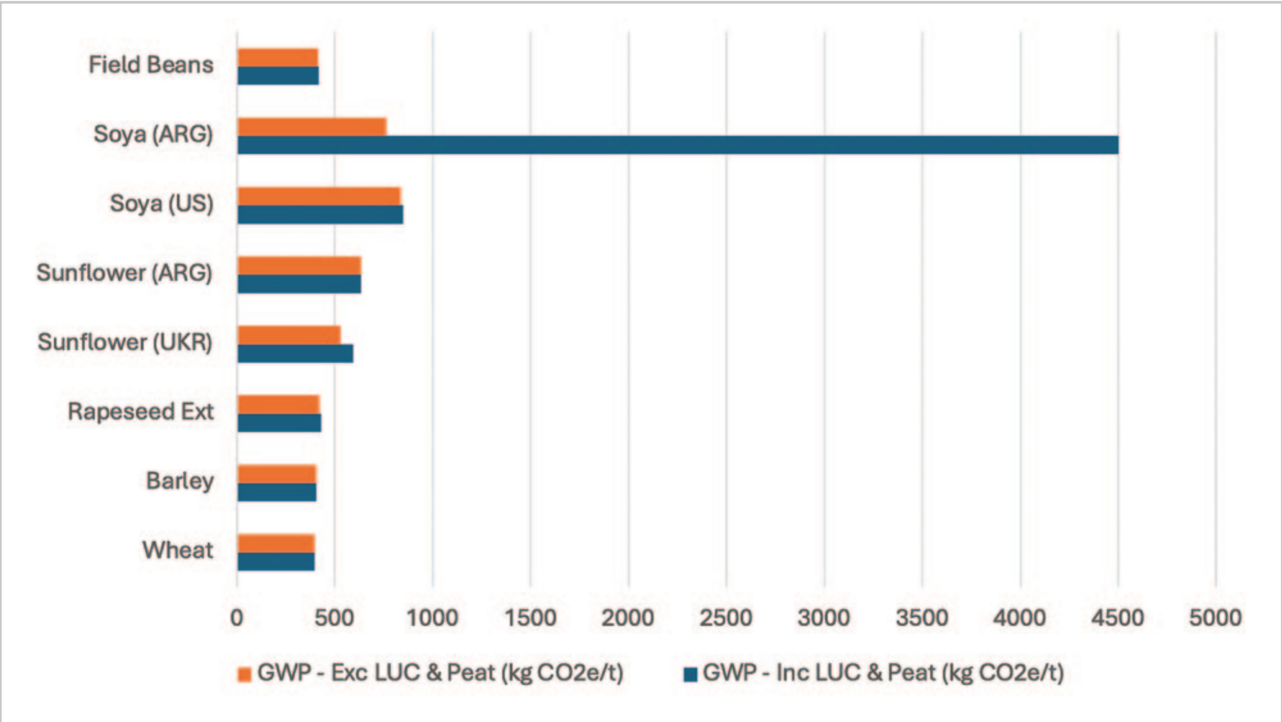
Using alternative raw materials and focusing on balancing amino acids is likely to be accelerated due to a drive for increasing sustainability and lowering feed and overall production carbon footprint. Figure 5 shows the global warming potential of different feed materials commonly used in feeds. The figures demonstrate both the difference between raw materials, and between raw material origins: for example, Argentinian soybean has an extremely high footprint when Land Use Change is accounted for, but even without LUC the values are different (762.06 kg CO_2e/t for Argentinian SBM and 836.75 kg CO_2e/t for US SBM).

Often the media narrative on sustainability is therefore about reducing the reliance on soybeans, and that this will by default reduce feed footprint. Driven by this narrative, sustainable formulation strategies increasingly rely on diversifying ingredient choice: legumes, oilseed meals, fermentation co-products, insect meals, and regionally sourced cereals all feature prominently in recent research (Grigore *et al.*, 2025; Wangui *et al.*, 2025; Zhang *et al.*, 2025).

The evidence suggests that turkeys can accommodate a wide range of alternative ingredients without loss of performance, provided diets are carefully balanced and supported by enzymes or processing technologies. What limits adoption is variability in nutrient composition, energy availability, and fibre characteristics.

However, it is important to remember that many of the alternative protein meals currently available at sufficient scale for commercial use have much lower overall nutrient density than soybean. Therefore, when the contribution of these ingredients to the carbon footprint of feed is calculated on a per unit of crude protein (or dLysine) basis, the assessment of soybean's impact changes substantially as shown in Figure 6.

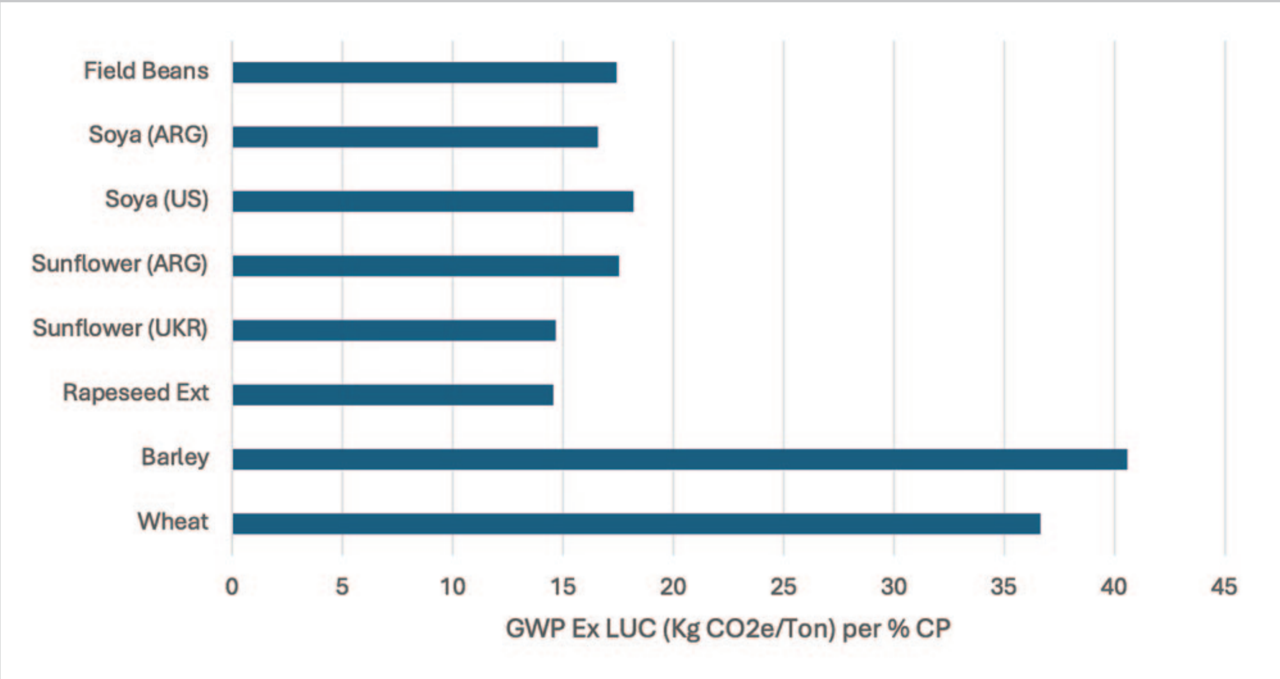
Figure 5. *Global Warming Potential (GWP) of feed raw materials expressed in kilograms of CO_2 equivalent per tonne (GFLI numbers)*



At the same time, sustainability in turkey production increasingly encompasses animal welfare and system robustness, not just environmental metrics. Diets that promote rapid and efficient growth, but compromise feathering, gut health, or behavioural stability are unlikely to be palatable to environmentally conscious consumers in the long term. As discussed, the literature highlights that nutritional imbalance first appears in welfare or resilience indicators, before any effect on performance can be measured. Maintaining balanced nutrient supply therefore supports not only productivity, but also the social and ethical dimensions of sustainability.

Finally, the future of sustainable turkey nutrition is inseparable from precision formulation and data integration. As discussed, monthly reformulation, ingredient QC data, digestible amino acid systems, and dynamic energy matrices already underpin commercial practice. Looking ahead, further integration of real-time ingredient quality data, predictive energy and amino acid models and precision feeding and monitoring technologies will allow sustainability targets to be met without increasing nutritional risk. In this sense, sustainability is less about radical dietary change, and more about reducing uncertainty within increasingly constrained systems.

Figure 6. *Global Warming Potential (GWP) of feed raw materials expressed in kilograms of* CO_2 *equivalent per percent of crude protein*



Conclusions

Looking forward, the future of sustainable turkey nutrition looks to be defined by precision and data-driven decision making, rather than simplification or huge changes in specifications. Lower protein diets, broader ingredient use, and improved efficiency are all achievable, but only when underpinned by robust amino acid balance, reliable energy prediction, and attention to welfare and resilience. The next phase of progress will therefore depend not on redefining requirements, but on how well nutritionists manage variability in a changing ingredient landscape.

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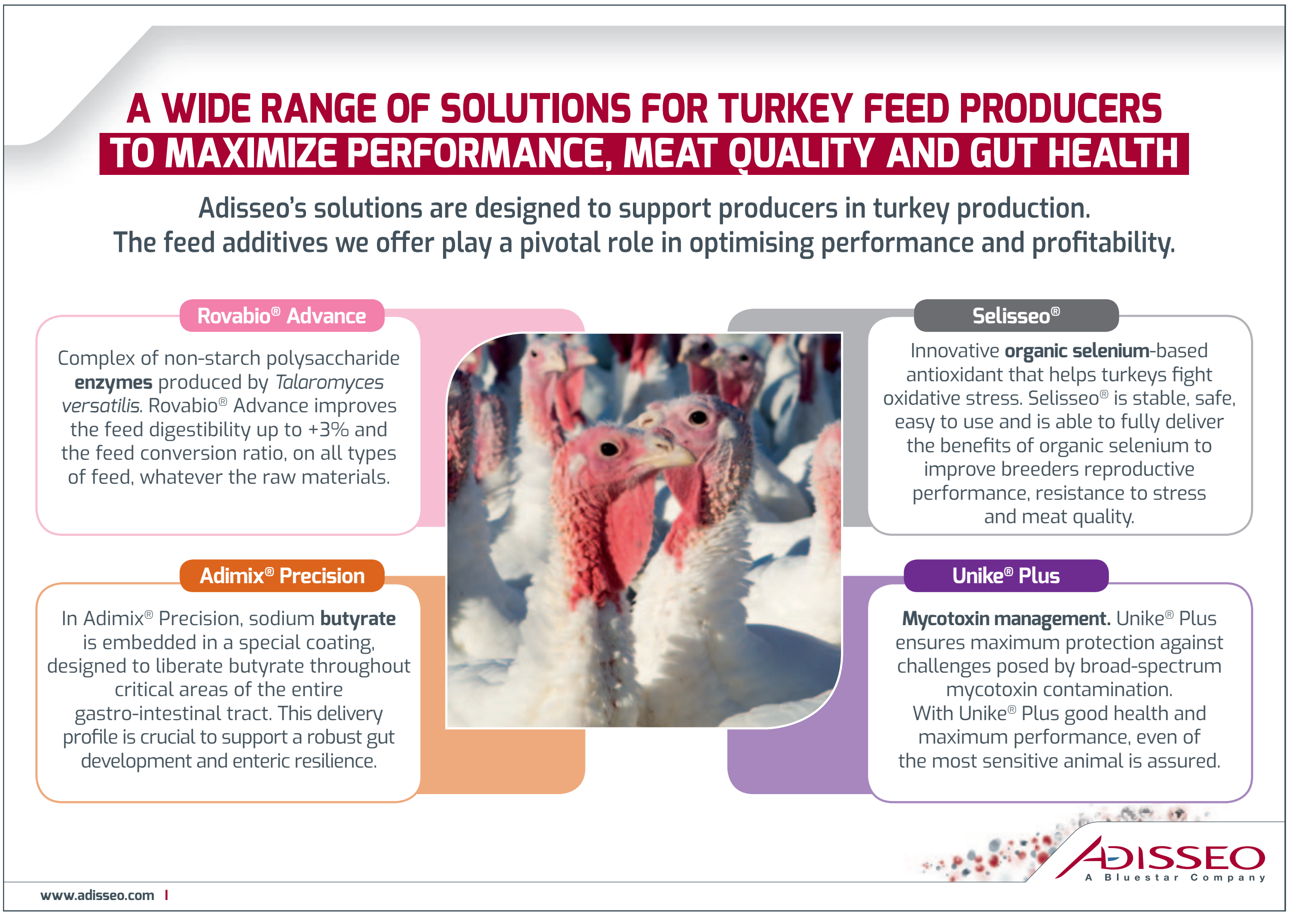
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Interimmun-APEC: Differentiation of Avian Pathogenic E. coli Field Isolates and their early Detection and Control in Poultry Farming

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Federal Ministry of Food and Agriculture
by decision of the German Bundestag

The Interimmun-APEC research project aims to reduce the use of antibiotics in commercial poultry through the early detection of pathogens. The joint project, funded by the Federal Ministry of Food and Agriculture (Bundesministerium für Ernährung und Landwirtschaft), started in spring 2023 and is scheduled for completion in 2026.

Antibiotics are used to treat bacterial diseases. In poultry farming, the normally harmless intestinal bacterium *Escherichia coli* (EC) is of particular relevance, as there are various strains of this germ that cause serious diseases in chickens and turkeys, among other animals. These strains are known as APEC (avian pathogenic EC). In many cases, APEC outbreaks are triggered primarily by viruses, but also by other bacteria. However, these relationships and the genetically determined virulence factors of APEC are largely unexplored. This is where the Interimmun-APEC project comes in.

APEC field isolates are systematically obtained and sequenced, allowing their virulence factors to be examined in their entirety. Co-infections by viruses are also recorded, diagnosed using molecular biology and their interaction examined in cell cultures. Finally, the research data obtained will be used to develop a tool for the early detection of pathogens and the prediction of their effects: the 'Interception Diagnostic Tool'. Where possible, this tool will replace direct manipulation of live animals by using environmental samples such as drinking water or stable litter, enabling preventive measures (e.g. cleaning, disinfection or the use of herd-specific vaccines) that avoid the subsequent use of antibiotics.
A particular focus of the project is the optimisation of autogenous APEC vaccines, the use of which is one of the most important ways of prophylactically controlling infectious diseases. In order to increase their effectiveness and safety, production parameters are being adjusted and a system for monitoring the immune response is being developed as part of the project.

One focus of the research project was the isolation and differentiation of *Escherichia coli* from the barn environment (drinking troughs and litter) and from sick or dead turkeys and chickens. To date, approximately 450 such isolates have been examined and assigned to the poultry-specific pathogen serotypes O1, O2, O18 and O78 as well as to additional 21 serotypes by slide agglutination. Additionally the number of virulence factors has been determined by multiplex PCR (see table 1). The results show a clear correlation between the origin and pathogenicity of the isolates. The proportion of poultry-specific serotypes and, above all, the number of virulence factors from isolates obtained from organs is significantly higher than in the comparison groups faeces/intestine and drinking water/litter. This shows how important it is to select strains correctly after differentiation with regard to sensitivity testing and the production of autogenous vaccines.

Table 1: *E. coli field isolates from sick chickens and turkeys as well as from drinking troughs and litter. Up to seven virulence factors can be detected using multiplex PCR. An isolate is defined as avian pathogenic E. coli (APEC) fit has four or more virulence factors.*

Origin	Number of Isolates	Share of O1, O2, O18, O78	Virulence factors*	APEC*
Organs (except intestine)	232	37,9%	3,29	48,3%
Organs (only bone marrow, joints, brain)	26	46,1%	3,46	60,7%
Feces, intestines	27	33,0%	1,19	7,7%
Drinking troughs, litter	204	21,0%	1,51	16,8%

* according to Ewers et al., 2004

The aim of the research project is to optimise the diagnostic detection of APEC. Building on the established multiplex PCR according to Ewers et al. (2004), it was investigated whether further virulence factors not previously considered occur in current field isolates. Based on a comprehensive literature review and the analysis of genome data sets (public databases and our own nanopore sequencing data), 13 additional virulence or APEC-associated genes were selected. Using two newly developed multiplex PCRs, several relevant factors (including *iut*A, *ompT*, *iro*N, *hlyF*, *sit*A, *ibe*A and *fyu*A) were identified that represent a useful addition to the existing PCR. The expansion of the detection spectrum thus contributes to improved molecular APEC diagnostics.

Whether colibacillosis breaks out in a poultry flock depends not only on the pathogenicity of the isolates, but also on the presence of numerous other stressors, such as viral co-infections (Dziva et al., 2008). For this reason, samples were taken regularly from selected farms in the form of swabs from drinking water and litter, as well as from sick animals, in order to test them for the presence of viruses using qPCR in addition to bacteriological examination. This led to the detection of rotaviruses of groups A and D, reoviruses, astroviruses, adenoviruses, coronaviruses, paramyxoviruses and pneumoviruses. The interaction between *E. coli* and avian viruses is currently being investigated in co-infection experiments in an organoid model.

One of the project's goals is to develop an interception tool that detects E. coli infections and enables them to be controlled in such a way that no clinically relevant outbreaks occur. Although litter and drinking water samples examined for this purpose using next-generation sequencing indicate *E. coli* infections, according to the current state of research, this detection does not yet provide the desired time advantage.

To prevent *E. coli* infections, autogenous vaccination is a routine tool in poultry farming. To improve the effectiveness of these vaccinations, an *E. coli* serotype O2-specific ELISA was developed as part of the project, which quantitatively indicates antibody titres after flock-specific vaccination. Furthermore, optimised vaccine formulations based on improved adjuvants and antigens were tested.

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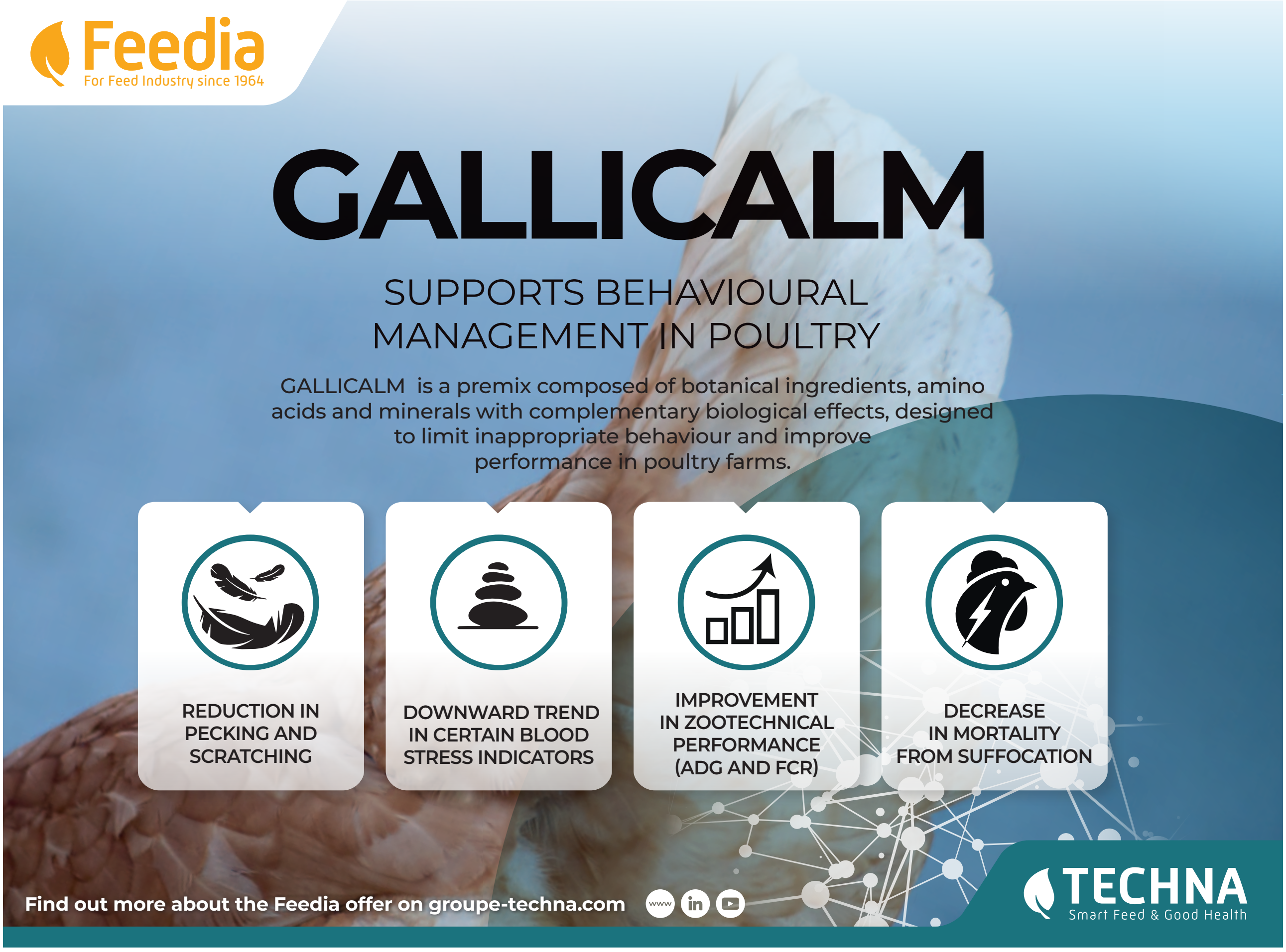
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Feed form matters: A longitudinal survey and experimental validation of physical feed form's effect on turkey zootechnical performance

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Abstract

The physical quality of feed constitutes a critical technical-economic lever in turkey production, often underestimated compared to nutritional formulation. This paper presents a dual approach: a longitudinal analysis of pellet durability in feed mills (Extralab database, 2015-2025) and a zootechnical trial comparing three feed presentations (Mash, Low PDI Pellet, High PDI Pellet) in male Premium turkeys. The survey reveals persistent industrial heterogeneity, with 7.7% of samples located in the "Alert Zone" (PDI < 80%). The trial demonstrates that degrading durability significantly impairs Average Daily Gain (ADG) and Feed Conversion Ratio (FCR). Turkeys fed a mash diet exhibited a **17% reduction in final body weight** compared to the control group (High Quality Pellet). The analysis confirms that industrial investment in pellet quality generates a positive Return on Investment (ROI) through the optimization of bioenergetic efficiency.

Keywords: *Turkey, PDI (Pellet Durability Index), Physical form, Feed efficiency, Feed intake.*

Introduction

Over the last four decades, genetic selection in commercial turkey strains has considerably increased their growth rate and, consequently, their metabolic requirements. This evolution necessitates a reconsideration of nutritional strategy: it is no longer solely about satisfying amino acid or metabolizable energy needs, but about optimizing the **physical availability** of these nutrients.

Scientific consensus establishes that feed form (pellet or crumble) directly influences the animal's time budget and the energetic cost of prehension. The objective of this study is to quantify the economic and zootechnical impact of physical feed quality through two axes:

1. **An industrial state of play:** What is the reality of pelleting quality in France and internationally?
2. **Experimental validation:** What is the real impact of a durability defect (fines) or a mash presentation on the growth physiology of the turkey?

Materials and Methods

Extralab: A Decade of Feed Analysis

Extralab is our proprietary suite of laboratory tools designed for the collection, storage, and analysis of lab results. This comprehensive study leverages the Extralab database, covering 10 years of feed analysis data collected across different periods, feedmills, and countries representing a total of 1671 samples on 9 feedmills.
eriod of collecting data: 2015 to 2025.

This data collection combined our own data from our lab and data from external feedmill.
PDI results were used to categorize production performance into three distinct zones:

- **Alert Zone (Low PDI):** <80%
- **Standard Zone:** 80-88%
- **Excellence Zone:** >88%

More details on Extralab:
https://www.groupe-techna.com/en/feedia/digital-tools/extralab

Turkey Feed Field Survey – 2022 Findings
This study analyzed turkey feed samples collected over three weeks from 11 feed mills across France and internationally. 231 feed samples have been collected from March 2022 to October 2022.

The dataset includes a comprehensive analysis spanning from starter to finisher feeds (Table N°1). However, this article focuses specifically on data gathered for grower and finisher feeds.

To assess feed quality, the Pellet Durability Index (PDI) was measured using the TECALIMAN durability methodology in our laboratory with a SABE durability meter.

Principle: The pellets undergo mechanical stirring. The analysis requires a sample of at least 500g, measured with a SABE device.

Initial Sieving:

1. Weigh a sample (550-600g) to obtain 500g after sieving.
2. Place the sample in a sieve of 0.8 times nominal diameter.
3. Sieve.
4. Weigh the fines to calculate the % of fines.

PDI measure:

1. Weigh exactly 500g of pre-sieved pellets.
2. Introduce the sample into the durability meter.
3. Run the device for 20 seconds.
4. Retrieve the sample.
5. Sieve again with the same sieve.
6. Weigh the contents of the sieve (pellets).

Calculations (in %):

- **% Fines** = (Weight of sieved fines * 100) / Sample Weight
- **PDI** = (Weight of sieved pellets * 100) / Initial Weight (500g)
- **Friability** = 100 - Durability

Table 1 : *Protocol for feedmill survey - 2022*

Period	Feed	Grinding	Intermediate Product	Final Product	Total Sample
Week No.1	Starter 0-21 days	Yes	1 pellet per crumble	1 Crumble	3
	Grower 36-56 days	Yes	No	Pellet	2
	Finisher 78-91 days	Yes	No	Pellet	2
Week No.2	Starter 0-21 days	Yes	1 pellet per crumble	1 Crumble	3
	Grower 36-56 days	Yes	No	Pellet	2
	Finisher 78-91 days	Yes	No	Pellet	2
Week No.3	Starter 0-21 days	Yes	1 pellet per crumble	1 Crumble	3
	Grower 36-56 days	Yes	No	Pellet	2
	Finisher 78-91 days	Yes	No	Pellet	2

PDI results were used to categorize production performance into three distinct zones:

- **Alert Zone (Low PDI):** <80%
- **Standard Zone:** 80-88%
- **Excellence Zone:** >88%

Experimental Trial Design - Feed forms Matter
A zootechnical trial was conducted on Aviagen Premium toms over a period of 112 days (6 feeding phases).

- **Design:** 3 experimental groups (6 replicates of 54 birds per group).
- **Treatments:** Three physical presentations were compared for a strictly identical nutritional value (iso-energy, iso-protein):
  1. **Control (Control Pellet):** High Durability Pellet (Excellence Zone).
  2. **Low PDI (Low PDI):** Degraded pellet simulating poor manufacturing.
  3. **Mash (Mash):** Non-pelleted feed (basal reference).
- **Measurements:** Body weight, ADG (Average Daily Gain), FCR (Feed Conversion Ratio), water consumption, and litter quality.

Table N°2: *Feed presentation protocol*

Groups	1	2	3
	Control	**Low pdi**	**Mash**
	0-21 days period		
Feed form	Sieved crumbles	Unsieved crumbles	Mash
	21-56 days period		
Feed form	Short cut pellets	Short cut pellets	Mash
	Durability 85-92	Durability 65-75	
	56-112 days period		
Feed form	Pellets	Pellets	Mash
	Finisher 78-91 days	Durability 88-95 days	
Repeats	6	6	6
Number of animals	54	54	54

Geometric Mean Diameter (GMD) or D50: It represents the average particle size of a feed sample (by mass) determined through a sieve analysis. Unlike the arithmetic mean, the GMD accounts for the log-normal distribution of particles produced by grinding processes (like hammer or roller mills).

The d_{gw} represents the median size of the particles by mass. According to the **ASAE S319.4** standard, it is calculated using the following formula:

$$d_{gw} = log^{-1}\left[\frac{\sum_{i=1}(W_i \log \bar{d}_i)}{\sum_{i=1} W_i}\right]$$

Definitions:

- d_{gw}: Geometric mean diameter by mass (µm).
- W_i: Mass of material retained on the i^{th} sieve(g)
- $\bar{d}_i$: Geometric mean diameter of the particles on the i^{th} sieve, calculated as:

$$\bar{d}_i = \sqrt{d_i \, x \, d_{i+1}}$$

- $\bar{d}_i$ = nominal aperture size of the i^{th} sieve (µm).d_{i+1} = nominal aperture size of the sieve above it (µm).
- n: Number of sieves used in the stack.

Table N°3 : *Granulometry profile of the starter for the period 0-21 days*

Groups	1	2	3
	Control	Low PDI	Mash
> 3,15 mm	1,8%	2,8%	7,5%
2 - 3,15 mm	36,7%	38,8%	18,0%
1 - 2 mm	54,9%	35,9%	37,8%
< 1 mm	6,6%	16,5%	36,7%
GMD / D50 - µm	1753	1567	1098

Table N°3 details the granulometry profile of the starter crumbles used during the first 21 days (0–3 weeks). This is essential for confirming the feed's physical quality (crumbles and fines distribution) meets specifications for optimal ingestion and early growth in young poults.

Table N°4 : *PDI Results and GMD/D50 results for the mash feed*

Groups	1	2	3
	Control	Low PDI	Mash
	PDI - %	PDI - %	GMD / D50 - µm
21 - 35 days	90,4%	80,4%	1328
35 - 56 days	90,6%	81,2%	1320
56 - 77 days	90,0%	85,2%	1329
77 - 91 days	92,6%	77,6%	1277
91 - 112 days	85,0%	77,2%	1705
GMD / D50 - µm	89,7%	80,3%	1391

PDI and Granulometry Results for Mash Feed (Table N°4)

Table N°4 reports the Pellet Durability Index (PDI) and granulometry (D50/GMD) for the Mash diet. Since mash is non-pelleted, its PDI is expected to be minimal. This table quantifies the physical characteristics of the mash, establishing a baseline for comparison against pelleted diets to isolate the effect of feed form on zootechnical performance.

Table N°5 **:** *Nutritional specification*

Phase		0-21 d	21-35 d	35-56 d	56-77 d	77-91 d	91-112 d
		Diets raw materials					
WHEAT	%	32,0	35,7	42,9	46,1	43,2	45,3
CORN	%	10,0	10,0	10,0	15,0	20,0	20,0
RAPESEED	%	2,0	4,0				
SOYBEAN MEAL	%	44,5	42,1	37,6	28,8	26,3	24,0
SUNFLOWER MEAL	%	2,2					
SOYBEAN OIL	%	0,65	1,45	2,80	2,7	2,5	3,0
PALM OIL	%					1,5	1,5
AMINO ACID PREMIX AND MINERALS	%	8,6	6,7	6,7	7,45	6,53	6,16

Table N°6 **:** *Diets*

Phase		0-21 d	21-35 d	35-56 d	56-77 d	77-91 d	91-112 d
		Nutritional value of the feed*					
METABOLISABLE ENERGY	%	2749	2870	2949	3051	3148	3202
CRUDE FAT	%	3,0	4,5	4,2	4,3	5,7	6,2
CRUDE PROTEIN	%	27,0	25,5	23,5	20,5	19,0	18,1
DIGESTIBLE ENERGY	%	1,55	1,40	1,30	1,15	1,05	1,00
CALCIUM	%	1,40	1,30	1,20	1,10	1,00	0,90
PHOSPHORUS Av	%	0,70	0,65	0,60	0,55	0,50	0,45

*According to TECHNA FRANCE NUTRITION *matrix nd energy system*

Tables N°5 and N°6 provide the foundational details regarding raw materials composition and nutritional values of feed during the experimental trial. The Nutritional Specifications (e.g., energy, protein, amino acid levels)were calculated using Techna's proprietary matrix system for Metabolizable Energy (ME) and held constant across all experimental groups for each of the six feeding phases This uniformity ensures that any observed differences in zootechnical performance are attributable only to the physical form of the feed, rather than to nutritional imbalances.

Economical criteria calculation;

Feed price (€ per ton of feed) = $\sum_{\text{for each phase}}$ *(feed quantity of the phase x feed price of the phase)*

Feed cost (€ per ton of live birds) = *Feed price x FCR*

Results

Extralab: A Decade of Feed Analysis (2015-2025)
The analysis of a decade of feed samples (Table N°8) reveals a strong overall performance in pellet durability within the sampled industry, with **79.8%** of the samples falling into the "Excellence Zone" (PDI > 88%).

However, the data highlights a persistent quality risk, as **7.7%** of production is consistently registered in the "Alert Zone" (PDI < 80%). This minority of low-quality feed represents a significant potential economic loss for producers due to compromised zootechnical performance (reduced ADG and higher FCR). The overall distribution, summarized in Table N°7, is heterogeneous, confirming that feed quality is not uniform across all mills or over time, indicating a need for greater process control in some facilities.

Table N°7: *Global distribution of PDI*

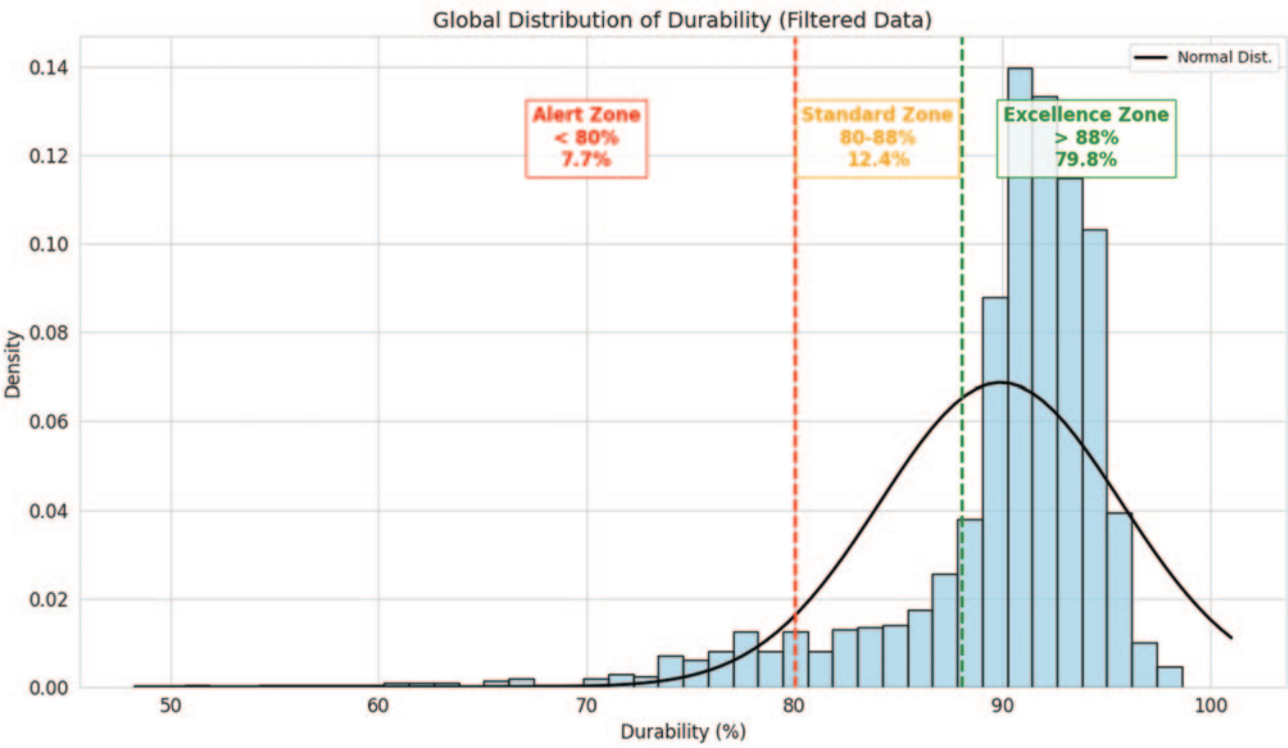


Table N°8: *Global distribution - figures*

PDI Zone (PDI % Range)	Percentage of Samples (2015-2025)
Alert Zone (< 80%)	7.7%
Standard Zone (80-88%)	12.5%
Excellence Zone (>88%)	79.8%
Total	**100.0%**

Tables N°9 and N°10 provide a granular look at the decade-long PDI data from the Extralab suite, detailing performance by individual feed mill and tracking chronological evolution, respectively.

Table N°9 : *A decade of Feed Analysis in Extralab - detail per feemill*

Feedmill	Sample Numbers	Average (%)	Standard-deviation	CV%	Minimum (%)	Maximum (%)
Feedmill A	2	85,1	0,01	0,02	85,09	85,11
Feedmill B	278	90,4	1,55	1,71	82,2	93,1
Feedmill C	468	92,26	2,24	2,43	75,9	97,6
Feedmill D	15	87,56	6,68	7,63	65,6	92,51
Feedmill E	140	83,18	9,08	10,91	50,68	95,6
Feedmill F	575	92,24	3,04	3,3	74,4	98,6
Feedmill G	38	84,95	5,96	7,02	72,9	97,2
Feedmill H	1	84,6	–	–	84,6	84,6
Feedmill I	154	80,771	7,48	9,26	55	94,4
Total	1671	86,78	4,51	5,29	50,68	98,6

Table N°9 demonstrates the strong heterogeneity in PDI results across the different participating feed mills over the 2015–2025 period. While the global average is high, individual mill performance varies significantly. This variation is directly linked to differing quality control processes, equipment maintenance regimes, and raw material utilization strategies among the facilities. The data underscores that achieving PDI excellence is not a universal industry standard but rather a function of specific, consistent operational management at the feed mill level.

Table N°10 : *Chronological evolution of PDI from 2015 to 2025 per feedmill*

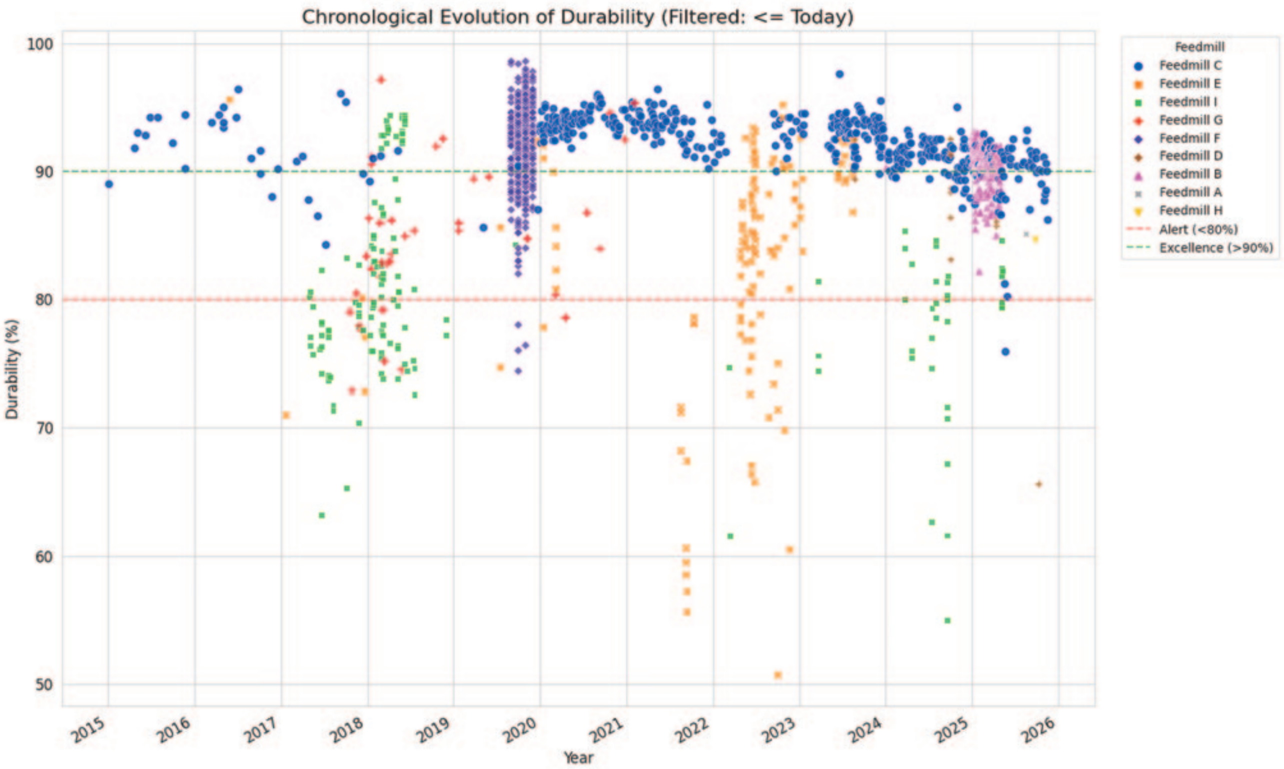


Table N°10 illustrates the PDI's chronological evolution from 2015 to 2025 for each feed mill. This temporal analysis confirms that feed quality is not only inconsistent between different mills but can also fluctuate significantly within the same mill over time. These fluctuations often correlate with changes in raw material batches, seasonal temperature variations, or modifications/failures in conditioning and pelleting equipment. The chronological view reinforces the necessity for continuous, proactive monitoring and adjustment of the pelleting process to consistently mitigate the risk of producing feed that falls into the "Alert Zone."

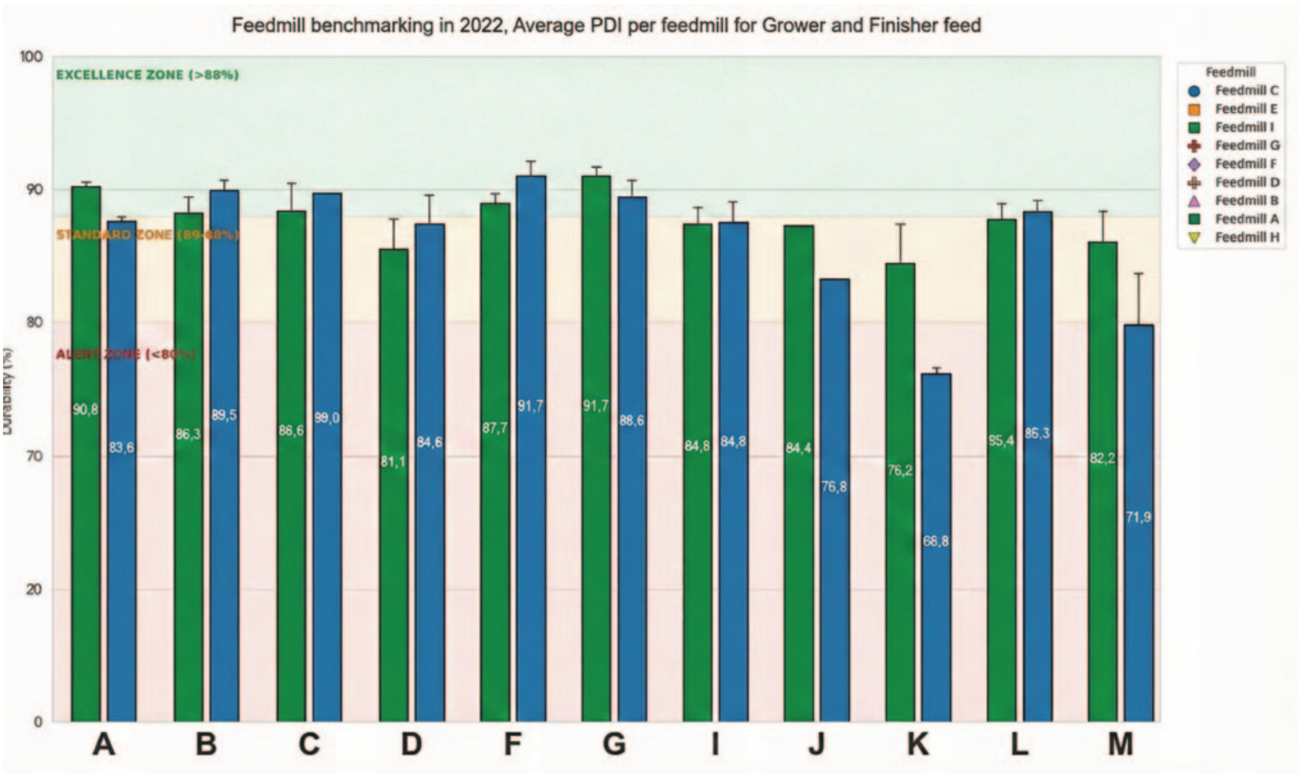
The decade-long analysis of PDI data through the Extralab platform confirms that while the sampled feed industry demonstrates a high overall standard of pellet durability, with nearly 80% of samples in the "Excellence Zone" (>88% PDI), significant challenges persist. The data reveals critical heterogeneity in quality, evidenced by the consistent presence of approximately 7.7% of production falling into the "Alert Zone" (<80% PDI). This persistent low-quality output, often linked to fluctuations within individual mills over time (Table N°10) and variations between different facilities (Table N°9), presents a non-trivial risk to profitability. The findings underscore that continuous, precise process control — from raw material management to equipment maintenance — is essential for consistently achieving high PDI and mitigating the economic losses associated with compromised feed physical quality.

Turkey Feed Field Survey – 2022 Findings: An In-Depth Analysis of Pellet Durability

The comprehensive field survey conducted in 2022 collected a total of 231 feed samples, encompassing both grower and finisher phases, to provide a statistically robust snapshot of current industry practices across the country. The primary objective was to assess the physical quality of pelleted feed, specifically focusing on the Pellet Durability Index (PDI).
Analysis of this extensive dataset, which incorporates data from 11 distinct participating feed mills, has revealed a significant and concerning degree of variation in PDI results across the industry. This heterogeneity, which echoes trends observed over a decade of historical data collected by Extralab, underscores the non-uniformity in feed processing and quality control standards currently employed.

Essentially, this segregated analysis moves beyond a simple quality assessment to provide actionable intelligence, enabling manufacturers to adapt quality control and production parameters to meet the unique demands and constraints of each critical feed type.

Table 11 **:** *Feedmill benchmarking, Average PDI per feedmill for Grower and Finisher Feed*



Experimental Trial Design - Feed forms Matter - Zootechnical Performance

Table N°12 : *Weight, Average Daily Gain (ADG), Average Daily Feed Intake (ADFI) and Feed Conversion Ratio (FCR) - 0-112 days*

		Groups			RSD	p-value
		Control	Low pdi	Mash		Groups
	WEIGHT D0, g	**62,5**	**62,4**	**62,5**		
0-21 days						
	WEIGHT, g	737^{b}	738^{b}	565^{a}	41	**0,000**
	ADG, g/d	32,1^{b}	32,2^{b}	23,9^{a}	1,9	**0,000**
	ADFI, g/d	44,0^{b}	45,8^{b}	36,6^{a}	1,9	**0,000**
	FCR	1,370^{b}	1,423^{ab}	1,542^{a}	0,083	**0,008**
21-35 days						
	WEIGHT, g	1,872^{b}	1,893^{b}	1,563^{a}	72	**0,000**
	ADG, g/d	81,2^{b}	82,5^{b}	69,8^{a}	3,3	**0,000**
	ADFI, g/d	125,2^{b}	120,8^{b}	107,4^{a}	8,4	**0,010**
	FCR	1,545	1,461	1,546	0,107	**NS**
35-56 days						
	WEIGHT, g	5,093^{b}	4,999^{b}	4,289^{a}	160	**0,000**
	ADG, g/d	153,3^{b}	147,8^{b}	130,0^{a}	6,8	**0,000**
	ADFI, g/d	231,2^{b}	222,9^{b}	194,5^{a}	10,5	**0,000**
	FCR	1,509	1,508	1,501	0,073	**NS**
56-77 days						
	WEIGHT, g	9,092^{b}	9,093^{b}	7,460^{a}	344	**0,000**
	ADG, g/d	190,4^{b}	195,0^{b}	155,8^{a}	9,2	**0,000**
	ADFI, g/d	376,9^{b}	372,7^{b}	328,0^{a}	12,1	**0,000**
	FCR	1,982^{b}	1,912^{b}	2,109^{a}	0,064	**0,000**
77-91 days						
	WEIGHT, g	11,826^{b}	11,572^{b}	9,537^{a}	398	**0,000**
	ADG, g/d	191,0^{b}	180,6^{b}	146,4^{a}	16,4	**0,003**
	ADFI, g/d	471,3^{b}	451,3^{b}	380,9^{a}	19,1	**0,000**
	FCR	2,450	2,549	2,662	0,234	**NS**
91-112 days						
	WEIGHT, g	15,317^{b}	15,040^{b}	12,717^{a}	541,9	**0,000**
	ADG, g/d	162,1	165,1	153,2	16,2	**NS**
	ADFI, g/d	462,4^{a}	465,5^{a}	415,1^{a}	26,7	**0,023**
	FCR	2,860	2,780	2,721	0,145	**NS**
0-112 days						
	ADG, g/d	136,2^{b}	133,7^{b}	113,0^{a}	4,8	**0,000**
	ADFI, g/d	287,2^{c}	276,9^{b}	247,1^{a}	6,4	**0,000**
	FCR	2,109^{ab}	2,072^{a}	2,189^{b}	0,1	**0,013**
	cFCR	1,969^{b}	1,968^{b}	2,387^{a}	0,122	**0,000**

RSD = *Residual standard deviation of the model with the fixed-factor group* (ANOVA)

Table N°12, detailing zootechnical performance over 112 days (Weight, ADG, ADFI, and FCR), demonstrated a clear performance hierarchy based on feed physical form:

- **Superior Performance (Control Pellet):** Turkeys fed the Control Pellet (High PDI) exhibited the best overall performance, achieving the highest final body weight, ADG, and the lowest FCR.
- **Significant Impairment (Mash Diet):** The Mash diet severely compromised growth, resulting in a 17% reduction in final body weight compared to the Control Pellet group, indicating a substantial loss of efficiency (higher FCR).
- **Moderate Decline (Low PDI Pellet):** The Low PDI Pellet group, simulating poor industrial quality, showed a measurable decline in key metrics (ADG and FCR) compared to the Control Pellet, confirming that compromised durability negatively impacts production efficiency.

Table N° 13 : *Water and Water on Feed ratio - D0 to 112 days*

		Groups			RSD	p-value
		Control	Low pdi	Mash		Groups
0-21 days						
	ADWI, ml/d	137	143	123	16	**NS**
	W/F	3,11	3,13	3,35	0,32	**NS**
21-35 days						
	ADWI, ml/d	314[b]	323[b]	262[a]	20	**0,000**
	W/F	2,58	2,68	2,48	0,19	**NS**
35-56 days						
	ADWI, ml/d	651[b]	636[b]	514[a]	50	**0,001**
	W/F	2,86	2,86	2,62	0,29	**NS**
56-77 days						
	ADWI, ml/d	931[b]	929[b]	783[a]	72	**0,005**
	W/F	2,47	2,50	2,39	0,20	**NS**
77-91 days						
	ADWI, ml/d	1210	1208	1081	168	**NS**
	W/F	2,55	2,70	2,83	0,39	**NS**
91-112 days						
	ADWI, ml/d	1283[b]	1170[b]	1115[a]	88	**0,035**
	W/F	2,78	2,57	2,70	0,25	**NS**
0-112 days						
	ADWI, ml/d	749[b]	731[b]	632[a]	30	**0,000**
	W/F	2,66	2,64	2,56	0,15	**NS**

RSD = *Residual standard deviation of the model with the fixed-factor group* (ANOVA)

Table N° 13: Water and Water on Feed ratio - D0 to 112 days provides metrics on the water intake of the turkey toms across the three experimental groups (Control Pellet, Low PDI Pellet, and Mash) over the 112-day trial. The data shows that turkeys fed the high-quality Control Pellet (which achieved the best growth performance) exhibited the highest Average Daily Water Intake (ADWI) and, consequently, the highest Water on Feed Ratio (W/F). This indicates that the superior performance achieved with high-quality pellets is associated with a greater overall intake of water and feed, consistent with higher metabolic rates and growth potential. Conversely, the Mash diet, which resulted in the lowest growth, also showed the lowest water intake.

Table N°14 : *Dry matter litter and Litter scoring at 56 days and 11 days*
(1 = Completely wet/greasy litter to 5 very dry litter)

		Groups			RSD	p-value
		Control	Low pdi	Mash		Groups
56 days						
	Dry Matter, %	49,8[b]	53,6[b]	62,6[b]	6,7	**0,014**
	Scale scoring, mean	3,2[b]	3,4[b]	3,9[b]		**0,007**
111 days						
	Dry Matter, %	45,7[b]	44,0[b]	50,6[a]	2,8	**0,003**
	Scale scoring, mean	2,8	2,5	2,9		**NS**

RSD = *Residual standard deviation of the model with the fixed-factor group* (ANOVA)

Table 14 examines the trade-off between feed physical form and litter quality, showing that while high-quality pellets maximize performance, the **Mash diet leads to superior litter quality (higher dryness)**. The Mash group had the highest Dry Matter Litter and Litter Scoring (closer to 5) due to lower water intake. Conversely, the Control Pellet (High PDI), which produced the best growth, likely resulted in the lowest Dry Matter Litter (closer to 1), associated with higher water consumption. The Low PDI Pellet group was intermediate. The data highlights the challenge of maximizing feed performance while managing the associated risk of wet litter.

Table N°15 : *Economical impact - Price list France 2025*

Groups	1 Control	2 Low pdi	3 Mash
Total Feed Consumption - kgs	32,17	31,02	27,67
Feed Price	322,0	322,0	308,0
			Minus Pelletization Charge
Body Weight - kgs	15,30	15,00	12,70
FCR Corrected	1,969	1,968	2,387
Feed charge per ton live bird - €/T	634	634	736

The zootechnical performance differences observed across the three feed forms translate directly into significant economic consequences, as detailed in Table N°15. This table quantifies the financial return on investment associated with maintaining high pellet durability. Specifically, the data reveals that the compromised growth and higher Feed Conversion Ratio (FCR) of the Low PDI Pellet group, and even more severely the Mash group, lead to substantial increases in the cost of producing one kilogram of turkey meat compared to the Control Pellet (High PDI) group. The analysis confirms that the marginal cost associated with industrial investments in superior pelleting technology and process control—to consistently achieve PDI values in the "Excellence Zone"—is far outweighed by the resulting optimization of bioenergetic efficiency, making high feed physical quality a critical determinant of farm-level profitability.

Discussion

The impact of feed form on the growth performance of turkeys is a well-documented area of study (e.g., Blakely et al., 1967, Flores and al. , 2021, Hassiby and al., 1983, Kenny and al., 2021,). With a lack of published and update study with modern turkey genetics, we could also take a look on the modern broiler to have a better understanding. Latest study in broiler have shown the same impact of feed physical forms on performance (e.g. Al-Nasrawi and al., 2016, Quentin et al., 2004,, Serrano and al., 2013).

Synthesis of Extralab, Benchmarking, and Trial Results

The results of the zootechnical trial demonstrate the importance of feed physical presentation in determining zootechnical performance, while the Extralab dataset and the field survey indicate that these physical quality criteria are both variable and amenable to routine monitoring. The findings converge on a single critical conclusion: the physical quality of turkey feed, specifically pellet durability, is a major, quantifiable driver of zootechnical performance and economic outcome.

Connecting Field Reality (Extralab & Benchmarking) to Zootechnical Impact (Trial)

The Extralab data (Tables N°8, N°9, N°10) established a concerning, albeit small, persistent quality gap in the industry, with approximately 7.7% of samples consistently registering in the "Alert Zone" (PDI < 80%). This historical inconsistency is supported by the 2022 benchmarking survey, which confirmed significant heterogeneity in PDI results among French feed mills (Table N°11), underscoring that process control is not uniform.

The zootechnical trial provides the direct, empirical evidence of the consequences of this industry-wide variability. By comparing a Control Pellet (High PDI) to a Low PDI Pellet and a Mash diet, the experiment successfully isolated the impact of physical form:

- **Low PDI Risk Realized:** The Low PDI group in the trial directly simulates the "Alert Zone" feed observed in the Extralab data. The performance degradation in this group—a measurable decline in ADG and FCR (Table N°12) — quantifies the economic loss incurred by producers who receive feed from mills operating in the "Alert Zone."
- **The Mash Baseline:** The Mash diet, representing the absolute minimum in physical quality, resulted in a striking 17% reduction in final body weight compared to the Control Pellet group (Table N°12). This outcome highlights the powerful, bioenergetic benefit of agglomerated feed forms by minimizing energy wasted on prehension and reducing nutrient sorting.
- **Litter Quality Trade-off:** While the performance metrics strongly favor high-quality pellets, the trial also confirmed a negative correlation between pellet quality and litter dryness (Table N°14). The Mash diet produced the driest litter, suggesting that the industry faces a technical compromise between maximizing growth/efficiency via pelleting and mitigating litter management issues related to higher water intake (Table N°13) and potentially softer fecal material associated with high-performance diets.

Implications for Feed Mill Management and Turkey Husbandry

The combined data set necessitates a shift in focus from merely achieving pelleting to ensuring consistent, *high-quality pelleting*. The findings suggest that investment aimed at moving production from the "Standard Zone" (80-88% PDI) into the "Excellence Zone" (>88% PDI) is a highly justifiable expense. The chronic fluctuations observed in the chronological Extralab data (Table N°10) indicate that process variability — linked to factors such as steam quality, conditioning time, die wear, and formula changes — is a primary economic detractor. Implementing real-time PDI monitoring, as enabled by tools like Extralab, is not merely a quality control measure but a direct profitability safeguard. The data strongly supports the view that the potential gains in FCR and ADG far outweigh the marginal manufacturing costs associated with achieving PDI excellence.

The correlation between durability and feed intake

The result of this trial confirms most of the theoretical scenarios used by authors for the estimation of poultry production.

The study highlights a direct correlation between feed physical quality and performance. Analysis suggests that a 10% decrease in feed durability leads to a 4.2% drop in feed consumption. Specifically, reducing durability from 90% to 81% was associated with a daily consumption drop from 450g to 431g. This reduced intake mechanically drives a decline in ADG -3%.

Conclusion

The physical form of feed is a major determinant of turkey performance. This study confirms that turkeys are highly sensitive to feed presentation. While Mash diets improve litter dryness, they severely compromise weight gain (17% reduction in final body weight) and FCR, demonstrating the necessity of feed agglomeration for maximizing bioenergetic efficiency. Furthermore, even a moderate degradation in pellet durability (Low PDI) negatively impacts finish weights and profitability metrics compared to high-quality pellets.

The longitudinal Extralab analysis and the field survey reveal a persistent, albeit small (7.7%), presence of low-quality feed (PDI < 80%) in the industry. The zootechnical trial quantifies the economic risk associated with this variability, establishing that the potential gains in ADG and FCR achieved by moving feed into the "Excellence Zone" (PDI > 88%) far outweigh the marginal costs of improved feed processing.

The physical form of feed is a major determinant of turkey performance. This study confirms that turkeys are highly sensitive to feed presentation. While Mash diets improve litter dryness, they severely compromise weight gain and FCR. Furthermore, even a moderate degradation in pellet durability (Low PDI) negatively impacts finish weights. For the industry, maintaining a PDI in the "Excellence Zone" (>88%) is essential to maximize the genetic potential of modern turkey strains and ensure economic profitability.

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Influence of superdoses of phytase on growth performance, dietary energy and nutrient availability, and inositol phosphate isomers in young turkey

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Introduction

Research with broilers showed that superdoses (>1,500 U/kg) of dietary phytase (PHY) improved feed efficiency when feeding diets low in Ca and available P (Walk et al., 2013). Further broiler studies (Walk et al. 2014) found that superdoses of PHY to low P diets resulted in almost complete hydrolysis of dietary phytate, an increase in inositol concentration in the gizzard and improved broiler growth performance including feed efficiency.

However, dietary PHY did not have a substantial impact on tibia ash beyond those of a mineral sufficient diet or a diet supplemented with excess Ca and P. Thus, suggesting that the improved broiler growth and feed efficiency when superdosing PHY may be associated with phytate destruction and provision of inositol (IN), rather than excess P and Ca (Walk et al., 2014). However, Bedford and Rodehutscord (2024) reported that exogenous PHY can produce different results in chickens and turkeys. Turkeys are more effective at absorbing IN from the small intestine than the broiler (Novotny et al., 2023) and information on the effect of PHY on dietary phytate degradation in chickens may not be translated to turkeys. Feeding high PHY doses to turkeys, Pirgozliev et al. (2025) found an increase in energy and nutrient availability that coupled with the reduction of phytate in excreta, but no response to growth performance was observed. There is a scarcity of information on PHY superdosing in turkey rations. In particular, little is known about the effect of very high PHY doses on phytate degradation in low P diets when fed to turkeys.

Therefore, the objective of this experiment was to examine the effect of high levels of exogenous PHY on energy utilisation, nutrient availability and phytate degradation when feeding low P diets to young turkeys. Growth performance variables were also measured.

Animals and Experimental design

A negative control basal diet met all nutrient requirements with the exception of AvP which was provided at 50% of requirement (NC) (Table 1). The NC diet was then split in five parts and PHY enzyme (Quantum Blue; AB Vista UK), was added at 0, 100 (0.02 g/kg diet), 1000 (0.2 g/kg diet), 10 000 (2 g/kg diet) and 100 000 (20 g/kg diet) to one of each part respectively (Table 2). One gram of this PHY contains 5000 FTU. An additional diet with adequate levels of P and Ca served as a positive control (PC) (Table 1), producing 6 diets in total. The nutrient specification of the PC met all breeder recommendations although the NC contained half of the available P recommended (Aviagen Ltd.). Nutrient availability was examined in the experiment from 70 to 77 d age using 72 female B.U.T. Premium turkey poults (Faccenda Foods Ltd., Dalton, UK). Each diet was fed to 6 pens (two birds each) following randomisation. Excreta were collected for the last 3 days of the study. All laboratory analysis and calculations were performed following standard procedures. Statistical analyses were carried out using GenStat (23rd edition) statistical software (IACR Rothamsted, Hertfordshire, UK).

The data were analysed using the general ANOVA procedure incorporating orthogonal polynomial contrasts to evaluate linear and quadratic trends associated with increasing PHY levels. Additionally, the PC and NC were compared with a single contrast comparison test. Prior to ANOVA, data were examined for homogeneity of variances and normality of residuals. Differences were considered statistically significant at $P < 0.05$. All data are presented as means together with their pooled standard errors of the means (SEMs).

Ingredients	**PC 4-8 wks. (%)**	**NC 4-8 wks. (%)**
Wheat	52.51	52.71
Prairie meal	2.50	2.50
Rye	2.0	2.0
Rape seed meal	5.00	5.00
Soya ext hipro	29.50	29.50
L-Lysine HCl	0.35	0.35
DL-methionine	0.35	0.35
L-threonine	0.09	0.09
Soya oil	3.00	3.00
Limestone flour tru.270	1.00	1.75
Dicalcium phosphate flour	3.00	2.05
Salt	0.30	0.30
Turkey premix	0.40	0.40
Calculated provisions %		
Oil	4.56	4.56
Crude protein	24.12	24.12
ME	12.16	12.16
Lysine available	1.39	1.39
Methionine + Cysteine	1.08	1.08
Ca	1.28	1.40
P available	0.68	0.52

Table 1. *Experimental diet*
[1]*Contained vitamins and trace elements to meet breeder's recommendation (Aviagen, Turkeys Ltd, UK) and provided per kg diet: 50 mg nicotinic acid, 34 mg □-tocopherol, 15 mg pantothenic acid, 7 mg riboflavin, 5 mg pyridoxine, 3.6 mg retinol, 3 mg menadione, 2 mg thiamine, 1 mg folic acid, 200 µg biotin, 125 µg cholecalciferol, 15 µg cobalamin, 100 mg manganese, 80 mg iron, 80 mg zinc, 10 mg copper, 1 mg iodine, 0.5 mg cobalt, 0.5 mg molybdenum and 0.2 mg selenium.*

Table 2. *Daily feed intake (FI), weight gain (WG), feed conversion ratio (FCR), dietary N-corrected apparent metabolisable energy (AMEn), calcium (CaR), phosphorus (PR) retention coefficients, inositol phosphate isomers (IP) and Inositol (IN) concentration in excreta*

	FTU* (kg)	FI (g/b/d)	WG (g/b/d)	FCR	AMEn (MJ/kg DM)	PR	CaR	IP3 (nmol/mL)	IP4 (nmol/mL)	IP5 (nmol/mL)	IP6 (nmol/mL)	IN (nmol/mL)
PC	0	192	113	1.706	13.46	0.413	0.439	2458	4990	7077	35337	94990
NC	0	176	96	1.861	13.00	0.368	0.256	1884	3630	6018	31423	69838
NC	100	171	98	1.772	13.09	0.386	0.243	2347	5487	7397	33776	56533
NC	1000	181	104	1.751	13.52	0.456	0.329	4632	11762	4481	15534	68132
NC	10000	188	109	1.727	13.65	0.460	0.360	1792	2223	634	5446	80160
NC	100000	181	118	1.527	13.73	0.496	0.384	550	408	212	1943	77481
SEM		4.0	3.7	0.0710	0.122	0.0202	0.0326	188.8	542.6	395.7	1577.3	4935.2
Probabilities												
PC vs NC		0.003	0.008	0.165	0.032	0.156	< 0.001	0.097	0.084	0.257	0.299	0.056
PHY		0.090	0.002	0.043	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.025
L		0.058	< 0.001	0.005	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.022
Q		0.642	0.355	0.409	0.519	0.696	0.822	< 0.001	< 0.001	0.006	0.553	0.254
D		0.103	0.965	0.556	0.409	0.444	0.220	< 0.001	< 0.001	< 0.001	< 0.001	0.060

**Levels of exogenous phytase (FTU)*

Results and discussion

The AMEn of the basal diet was close to the calculated values (Table 2). Results in this study show an improvement of most of the studied variables by PHY supplementation (Table 2). Relative to the PC diet, birds receiving the NC diet exhibited reduced FI (P = 0.003), WG (P = 0.008) and AMEn (P = 0.032). Supplementation with ≥1000 FTU/kg largely eliminated these deficits. Increasing dietary PHY concentration produced significant positive linear responses in WG (P < 0.001), reduced FCR (P = 0.043) and AMEn (P < 0.001). There were no significant differences between NC and PC (P > 0.05) regarding IP isomers. Marked reductions in IP isomers occurred at 1000 FTU/kg, and responses for both IP3-6 isomers followed a curvilinear pattern (P < 0.001), involving linear and quadratic components. Excreta IP6 linearly decreased (P < 0.001) although IN concentration linearly increased (P = 0.022) with PHY supplementation. Most mineral retention values increased at PHY doses ≥1000 FTU/kg. Increasing PHY dose resulted in significant positive linear responses for Ca and P retention (P < 0.001). Despite the relatively short feeding period, daily WG and FCR of turkeys improved in agreement with previous reports with chickens (Walk et al. 2013, 2014). The linear improvement in dietary AMEn with dietary PHY increase agrees with previous turkey research (Pirgozliev et al., 2007, 2025). In the reported study, the retention coefficients of Ca and P responded in a linear dose dependent manner to PHY supplementation. This increase in available energy and nutrient retention was negatively correlated to the reduction of the concentration of IP3-6 isomers in this experiment.

The results in this study suggest that very high dosage of PHY can reduce the IP6 concentration in the excreta by 95%. Similarly, IP5 concentration in the excreta was decreased by almost 96.5% of the NC value. Both, IP6 and IP5, are highly potent chelators of minerals and may interfere with digestion of nutrients. In accord with Bedford and Walk (2016) IP3 and IP4 initially increased by 25% and 51%, respectively with 100 FTU/kg phytase, but superdosing PHY at 100 000 FTU/kg resulted in a reduction of 71% and 89%, respectively, compared with the NC. These lower esters are still highly capable of binding Mg and first order transition metals such as Zn, Cu and Fe (Persson et al., 1998). These elements are critical for the maintenance of the immune system and for activation of digestive proteases amongst their many functions. This may explain the positive and linear improvement WG and FCR with increasing PHY dose, as it is not until the highest dose fed in this study is utilised that performance is maximised which correlates with minimum levels of all IP esters and as such compromise mineral status of the bird and efficacy of digestive proteases which rely on these metals for activation. A previous turkey study (Pirgozliev et al., 2025) showed that superdosing PHY at 12 500 FTU/kg reduced IP3 and IP4 isomers by only 32% and 44%, which is more than that achieved with 10000 FTU in the current study but half of that achieved with 100,000 FTU, further suggesting that significant degradation of IP3 and IP4 requires a lot more phytase than likely is needed in broilers.

Overall, the findings confirm that turkeys respond to high PHY inclusion in a manner broadly consistent with broilers. The present data also indicate that very high superdoses (>10000 FTU/kg) provide additional benefit beyond 1000 FTU/kg, particularly with respect to growth performance, and that megadosing (>100000 FTU/kg) may even be warranted for turkeys. Furthermore, the digesta inositol levels did not increase with increased phytase as is usually found in broilers, and the reason for this is probably due to the much more efficient absorption of inositol by turkeys compared with broilers (Novotny et al., 2023). Thus, improvements in WG and FCR associated with superdoses of PHY may be attributed to phytate destruction although from the current data it cannot be ruled out that the provision of IN was involved.

These findings contribute valuable new evidence toward defining optimal phytase dosing strategies for turkey nutrition and support the potential for phytase to reduce reliance on inorganic phosphorus sources in commercial turkey production.

Conclusion

In conclusion, the reported results confirm that super dosing of phytase in turkeys is an effective strategy for improving the nutritional value of diets through the reduction of the anti-nutritional factors IP6 and IP5 and possibly IP4 and IP3. Results indicate improvements in growth performance, metabolisable energy and mineral retention coefficients.

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Poland at a Glance: Disease Dynamics and Market Outlook

Beata Ogonowska-Woźniak
Hybrid Turkeys, Poland

The turkey sector in Poland is one of the key components of national animal production, contributing significantly to both the European and global poultry meat markets. For many years, Poland has maintained a leading position in turkey production within the European Union, with annual placements of turkey poults reaching approximately 40–45 million. Unfortunately, this sector remains particularly vulnerable to epizootic threats, among which highly pathogenic avian influenza (HPAI) and Newcastle disease (NDV) play a central role. Although these pathogens differ in their biological characteristics and transmission dynamics, both pose substantial challenges to production stability, biosecurity, and the continuity of the supply chain. In the global context, both HPAI and NDV continue to be diseases of major trade significance, and their occurrence leads to temporary restrictions on the export of poultry products.

Avian Influenza (HPAI)

In recent years, Poland has experienced recurring waves of highly pathogenic avian influenza (HPAI), each characterized by varying epidemiological dynamics. The occurrence of outbreaks is strongly correlated with wild bird migration patterns, environmental conditions, and the density of poultry farms.

In 2025, a total of **128 outbreaks** were recorded, resulting in the loss of **over 10 million birds**. For comparison, the figures for previous years were as follows:

- **2024** – 50 outbreaks and 3.2 million birds lost,
- **2023** – 68 outbreaks and 1 million birds lost,
- **2022** – 68 outbreaks and 2 million birds lost,
- **2021** – the most severe year, with **403 outbreaks** and a total loss exceeding **14.2 million birds.**

In 2021, outbreaks numbered 1 to 339 were caused by the H5N8 subtype of the avian influenza virus, while outbreaks 340 to 403 were attributed to the H5N1 subtype. Currently, **H5N1 is the only subtype detected in poultry outbreaks**. Genetic analyses have confirmed that, for the first time in several years, the virus did not originate on the European continent. Instead, it was introduced from outside Europe. Molecular evidence indicates that it likely originated in regions of **Central Asia or the Middle East** and was carried into Poland and Western Europe by migrating wild birds.

In Poland, HPAI outbreaks are distributed across the entire country, with higher concentrations observed in regions with intensive poultry production.

Due to the high number of outbreaks, in April 2025 the European Commission proposed the introduction of restrictions aimed at slowing the spread of the avian influenza epidemic. The proposal included, among other measures, the establishment of three territorial clusters placed under intensified supervision by the Veterinary Inspection authorities. These clusters were to be subject to a series of mandatory measures and prohibitions, such as extending the downtime between production cycles, increasing the radius of the protection zone to 12 km in the event of an outbreak, prolonging the production break to 40 days after final disinfection on farms where an outbreak had occurred, banning bird fairs and exhibitions, and implementing strict oversight of loading crews. Ultimately, due to the decline in new avian influenza outbreaks in the second half of April and early May, none of these restrictions were implemented.

At present, no work is underway in Poland to introduce vaccination against avian influenza, and biosecurity remains the only available tool—one that is clearly insufficient in large poultry production regions. Increasing attention is being drawn to the need for more advanced monitoring systems and early virus detection technologies.

Newcastle Disease (NDV)

Newcastle disease, although less common in past years in Poland than HPAI, remains a condition with high epizootic potential. NDV is characterized by high contagiousness, and its clinical course may include respiratory and neurological symptoms as well as reduced productivity.

In April 2025, the Polish Ministry of Agriculture and Rural Development introduced a regulation outlining measures to be taken in response to the occurrence of Newcastle disease. The regulation provided guidelines for controlling the NDV situation in Poland, which—similarly to avian influenza—had been gaining momentum. Poland had been officially free from Newcastle disease since 1974, and the first confirmed outbreak after 49 years was detected in the eastern part of the country. An analysis of the spatial distribution of NDV outbreaks shows a westward shift over time, with outbreaks increasingly concentrated in major poultry production regions and intensifying year by year. In contrast to avian influenza, where wild birds serve as the primary vectors, the main reservoir of NDV is backyard poultry, over which effective control is significantly more challenging. In 2025, **86 outbreaks** were detected in commercial poultry, while **95 outbreaks** occurred in backyard flocks. This clearly demonstrates the substantial threat posed by backyard poultry as a reservoir for NDV.

In October and November 2025, authorities decided to implement emergency vaccination against NDV in five counties with the highest outbreak incidence. The vaccination campaign targeted backyard poultry and was carried out by administering live vaccines via drinking water.

In contrast to HPAI, vaccination against NDV is widely practiced; however, the effectiveness of immunization programs depends on several factors, including the appropriate selection of vaccines (genotype homology), the quality of vaccine administration, the overall health status of the flock, and the level of biosecurity. According to the previously mentioned Regulation on the control of Newcastle disease, as of 13 May 2025, Poland has introduced a mandatory requirement to vaccinate all chickens and turkeys against NDV, including compulsory vaccination in hatcheries before birds leave the facility. In Poland, only live vaccines are registered for use in day-old turkeys. Vector vaccines against NDV are not registered for this species and therefore do not meet the requirements of the Regulation regarding the protection of turkey flocks against Newcastle disease. Although genotype VII is the virus detected in current outbreaks, no vaccines containing this genotype are presently registered in Poland.

Additionally, the Regulation imposes an obligation on poultry producers and the Veterinary Inspection to monitor the effectiveness of vaccination through serological testing.

Without addressing the issue of backyard poultry and improving vaccination effectiveness, NDV will continue to pose a significant challenge to the poultry industry. It is also important to remember that vaccination is only one piece of the puzzle, and without proper biosecurity measures, success is unattainable.


Danisco Animal Nutrition & Health

Advanced technologies and animal welfare go hand in hand – Producing for the Future

Jörg Hurlin[a], Dr. Anke Förster[b], Josefine Stuff[b]
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The poultry sector is experiencing rapid transformation through the development of advanced machines and automation technologies designed to address persistent challenges in animal welfare, operational efficiency, and sustainability. Automated grading and vaccination systems for broiler breeders, electron-based hatching egg disinfection in hatcheries, and in-ovo sexing for layers are notable examples of how these machines and processes are redefining farm equipment and hatchery operations. These technologies are currently most prominent in the broiler breeder and layer sectors, creating a foundation for further technological advancement and innovation across the wider poultry industry, especially for turkeys.

Advanced farm equipment for broiler breeders:

The poultry industry faces challenges such as labor shortages and rising operational costs. Tasks like weighing, sorting, and vaccinating broiler breeders as well as turkeys are more difficult due to a fewer qualified staff, high workloads, time pressure, and increased living costs.

For broiler breeders automated grading and vaccination technology offers a promising solution. These systems use robotics, near-infrared imaging, and real-time data analytics to improve flock management, reduce labor needs, and enhance animal welfare. High throughput, combining multiple tasks in one pass, and precise, gentle handling of birds help lower operational costs and workforce requirements. For the automated process birds are placed in moving cradles for automated weighing and, optionally, vaccinating with the Vaccybot system. Each bird is sorted into weight categories, with all data recorded and analyzed in real time. Individual weights are logged automatically for precise monitoring and management. The system calculates the average weight and coefficient of variation for consistent flock management. After processing, graded birds are gently released to minimize stress. The patented cradle design supports the birds, and high-precision weighing cells allow throughput of up to 3.000 birds per hour. Combining vaccination and grading in one process increases efficiency. For example, hourly performance improves from 2,136 broiler breeders (with 8-10 people manually) to 3,500 broiler breeders (with 5 people and GRADY), reducing labor time by up to 64%.

The Vaccybot, which can be added to the GRADY in broiler breeder farming, uses near-infrared (NIR) camera technology that penetrates thin layers of fog, dust, and smoke. This technology, used in surveillance cameras, night vision, biometric scanners, forensics, and medical imaging, is highly effective for monitoring and processing poultry in tough farm environments. A multi-axis robot moves along linear guides and a 2D rotary arm for precise three-axis control. This robotic system can be combined with cameras for quality control. The system detects moving chickens using both NIR and real images. High-speed processing merges the images into a 3D cloud, allowing the chicken breast to be identified and measured with sub-millimeter accuracy. The data is matched to a digital twin model. Target injection positions are determined by image matching against the millions of data points. The calculated injection points are sent to the multi-axis robot, which then injects at the target position with high precision. The Vaccybot system can vaccinate up to 2,800 broiler breeders per hour with up to six different vaccines. This leads to labor savings, increasing output per employee from 267 to 467 broiler breeders per hour, up to a 75% reduction in labor time.

Figure 1: *A multi-axis robot moves along linear guides and a 2D rotary arm for precise three-axis control*

Hatching egg disinfection:

Effective hatching egg disinfection reduces bacterial load, prevents the spread of diseases, improves hatchability, and enhances the overall quality of chicks. Several disinfection methods include ozone, UV light, formalin, and steam. Formalin, as a traditional, effective method, can affect embryonic development, pose health risks to workers, and impact the environment.

Accelerated electron technologies like the eggytizer replace traditional chemicals and UV light with a safe, chemical-free process that penetrates eggshells to destroy pathogens at the DNA level. Electrons are accelerated from a standard electrical current to high speeds and are directed toward the eggshell. These electrons interact with molecules in the shell, generating free radicals that break the DNA of pathogens and prevent replication. This method can reduce germ load by up to 5 log10 steps, outperforming the other disinfection methods. Incubation tests have shown improved hatchability (1.65% increase per eggs set), lower first-week mortality, and better biosecurity by reducing disease transmission and antibiotic use, with no harmful residues. Therefore, it is chemical-free, and environmentally friendly. This method is more effective, supports regulatory compliance, and is safe for both humans and animals. It also improves hatchability, reduces mortality, and enhances biosecurity.

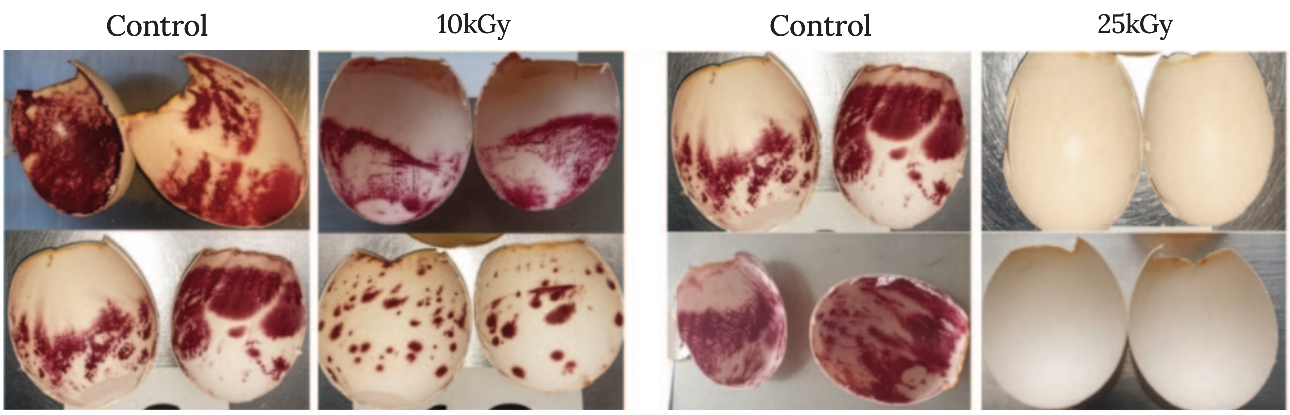

Figure 2: *Indicating bacterial growth by dark purple discolouration*

In-ovo sexing in the layer industry:

Male chick culling is a significant ethical and practical challenge for the layer hatchery industry, with over 7 billion male day-old chicks culled worldwide each year. Therefore, across Europe, more countries are banning the culling of day-old chicks. While there is no EU-wide regulation, Germany has prohibited the culling of day-old chicks since 2022. France implemented a ban on January 1, 2023, and Italy will enforce a ban by the end of 2026. As a result, the industry must consider how to comply with these laws. Three main approaches are under discussion: Growing of males of the laying hybrids (brothers of laying hens), change from specialized breeds to dual purpose lines and in-ovo sexing. The last one is currently emerging as the leading sustainable alternative to male chick culling.

With hyperspectral imaging technology, a detailed analysis of eggs by splitting images into many wavelength ranges is possible. Based on the sex-linked gold/silver factor used in the brown laying hybrids, males have silver/white plumage and females have gold/brown plumage. Once the first feathers appear during embryonic development, sex determination is feasible. The machine illuminates a set number of hatching eggs from below in a closed measuring chamber, while a hyperspectral camera captures images from above. A specialized algorithm then automatically identifies unfertilized and early dead eggs ("clear eggs") and determines the size of embryos in fertile eggs. Eggs with female embryos are incubated further, while clear eggs and those with male embryos are removed.

This process is resource-saving and sustainable. Unhatched eggs can be processed into dry egg powder, a high-quality protein source for feed and cosmetics. The system handles up to 25,000 eggs per hour, processing up to 20 million DOC per year. Advantages include environmental friendliness, low energy consumption, no consumables, and a compact design (29 square meters per unit). The system is fully automated, gentle with no hatching losses, accurate (97% on average), and non-invasive. This ensures no risk of contamination or negative impact on embryonic development.

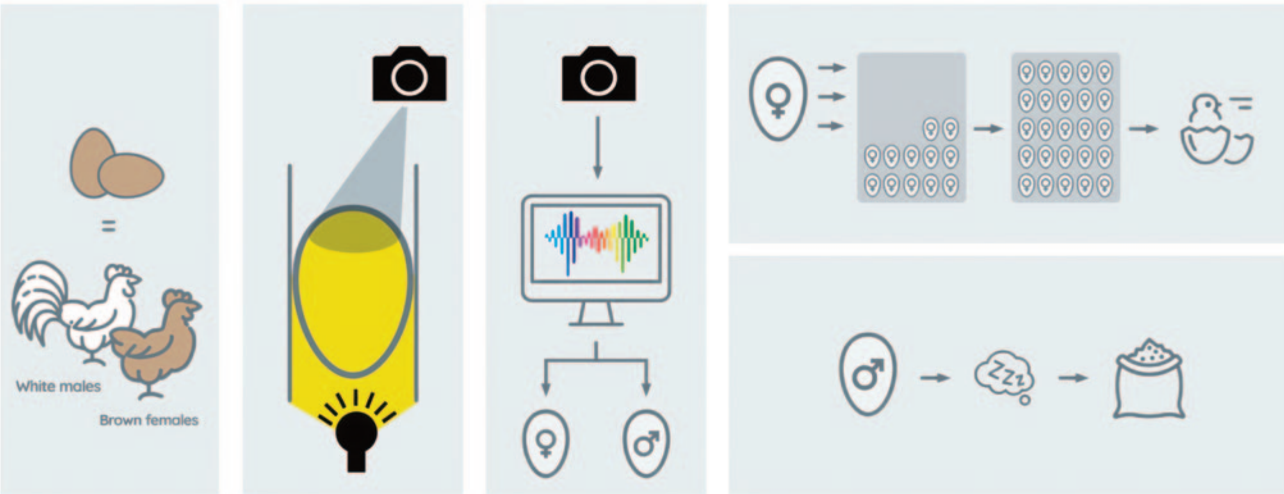

Figure 3: *Process overview: Hyperspectral imaging*

Future opportunities

In summary, advanced technologies and animal welfare are closely interlinked, paving the way for production for the future. These technological innovations collectively address important challenges in poultry production. Automated grading and vaccination systems, utilizing robotics and real-time analytics, have the possibility to reduced labor requirements by up to 64% and improved flock management precision. Electron-based egg disinfection technologies, such as eggytizer, have demonstrated a 5-log reduction in pathogen load without chemical residues, resulting in improved hatchability and lower first-week chick mortality. In-ovo sexing using hyperspectral imaging enables non-invasive, high-throughput (up to 25,000 eggs/hour) sex determination with up to 97% accuracy, mitigating the ethical issue of male chick culling and allowing resource-efficient repurposing of non-viable eggs.

Against the backdrop of increasing automation requirements in poultry production, the turkey sector offers a relevant but currently underdeveloped area of application for automation. Although these presented innovations have been widely adopted in broiler breeder and layer operations, there is still scope to adapt and customise automation solutions, such as automated vaccination and egg disinfection, for turkey production. Exploring these opportunities could yield significant improvements in biosecurity, labor efficiency, and animal welfare within the turkey sector. But also ongoing discussion and research are essential for advancing automation, fostering innovation, and encouraging new ideas for turkeys. Initial technical evaluations indicate that artificial insemination of turkeys could also be supported technically. AAT could thus address a previously underrepresented area of poultry production and strategically align future development programs with it. Such efforts will support continued progress and positive impact across all segments of the sector.

AAT and Turkeys

Agri Advanced Technologies GmbH (AAT) is a subsidiary of the family holding EW GROUP, headquartered in Visbek, Germany. AAT´s main field of activity is the development of specialized application technologies for poultry breeding. Thus, AAT is working closely together with its sister companies, e.g. AVIAGEN Turkeys.

Against the backdrop of increasing automation requirements in poultry production, the turkey sector opens up a relevant, but as yet only partially developed field of application. AAT could thus address a previously underrepresented area of poultry production and strategically align future development programs with it.

H5N1: Where have we been and where are we going?

Prof. Ashley C Banyard
Animal and Plant Health Agency GOV, UK

Since 2020, High pathogenicity Avian Influenza Virus (HPAIV) has decimated both captive and wild bird populations globally. Further there has been a shift in infection dynamics that has meant an extension of infection range in wild birds affected, as well as the detection of infection events in numerous wild mammalian species and the emergence of the virus in dairy cattle in the USA. The mechanisms driving these events are likely linked to both viral and host genetics.

Here the emergence of HPAIV in the UK and Europe is described alongside some of the significant events that have underpinned the emergence of this virus in different environments around the world. Further, we describe research efforts to try and better understand viral factors that have driven the emergence of these viruses in some species, whilst others remain unaffected.

Critical to this, factors effecting: receptor binding, and hence host susceptibility; replication kinetics in different species; *in vivo* assessments of policy relevant species; factors driving shifts in infection dynamics; bridges to mammalian infection and zoonotic risk and optimizing diagnostic pipelines are discussed.

Finally, we will describe potential future mitigating strategies to demonstrate how vaccination might aid in protecting the national flock but how significant hurdles need to be overcome to best design strategies for implementation of such mitigation strategies.

Keywords: *high pathogenicity avian influenza, pathogenicity, host susceptibility, zoonotic risk, vaccination approaches.*

H9 epidemiology in turkeys and new dimensions for H9 control using an innovative hatchery vaccine

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Avian influenza, both highly pathogenic (HPAI: H5/H7) and low pathogenic (LPAI: H9N2), remains a major global poultry disease.

LPAI-H9, usually cause respiratory disease complex with other respiratory disease pathogens like IB, ND and others. Therefore, it may be missed or underestimated if there is not a routine and comprehensive monitoring at the field.

To overcome the H9 challenge, Ceva Animal Health developed Newflend® ND H9, a recombinant herpesvirus vector vaccine (rHVT) expressing the NDV F gene and a consensus H9 gene designed to cover all major H9N2 lineages. Approved in Europe in 2023, the vaccine is administered in ovo or subcutaneously at hatcheries for chickens and turkeys. Immunity begins at three weeks for ND and four weeks for H9, with documented duration of nine weeks and likely longer due to the herpesvirus vector.

All immune channels induction, broad spectrum with consensus sequence, shedding reduction, lifelong continuous replication, and DIVA compatibility bring advantage of high and long lasting H9 and ND protection for every bird and every flock with an efficient monitoring.

EU legislation requires monthly swabs from 60 healthy birds and weekly swabs from dead or sick birds to monitor influenza A infections in vaccinated flocks. This study assessed two alternative environmental sampling methods—litter boot swabs and drinking cloths—in 56 turkey flocks across 23 farms in Lower Saxony, all vaccinated with Newflend® ND H9 at hatch.

H9 infection was detected in 46 of 56 flocks during fattening (up to 22 weeks) via RT-qPCR and at least one sampling method. Detection rates were significantly higher with environmental samples compared to conventional monthly swabs. Environmental samples consistently yielded positive results when conventional monitoring did and remained positive longer after initial detection. Farmers integrated these methods smoothly, appreciating their non-invasive, animal welfare-friendly nature.

Thanks to the vaccination, despite of H9 challenge at the field, production parameters are under control due to the H9 protection.

Our findings highlight environmental sampling as a cost-effective, sensitive, and practical tool to complement or potentially replace current intensive monitoring programs in influenza-vaccinated flocks, with possible application to HPAI vaccination monitoring.

Solving Incubation Problems

Dr Nick French
Consultant, UK

Successful incubation of turkey eggs depends on many factors, including:

1. good clean nest eggs,
2. good artificial insemination technique,
3. proper egg handling and storage prior to incubation,
4. correct incubation environment,
5. correct hatching environment,
6. optimizing hatch timing so that poults are not too young or old (dehydrated).

The definition of successful incubation is not only the maximization of hatching results, but also the hatching of vigorous poults that grow well when they reach the farm. The focus of this talk will be the ensuring that the incubation environment is optimal for hatching success.

Today we have a good understanding of the optimal incubation environment for turkey eggs. The most important factor is incubation temperature, and when we are talking about incubation temperature it is the temperature experienced by the embryo inside the egg not the operating temperature of the setter. It is difficult to measure the internal egg temperature during incubation, but it has been shown that the temperature on the eggshell surface (eggshell temperature, EST) can be a good estimate of internal egg temperature and in practice it is used as the target temperature for incubation. The target EST for turkey eggs is 37.8 ± 0.5°C (100 ± 0.9°F). Overheating is more critical to hatch and poult quality than underheating, which tends to delay hatch.

In the first half of incubation the EST will be close to the machine air temperature, but as the embryo starts to grow inside the egg it starts to produce a lot of metabolic heat, and the EST starts to exceed the operating temperature: how much will depend on the design and operating practice of the incubator being used. It would not be unusual for a single stage setter to have an operating temperature almost 2°C lower than the eggshell temperature on day 25 of incubation. In addition to managing the EST, incubator humidity, ventilation of fresh air into the setter and the regular turning of the eggs also need to be managed. It should be noted that, while all three factors have important effects on embryo directly, they will also impact EST and how this is managed will be discussed later.

Incubator humidity is important because it affects how much water the eggs lose during incubation. Eggshells are porous, primarily to allow the embryo inside the egg to breathe, but consequently it also allows water vapour to escape from the egg by diffusion. The loss of water from the egg allows an air cell to form in the blunt end of the egg and this space in the egg is essential during the hatching process to allow the embryo to inflate its lungs. If the air cell is too small the hatching embryo will not be able to fully inflate its lungs and therefore have insufficient oxygen to hatch resulting in unhatched pipped eggs. If incubator humidity is too high, then eggs will not lose enough water, and the air cell will be too small. If incubator humidity is too low, then the eggs lose too much water and the embryos become dehydrated.

We can measure how much water eggs lose by weighing them. All the egg weight loss during incubation is due to water loss so we can use egg weight loss as a method for controlling incubator humidity. As a target, turkey eggs should lose 11 – 12% of their fresh egg weight by day 25 of incubation. This target is the average egg weight loss of all the eggs in a batch, not for each individual egg within the batch. The water loss does not need to be at a uniform rate over the whole incubation period as long as the 11 – 12% target is achieved by day 25. Indeed, some studies have shown better hatch when eggs lose less water in the first half of incubation, and more water lose in the second half of incubation.

Egg water loss also has a small evaporative cooling effect on the egg, which may explain why losing more water in the second half of incubation improves hatchability as the extra cooling may reduce the risk of overheating in the second half of incubation.

Fresh air needs to be brought into the incubator to provide oxygen and remove carbon dioxide and water vapour from the setter. The fresh air entering the setter will also be cooler than the setter air and will provide some of the cooling capacity of the machine. Indeed, in some setters and hatchers the ventilation is the primary cooling system. So how much ventilation is required in a setter and hatcher will depend on what is its primary function. Table 1 shows the amount of ventilation required to remove the heat, carbon dioxide and water vapour in a single stage machine at 25 days. If the single stage setter does not have an alternative cooling system (water cooling pipes) then the ventilation would be determined by the heat removal.

Table 1: *The calculated ventilation requirement to remove heat, carbon dioxide and water vapour from a single stage incubator containing 10,000 80g fertile turkey eggs on 25 day of incubation.*

	Ventilation (m3 / hour)
Heat Removal	162.0
Carbon Dioxide Removal[a]	63.0
Water Vapour Removal	13.7

a. to maintain carbon dioxide at 4000 ppm

In practice, all single stage setters do have water cooling systems installed and so the amount of ventilation is normally dependent on carbon dioxide removal. The normal recommendation is that carbon dioxide levels in the incubator are maintained below 4000ppm, although higher levels (up to 10000ppm) are often allowed during the first third of incubation. Carbon dioxide is normally measured rather than oxygen because the ventilation required is higher and because carbon dioxide is easier to measure. If the setter is ventilated to maintain the carbon dioxide at 4000 ppm, then the ventilation will be sufficient to remove the water vapour lost from the eggs.

The above discussion on ventilation requirement is specific to the single stage incubator on 25 days of incubation, but for most of the incubation period, the ventilation required will be much lower. During the first half of incubation the developing embryos are very small and generated very little heat and carbon dioxide and only after 12 days do they start to significantly increase.

This means that single stage machines are normally operated with minimal ventilation up until 11 days of incubation to ensure that humidity does not become too high that condensation starts to occur within the machine. Carbon dioxide will increase up to 10000 ppm, but this does not appear to have any negative effects on hatch or poult quality. Some studies suggest that high carbon dioxide may be beneficial as it stimulates a more vascularised chorioallantois which assists oxygen uptake by the embryo. Humidity will also get high (>90 %RH) so the egg water loss will be very low for the first 12 days and so the rate of water loss (low humidity) must be increased during the second half of incubation.

The main benefit of closing the ventilation during the first 12 days is that the single stage setter operates in a much more stable way. Bringing cool drier air into the machine will normally require the heaters and humidifiers to operate more frequently and consequently there is an increased risk of hot and cold spots within the machine, creating a less uniform temperature environment.

While single stage incubation does not have to rely on ventilation for cooling, this is not always true in multistage incubators. Multistage setters contain eggs at 4 different stages of incubation, ideally seven days apart. Table 2 shows the required ventilation to remove heat, carbon dioxide and water vapour from a multistage setter. In this situation, more ventilation is required for water vapour removal than carbon dioxide removal, but if there is no water cooling the main requirement is still to remove heat.

The values for the ventilation requirement to remove heat shown in Tables 1 and 2 are slight overestimates because they do not take into account: (1) the cooling effect of water loss from the eggs; and (2) the cooling effect of humidifiers evaporating water to maintain the relative humidity. In some setters and hatchers, particularly those without water cooling systems, the extra cooling from the humidifiers can be critical to reducing the temperature.

Table 2*: The calculated ventilation requirement to remove heat, carbon dioxide and water vapour from a multistage incubator containing 10,000 80g fertile turkey eggs.*

	Ventilation (m3 / hour)
Heat Removal	22.5
Carbon Dioxide Removal[a]	9.6
Water Vapour Removal	13.7

a. to maintain carbon dioxide at 4000 ppm

The final factor for successful incubation is egg turning. To develop properly, turkey eggs need to be turned during the first 18 days of incubation once per hour. Eggs are placed in setter trays with the pointed end pointing down and then the trays are tilted at an angle of 38 - 45° from vertical first to the left and then after one hour to the right, so that the eggs pivot through 76 - 90°. Eggs that are not properly turned tend to have high early and late embryo mortality with a high incidence of malpositioned embryos.

In the second half of incubation, once eggs need to start losing heat, turning will also affect the EST. How quickly eggs lose heat depends greatly on how much air is flowing over the eggs and turning normally affects the airflow between the egg trays. One benefit can be that when the eggs are turned in one direction they may be in a faster or slower air flow, but after 1 hour they are then moved to a new position with a different air flow and the EST changes. Effectively the turning helps by moving the eggs from warmer to cooler conditions and back again so on average the EST is equalised. A second potential benefit can be obtained if the trays are levelled after day 18 to increase the space between trays. This increased space improves the airflow resulting in cooler EST. How effective this is will depend on the machine design, but it has been done successfully with some machine types.

All the discussion to this point has been to describe how temperature, humidity, ventilation and egg turning interact with each other and how this can be impacted by different incubator and hatcher designs. How can this information be used to solve incubation problems? How can we optimise our incubation environment to ensure maximum hatch and poult quality?

The main target is to achieve a uniform target EST (37.8 ± 0.5°C) throughout the setter and hatcher. The main causes of EST variation are: (1) Incorrect setter operating temperature, (2) Variation in airspeed over the eggs (3) Over-ventilating the setter resulting in too much cool air entering the setter, and heaters / coolers / humidifiers operating more than necessary. However, it is still important to ensure that the correct egg water loss and carbon dioxide levels are achieved, and these targets need to be balanced with the EST target.

The first step is to understand how your incubators and hatchers operate. The incubator manufacturers will provide the basic settings for their machines, but much can be learned by watching how the machines operate: how much and when heaters, coolers, humidifiers and ventilation come on and off. This needs to be combined with monitoring the incubation environment at the level of the egg.

EST can be monitored using infrared ear thermometers, or even better small data loggers with probes attached to the shell surface. Egg water loss can be monitored by weighing eggs through incubation, normally by weighing whole trays of eggs. Carbon dioxide levels can be checked using gas diffusion tubes or accurate carbon dioxide meters.

Airflows within setters can be measured using a thermal anemometer, and ventilation rates by vane anemometers. In some machine designs (but not all) it is important to maintain a pressure differential between air inlet and air exhaust to ensure sufficient ventilation, and this will need to be checked using a manometer. Egg turning needs to be checked using an angle meter. These are the basic monitoring tools every hatchery should have.

So how do we bring all this information together? Let's look at two scenarios:

Scenario 1

Poor hatch results with late embryo mortality and high incidence of cracked eggs. Thin, very active and noisy poults at hatch. High ESTs (39 - 40°) measured during the last week of incubation throughout the setter. Looking inside the setter eggs are being cracked during egg turning and when fully turned there is very little space between trays of eggs. Hatch loss is occurring because, firstly eggs are being broken by the trays being too close together and secondly airflow is impeded between the trays resulting in overheating.

The ideal solution to this problem would be to increase the spacing between the egg tray to improve the airflow, but this may result in a reduction in setter capacity. An alternative solution may be to reduce the angle of turn from 45° to 40°, which will increase the space between the setter trays, reducing the risk of cracked eggs and improving the airflow. If practically possible, the trays could be levelled after day 18 to further increase the airflow across the eggs.

Scenario 2

A large variation in hatch results between hatcher trays, with some trays having a high incidence of pipped unhatched eggs and late hatching poults. Measuring EST in the setter shows that some areas within the machine are cooler than others. Carbon dioxide readings are below 3000ppm. Watching the setter operate, the humidifiers are coming on very frequently. All the information suggests that the setter is being over-ventilated resulting in cool spots in the machine from entering fresh air and excessive humidification.

These two scenarios show how information is brought together with an understanding of what is required by the embryo and how the setter, or hatcher, operates. It should also be noted that hatcheries obtaining good result invariably have good maintenance and calibration programs. Many issues are caused by machine sensors out of calibration or machines not functioning correctly.

New Marketing Opportunities for the Turkey Industry

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Abstract
Turkey meat production in the United States and the European Union has been steadily declining over the past five years due to a wide range of contributing factors. These include recurring outbreaks of avian influenza, the introduction of stricter animal welfare standards and other regulatory requirements, the transition of many turkey producers to broiler production, growing competition from pork and chicken, as well as several additional structural challenges within the industry.

As a consequence, consumers are increasingly shifting toward alternative protein sources, either excluding turkey from their regular diets altogether or limiting its consumption to seasonal holidays and special occasions. Projections based on this negative trajectory indicate that the turkey industry could shrink by as much as 50 percent by 2050, a development that would pose significant risks for a large number of industry stakeholders.

Traditional meat markets in North America and Europe clearly demonstrate an inability to sustain stable sales volumes of turkey meat, largely due to insufficient innovation and limited promotional activity. At the same time, new and emerging markets show minimal interest in turkey products, primarily because limited availability prevents consumers from developing a clear understanding of turkey meat's characteristics, versatility, and nutritional benefits.

Meanwhile, global population growth continues to drive rising demand for animal protein, particularly meat. Beef production has been declining for several consecutive years at an accelerated pace, leading to worldwide price increases and making beef increasingly unaffordable for a growing share of consumers.

In this context, turkey meat represents a unique opportunity to fill the emerging gap in the protein market by offering a healthier, nutritious, and more affordable alternative to red meat. This opportunity applies to both traditional and emerging markets, particularly in the Middle East and North Africa, Southeast Asia and China, Sub-Saharan Africa, and Latin America.

The time has come to reposition turkey meat in the minds of consumers and to actively promote its advantages on a global scale. To achieve this, the turkey industry must consolidate its efforts and adopt advanced marketing strategies, with a particular focus on younger generations of consumers who will be key to ensuring long-term, sustainable demand and securing a strong future for all industry stakeholders.

Turkey gut health update: latest trends in coccidiosis and necrotic enteritis

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Introduction

A recent European survey of turkey veterinarians and production professionals identified necrotic enteritis and coccidiosis as leading health concerns in commercial turkey production.

Caused by protozoan parasites of the genus *Eimeria*, coccidiosis compromises intestinal integrity, leading to impaired nutrient absorption, reduced growth performance, increased feed conversion ratios, and, in severe cases, mortality. By affecting intestinal integrity, coccidiosis predisposes birds to secondary infections such as necrotic enteritis (NE).

To date, seven *Eimeria* species have been described in turkeys. Among these, *Eimeria meleagrimitis*, *Eimeria adenoeides*, *Eimeria gallopavonis*, and *Eimeria meleagridis* are considered pathogenic, whereas *Eimeria dispersa*, *Eimeria innocua*, and *Eimeria subrotunda* are generally regarded as low- or non-pathogenic (Chapman, 2008, Vrba and Pakandl, 2014). *E. meleagrimitis*, *E. dispersa*, *E. innocua*, and *E. subrotunda* have been reported to replicate primarily in the duodenum and/or mid-intestinal regions. Lesions in the lower intestine have also been described and may be associated with infections caused by *E. adenoeides* and *E. meleagridis*, which can result in caecal cores, or by *E. gallopavonis*, which is linked to caseous lesions in the lower jejunum, ileum, and caecal neck (El-Sherry et al., 2018; Gadde et al, 2019). With the exception of *E. subrotunda*, the morphology and pathogenicity of turkey *Eimeria* species have been confirmed using pure *Eimeria* lines.

The availability of molecular diagnostic techniques provides possibility for more accurate identification of *Eimeria* species than conventional microscopy, as overlap in oocyst size among species increases the risk of misclassification. With the exception of *E. subrotunda*, species-specific primers have been described for all recognized turkey *Eimeria* species. Application of these molecular approaches has revealed a close genetic relationship between *E. adenoeides* and *E. meleagridis*. As a result, these species have been classified by some authors as a single species (Vrba and Pakandl, 2014), whereas others continue to recognize them as two distinct species (El-Sherry et al., 2015; El-Sherry et al., 2018).

Prevalence and identification of *Eimeria* species in European turkey flocks

Despite the high prevalence of coccidiosis in turkey flocks, data on the prevalence of the different *Eimeria* species in turkey flocks are limited. Therefore a survey was conducted on prevalence and identification of coccidiosis in turkeys, using microscopy and PCR techniques. In total, 387 samples collected between 2019-2025 from 127 different commercial turkey farms located in 7 different EU countries and UK, were investigated. The age of the turkeys at sampling ranged between 1 and 15 weeks, with a median of 6 weeks. Samples were collected using a standardized protocol with the request to collect intestinal and cecal droppings on well distributed places, according to a sampling scheme, in the turkey houses. It should be noted that samples were collected both from farms experiencing gastrointestinal health issues and from farms without reported problems for monitoring purposes. In addition, for the majority of samples obtained from birds younger than 8 weeks of age, coccidiostats were present in the feed at the time of sampling.

First, samples were microscopically examined for identification of *Eimeria* species and determination of oocyst per gram (OPG) in the same laboratory. In 118 of the 387 samples no oocysts could be detected. In 25% of the 269 positive samples, OPG ranged between 200-1000, in 27% between 1000-10.000; in 33% between >10.000-100.000 and 15% of the samples had an OPG higher than 100.000. Microscopic examination differentiated between the following groups: *E.meleagrimitis/E.adenoeides*; *E. dispersa*, *E. meleagridis/E. gallopavonis* and *E. innocua*. In 95% of the positive samples *E.meleagrimitis/E.adenoeides* were identified, in 10% of the samples *E. dispersa*, in 39% *E. meleagridis/E. gallopavonis* and in none of the samples *E. innocua*.

Further identification of *Eimeria* species was performed by qPCR on 47 samples from 31 different farms, using the primers described by Vrba et al. (2010). Overall, qPCR results were consistent with microscopic identification but allowed for individual differentiation. The prevalence of *E. meleagrimitis*, *E. meleagridis*, *E. adenoeides*, *E. gallopavonis*, *E. dispersa* and *E. innocua* as determined by qPCR was respectively 72%, 33%, 17%, 9%, 26% and 0%.

E. meleagrimitis was the most prevalent species and was detected throughout all ages. With increasing age of the turkeys, co-infections with multiple *Eimeria* species or infections with other species alone were more frequently observed. In Europe, control of coccidiosis is achieved through the inclusion of coccidiostats in feed, the majority of which are ionophores. In other markets outside Europe, coccidiosis vaccines are also available, with vaccination representing a potential alternative control strategy.

Necrotic enteritis

As *Eimeria meleagrimitis* primarily replicates in the duodenum, infection with this species may compromise intestinal integrity and thereby predispose turkeys to the development of NE. Outbreaks of NE have emerged as an increasing health concern in commercial turkey production. These outbreaks typically occur in turkeys between 4 and 8 weeks of age, are often observed during the spring period, and are characterized by a sudden increase in mortality. The most prevalent *Clostridium perfringens* toxinotype associated with necrotic enteritis outbreaks in turkeys is toxinotype A. Additional toxins detected in *C. perfringens* strains isolated from clinical outbreaks in turkeys include beta2 toxin and, less frequently, netB (Giovanardi et al., 2016; Lyhs et al., 2013; Vereecken et al., 2022).

In susceptibility testing against the most frequent used ionophores in turkeys (monensin and lasalocid) low MIC values have been observed, indicating the importance of other predisposing factor for the development of clinical NE (Vereecken et al., 2022).

In a recent study (Cordioli et al., 2025), necrotic enteritis (NE) was experimentally induced using established predisposing factors commonly applied in chicken models, including a sudden switch to a high-protein diet and infection with *Eimeria meleagrimitis*. Turkeys were subsequently challenged with *C. perfringens* strains differing in their genetic virulence profiles, isolated from chickens and turkeys affected by necrotic enteritis. Infection with a netB-positive *C. perfringens* strain originating from a chicken NE outbreak resulted in high mortality (80%) as well as pronounced macroscopic and microscopic intestinal lesions in turkeys, whereas no mortality was observed in birds infected with a netB-negative strain isolated from a turkey NE outbreak. These findings demonstrate that successful reproduction of NE in turkeys is strain-dependent and questions the toxins involved in the pathology.

In conclusion, *Eimeria meleagrimitis* is currently the most prevalent *Eimeria* species detected in commercial turkey flocks. Nevertheless the importance of *Eimeria meleagrimitis* in the pathogenesis of necrotic enteritis, additional factors, including strain-specific virulence factors, are critical contributors to disease development.

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Adapting to a changing world: Artificial intelligence and the future of the poultry meat industry

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1. Introduction: Adapting to a Changing World

The poultry meat industry has achieved its position as the world's leading meat protein through decades of optimisation, innovation, and strong on-farm management. Yet the pace of change affecting the sector today is unprecedented. Consumer expectations, welfare scrutiny, environmental pressures, labour constraints, disease risk, and economic volatility are all intensifying at the same time. These forces are not operating independently; they interact in ways that amplify complexity and risk across the entire value chain.

For poultry growers and the wider industry to remain resilient, productive, and trusted, adaptation is essential. Incremental improvements alone are no longer enough. Decision-making must evolve from largely experience-based and retrospective approaches toward systems that are predictive, objective, and evidence-driven. Artificial intelligence (AI) represents one of the most powerful tools available to support this shift. This paper sets out to demystify AI, ground it in real poultry production, and explore how it can support birds, people, and businesses both now and in the future.

2. What Is Artificial Intelligence?

If AI is to be meaningfully adopted, it must first be understood. Too often, AI is perceived as abstract, complex, or disconnected from practical farming. In reality, AI is best described as the replication of human senses and judgement, combined with the ability to solve complex problems at a scale and speed that humans cannot achieve alone.

At farm level, poultry producers already rely on sight, sound, and experience to assess birds: how evenly they are distributed, how active they are, whether behaviour has changed, or whether something feels "not quite right." AI mirrors these same processes using cameras, microphones, and data streams, but does so continuously, objectively, and without fatigue. It observes patterns over time, learns what is normal, and highlights deviation early.

Crucially, AI is not a single technology and it is not about replacing people. It is a set of tools that augment human expertise by analysing large volumes of data, identifying trends and relationships, and supporting more consistent decision-making. AI is already deeply embedded in everyday life, often without us realising it. Automatic number plate recognition systems use cameras and algorithms to identify vehicles in real time. Navigation apps such as Google Maps continuously analyse traffic patterns and reroute journeys dynamically. Smartphones use AI for facial recognition, voice control, and image sorting. These familiar examples help de-alienate AI: we already trust it to guide, protect, and assist us. The same underlying principles can be applied in poultry production.

3. Challenges Facing Poultry Production

The relevance of AI becomes clearest when the industry reflects on what it is fundamentally trying to manage. Poultry production is not the farming of buildings, ventilation systems, or equipment; it is the farming of birds. Birds are living organisms operating within a complex biological web influenced by genetics, nutrition, environment, health status, and human intervention. Yet many of the tools historically used to manage poultry focus on controlling inputs rather than directly measuring outcomes at bird level.

At farm level, growers are expected to manage increasingly complex biological systems with fewer skilled people, tighter margins, and greater scrutiny. Labour availability and capability are under sustained pressure, while biosecurity risks continue to rise with severe financial and emotional consequences when failure occurs. Alongside this, producers are asked to evidence best practice in welfare and management, often through indirect or proxy measures rather than direct observation of the bird itself.

This creates a disconnect. Ventilation rates, temperature set points, lighting programmes, and feed specifications are all important, but they are means to an end. The true indicator of success or failure lies in how birds respond. Without objective, continuous measurement of bird behaviour, growth, and distribution, producers are left managing a complex biological system largely through inference.

Beyond the farm gate, these challenges are amplified at industry level. Poultry sits at the centre of increasing tension between consumer expectations, animal welfare, environmental sustainability, and economic reality. NGO pressure, retail audit schemes, and evolving standards have introduced layers of complexity that often prioritise system design and compliance over measurable bird outcomes.

Historically, the industry has responded by adding more prescriptive rules, audits, and standards. While often well intentioned, this approach has led to unintended consequences: increased administrative burden, conflicting requirements, and standards that do not always reflect how birds actually perform or experience their environment. In effect, the industry has become better at measuring systems than measuring birds.

To adapt successfully, this imbalance must be addressed. The future resilience of poultry production depends on shifting the focus from managing assumptions to measuring reality. Objective, bird-centric measurement is essential if the industry is to navigate biological complexity, defend or reshape standards, and align welfare, environmental, and economic goals in a credible and sustainable way.

4. Where My AI Journey Began

My own engagement with AI did not originate from an interest in technology itself. It started on my farm, driven by the same pressures experienced by poultry growers across the sector. Labour was becoming more constrained, expectations around welfare evidence were increasing, and I wanted a better understanding of how birds were actually responding to management decisions—not just how I believed they were responding.

At the heart of this journey was a simple, bird-centric belief: if we help birds grow better, everything else follows. Performance, welfare, efficiency, and resilience are all downstream of how well birds are supported throughout the production cycle. The challenge lay in finding a reliable and objective way to understand birds continuously, rather than through periodic checks or subjective observation. AI offered a potential pathway to achieve this.

5. The AI Solution on My Farm

The AI system introduced on my farm is based on computer vision. Cameras installed in the sheds observe birds continuously, analysing movement, distribution, activity, and growth patterns twenty-four hours a day. This creates a fundamentally different management dynamic. Instead of relying on intermittent sampling and human interpretation, bird behaviour and performance are measured objectively and consistently.

This continuous measurement matters because change in biological systems is often gradual. AI enables early identification of subtle shifts in behaviour or growth that would otherwise go unnoticed until they manifest as a larger problem. Importantly, concerns around complexity proved largely unfounded. Installation was straightforward, systems run largely autonomously once in place, and data is presented in a clear, accessible format that supports rather than complicates decision-making.

6. Benefits and Practical Outcomes

One of the most immediate benefits observed has been a clearer understanding of weight distribution and uniformity. Rather than relying on periodic weighing, AI provides a continuous view of how the crop is developing, highlighting divergence early and enabling more timely intervention. Behavioural insights, such as changes in feeder and drinker activity or huddling patterns, have been particularly valuable when viewed alongside growth data. These combined datasets have helped link environmental or management factors directly to uniformity outcomes.

Feed programmes and vaccination plans have also benefited from this enhanced visibility. Decisions can be aligned more closely with how birds are actually developing, rather than with assumed timelines. Beyond bird management, AI has delivered value in people development. Staff benefit from objective, visual feedback that supports learning and confidence. Vets and nutritionists gain access to shared datasets that allow more meaningful analysis and more informed recommendations.

The value of these insights extends beyond the farm gate. Integrators benefit from improved predictability and reduced variability. Retailers gain stronger, evidence-based welfare assurance. Technical specialists can move from anecdotal discussion to data-driven collaboration. AI therefore creates value across the entire supply chain, not just at the point of adoption.

7. AI Today and Tomorrow

Looking ahead, the potential of AI extends well beyond current applications in bird monitoring and day-to-day decision support. One of the most significant, and often overlooked, opportunities lies in AI's ability to reduce risk within poultry enterprises and, in doing so, fundamentally change how those businesses are perceived and financed.

On farm, as AI systems mature, they will move increasingly from descriptive insights toward predictive and prescriptive capability. The expansion of behavioural indicators, deeper cause-and-effect analysis, and continuously improving management recommendations will allow producers to identify risk earlier and intervene with greater precision. Health challenges, welfare issues, and performance deviation can be detected sooner, reducing both biological and financial volatility. Stronger biosecurity insights will further support resilience by helping anticipate and mitigate threats rather than simply reacting to them.

From a business perspective, this reduction in variability has profound implications. Poultry enterprises are capital-intensive, long-term investments that are highly exposed to biological, market, and regulatory risk. AI-driven insight has the potential to make these risks more visible, measurable, and manageable. When bird outcomes, welfare performance, and operational consistency can be demonstrated objectively over time, uncertainty is reduced.

This level of insight has relevance beyond the farm gate. Lenders, investors, and integrators all seek confidence in predictability and control. AI can provide a data-backed narrative that demonstrates robust management, early risk detection, and consistent outcomes. In doing so, it has the potential to support access to capital on more favourable terms, reduce the cost of finance, and underpin investment decisions with evidence rather than assumption.

At an industry level, the aggregation of AI-driven data opens further opportunity. Objective measurement at scale could inform welfare standards that are grounded in bird response rather than system design, reducing regulatory uncertainty and investment risk. By aligning welfare, environmental sustainability, and economic performance through measurable outcomes, AI can help create a more stable and investable sector.

Ultimately, AI is not simply a production tool; it is a risk management and assurance mechanism. Its ability to bring clarity to complexity may prove just as valuable in supporting long-term enterprise resilience and capital confidence as it is in improving day-to-day crop performance.

8. Adoption, Change Management, and Funding

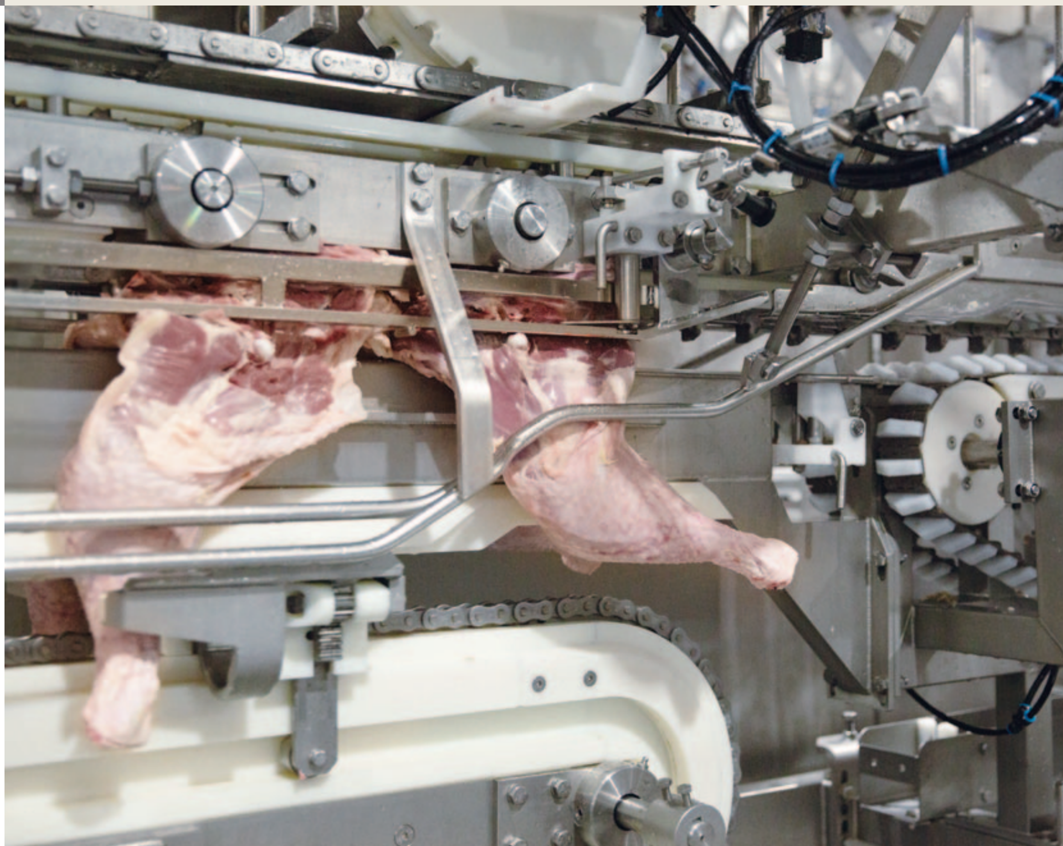
Technology alone does not deliver transformation. Successful AI adoption requires cultural change, skills development, and trust. Producers must be comfortable with data-led decision-making and with sharing information responsibly across the value chain. This is particularly important if AI is to support the evolution and defence of standards.

Funding presents an additional challenge because AI delivers value across multiple stakeholders. Models that recognise shared benefit—such as partnerships, subscription approaches, or outcome-based pricing—are likely to be more effective than expecting individual actors to carry the full cost of adoption.

9. Conclusion

Artificial intelligence is not a passing trend. Trillions are invested globally each year, with growth rates exceeding 30 percent annually. The question facing the poultry sector is not whether AI will play a role, but how thoughtfully and collaboratively it will be integrated.

AI is never finished. Unlike traditional equipment, it learns continuously, evolving as more data is generated. This demands a mindset shift and ongoing cultural adaptation. For me, AI has reinforced a fundamental principle of poultry production: when we truly understand our birds, better decisions follow. Used responsibly, AI strengthens good stockmanship, supports resilience, and helps the industry adapt confidently to a changing world.



Automation level in Turkey Processing Plant

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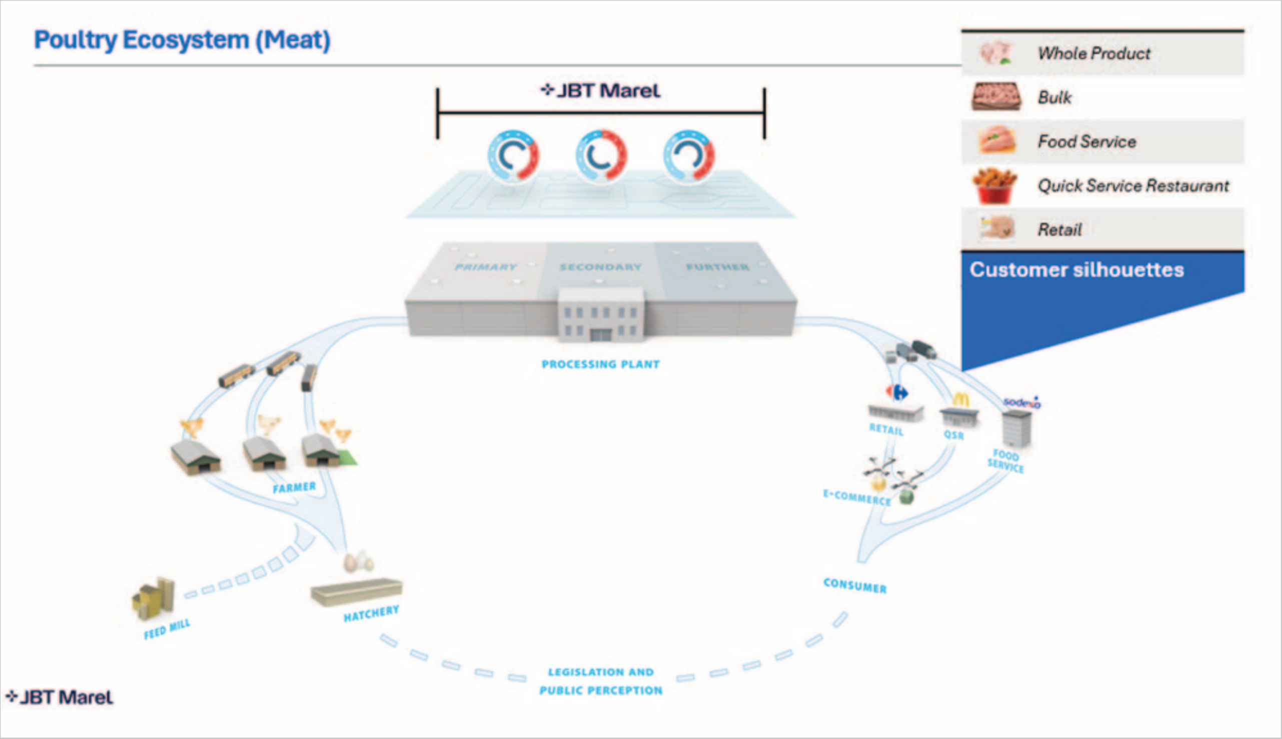
Turkey processing automation in relation to chicken processing automation.

Often when people talk about turkey processing automation, the chicken processing automation is seen as the benchmark.

The "ecosystem" for a chicken processing plant or a turkey processing plant are similar. The main difference is in the customer mix as the turkey end products are mainly missing in the quick service part and limited present in the HoReCa/Foodservice segment.



Exploring turkey processing automation in relation to chicken processing reveals an interesting intersection of technology, efficiency, and sustainability in poultry production. Both turkey and chicken processing share many similarities, but turkey automation systems often need to be tailored due to differences in bird size, anatomy, and market demands.

Hereby a summary of the similarities and differences:

1. Similarities Between Turkey and Chicken Processing Automation

- **Basic Processing Steps:** Both involve stunning, bleeding, defeathering, evisceration, chilling, cutting, and packaging.
- **Automation Goals:** Increase throughput, improve food safety, reduce (skilled) labor costs, and enhance product consistency.
- **Technology Used:** Overhead conveyor systems with automated slaughtering and evisceration equipment. Systems for quality control. And automated cut up and deboning equipment.

2. Differences and Challenges in Turkey Processing Automation

- **Size and Weight:** Turkeys are larger and heavier than chickens, requiring more robust handling equipment and slower processing speeds. Especially the big difference between male and female turkeys enlarges the challenge in automated turkey processing.
- **Anatomical Differences:** Different body proportions mean that cutting and deboning machines must be adjusted and specially designed.
- **Throughput Rates:** Chicken processing lines generally run faster due to smaller bird size and higher market demand. It is more common in a chicken plant to run double shift then it is in a turkey processing plant.
- **Product Variability:** Turkey products often include whole birds, large parts (breasts, deboned drumsticks and thighs) and a single plant often supplies all types of customers. In the chicken it is often common to have a processing plant dedicated to a certain customer silhouette.
- **Market scale:** Chicken is produced and consumed at much larger volumes globally, which drives more investment in highly optimized, high-speed automation. Turkey processing lines may be less automated or use semi-automated processing technology due to smaller market scale.

Looking to the automation its selves then we can see the following:
In the first part of the processing plant, the primary processing the automation level between chicken and turkey is on a similar level, except of the chilling of turkey due the larger product size and the required chilling times.

In the second part after the chilling, the secondary processing which contains cut up and deboning the automation level is more simplified due to the difference in product variability and market scale. But when it is compared with pork processing there is more automation in a turkey processing plant.

The biggest difference in turkey processing and chicken processing is the part we call further processing. The chicken is far advanced in this part which is also brings often best added value. For instance, chicken wings, the variety on burgers and nuggets.

Managing bodyweight in the modern female turkey breeder: Effects on growth and egg production

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Introduction

The genetic potential of the commercial turkey has evolved rapidly over the last decade, driven by balanced selection for feed efficiency, breast meat yield, and growth rate alongside maintaining good reproductive performance, good health and high welfare. These changes in biological potential necessitates a practice of continuous review and updating of rearing management strategies, particularly concerning female breeders (Aviagen Turkeys, 2024). The traditional view of the rearing period as merely a holding phase before photostimulation is increasingly obsolete as the impact this period has on subsequent performance becomes better understood. Modern turkey genotypes exhibit a propensity for rapid early development and recent industry analysis suggests that the first few weeks of life constitute a critical 'investment phase' where physiological templates for future performance are established.

The management of bodyweight to breeder targets during the brooding and rearing phases is paramount, failure to achieve these targets often requires corrective interventions later in life. Recent literature indicates that such corrective actions can be as detrimental to flock uniformity and subsequent egg production as the initial weight deviation itself (Flores et al., 2022). Consequently, the primary objective for flock managers is to achieve a consistent growth trajectory that closely follows the natural growth profile in rear.

Why Early Weights Matter

The initial weeks of a turkey poult's life are often viewed simply as a starting period for weight gain. However, recent insights suggest this phase has a stronger impact on future development than previously realised and can be considered a principal determinant in setting the metabolic and physiological trajectory for life. Therefore, resources and management applied in these first few weeks should be seen as an investment.

Skeletal muscle growth in turkeys during the post-hatch period is primarily driven by the proliferation and differentiation of satellite cells (Velleman et al., 2010). Studies have explained the critical role these cells play in determining the long-term structural integrity and metabolic capacity of the bird. Yu et al. (2025) demonstrated that early rapid growth stimulates greater satellite cell proliferation. Crucially, this early proliferative phase is subject to epigenetic regulation. Variations in early nutritional status and growth rate can induce epigenetic modifications that permanently alter gene expression patterns in muscle tissue (Reed et al., 2022). These modifications effectively 'lock in' the metabolic characteristics of the muscle, rendering later attempts to constrain growth less effective. If a flock is allowed to deviate significantly from its target growth curve in the first weeks of life, the satellite cell population may be programmed in a way that is resistant to later management interventions.

As the industry is asking the modern commercial turkey for improved growth year on year, this means breeders also have the potential to exhibit higher growth rates and overshoot recommended bodyweight profiles. Because of this genetic improvement, management practices need to evolve in keeping with these changes.

Rearing Bodyweight and Reproductive Performance

Internal data from industry observations often shows that flocks with a smoother, slower growth profile in the first half of rear outperform those that had a volatile growth curve. Similarly, there is negative correlation between early excessive rearing bodyweight and the succeeding reproductive performance. The act of forcing bodyweight back to the target line creates a metabolic pressure (Hadinia et al., 2020). When a bird grows aggressively in the early rearing period, and, through changes in diet phasing, has its growth slowed to meet breeder targets, it experiences significant physiological disruption. Because of this, bringing the bodyweight back to target profile needs careful and proactive management through diet phasing otherwise this "shark toothing" cycle (seen in figure 1) can disrupt the hormonal signals required for the development of the reproductive tract resulting in poorer reproductive performance.

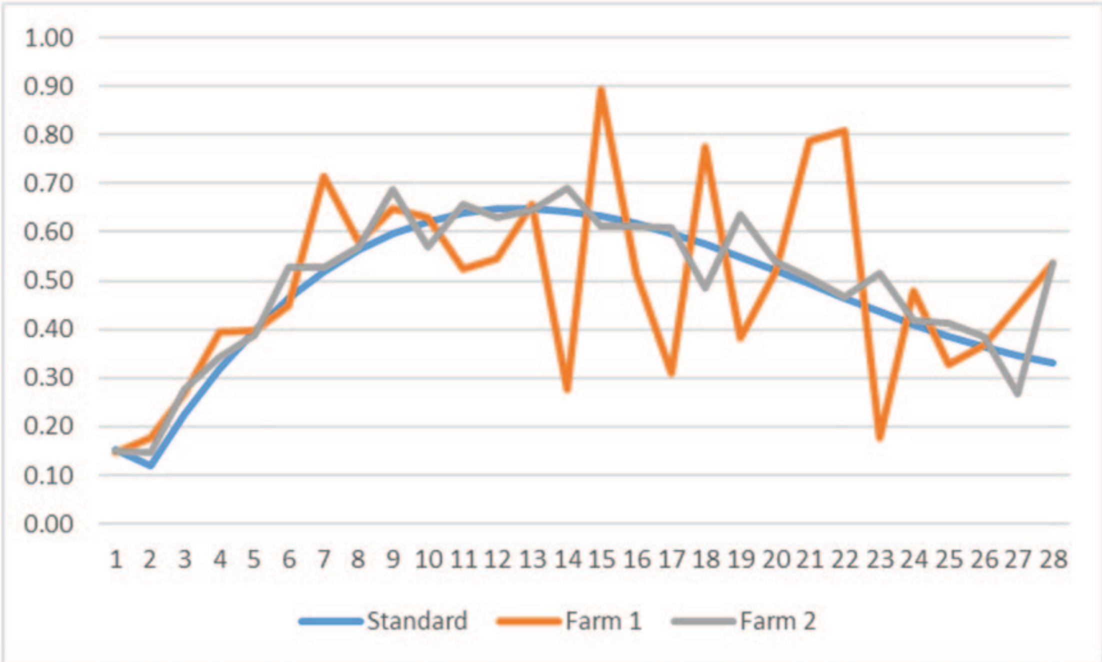


Figure 1 – *Example of weekly weight gain in a "shark toothing" flock (Farm 1) against a controlled flock (Farm 2) which shows a smooth transition into each phase resulting in less physiological disruption.*

The majority of flocks in recent years demonstrate high growth in the first few weeks of life; analysis of flock data from 2020 to 2025 shows a negative correlation between early bodyweight gain and 24-week egg production numbers (see figure 2). These figures are collected from turkey parent stock breeders across Europe, which provides a robust understanding of how the bird is developing and how the bird should be managed. From this data we can see that regulating growth in the first few weeks of life positions the bird to produce a higher number of eggs in the breeding period.

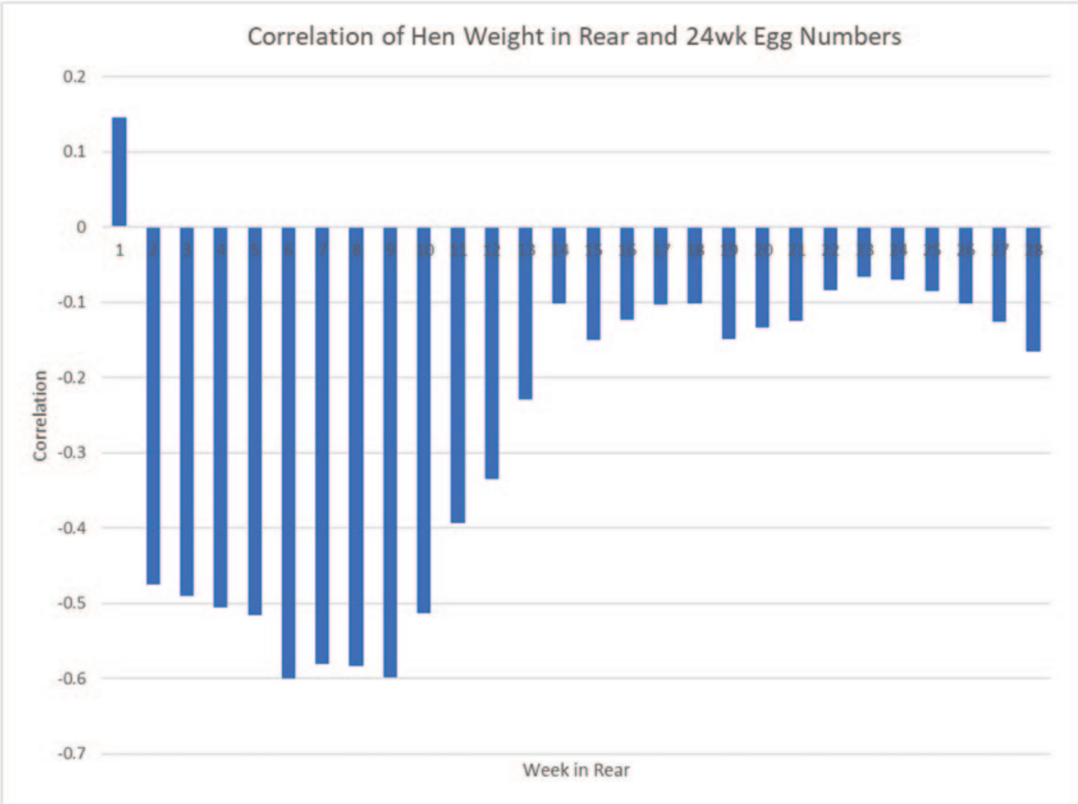
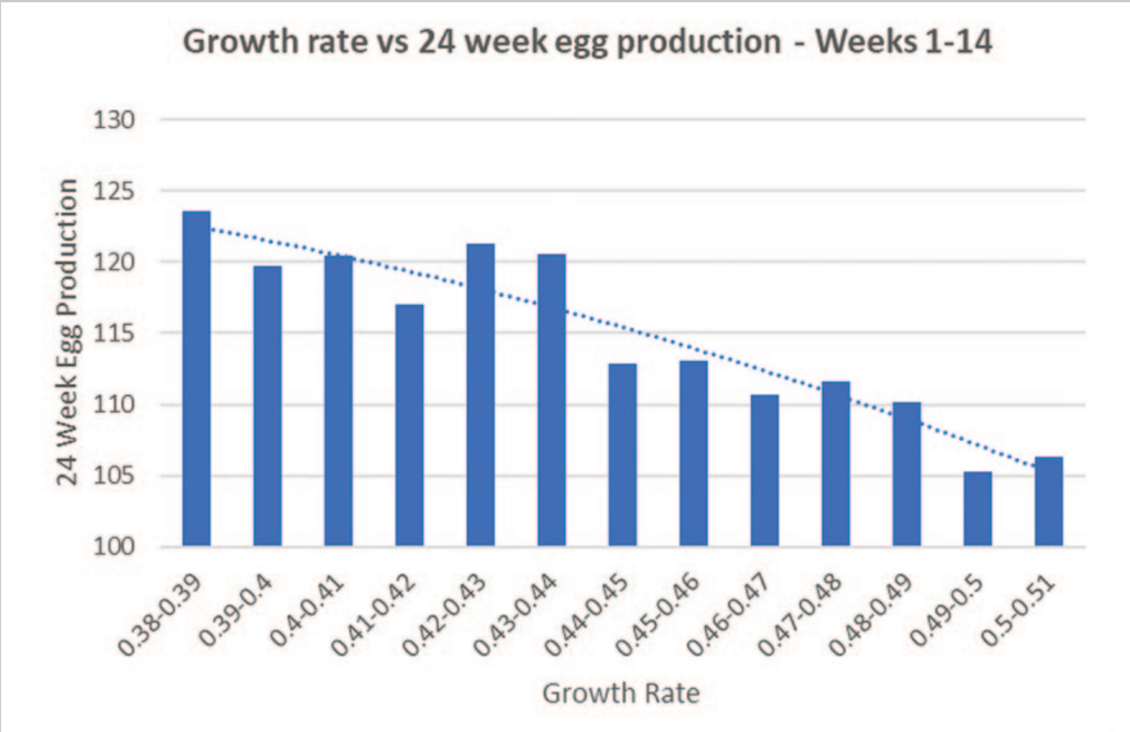


Figure 2 *– Correlation of hen weights in rear and 24-week egg production. A negative correlation indicates more eggs were produced by lighter flocks.*

Additionally, the nature of that growth is as important as the absolute weight. Flocks that exhibit a slower growth in the first half of rear tend to have better uniformity at the point of photostimulation. Uniformity is a critical factor for flock performance, a uniform flock responds simultaneously to light stimulation, resulting in a high peak of production and persistent lay (Aviagen, 2023). In contrast, flocks that have been subjected to 'shark-tooth' growth curves, characterised by periods of rapid gain followed by slower growth, often display poor performance.

As shown in figure 3, flocks that grow slower in the first 14 weeks of rear are associated with better reproductive performance. Regulated growth in this period avoids the need to constrain excessive growth for the rest of the rearing period and predisposes to a more positive growth trajectory to sexual maturity (figure 4). This will help support the reproductive tract development (Noetzold, 2025) and transition to production without imposing stress.



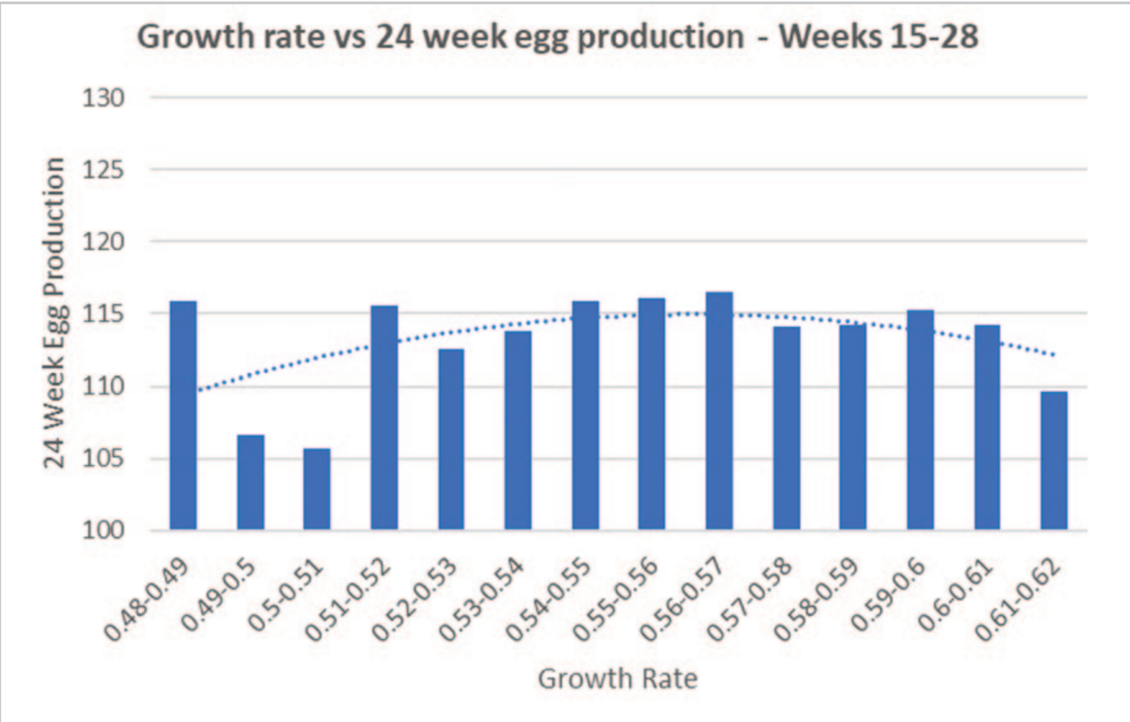


Figure 3 and 4 *– Relationship between growth rate in the first 14 weeks and growth rate between 15 and 28 weeks with 24-week egg production results. Slower growth in first 14 weeks is associated with better egg output, where the opposite can be seen in the second half of rear.*

Nutritional and Flock Management

Achieving the growth targets required by modern turkeys demands a careful approach to nutrition and flock management. The traditional practice of feeding a standard ration regardless of the flock's development is being replaced by matching diet nutrient density, particularly amino acids and metabolisable energy density, to the specific requirements of the bird in rear. Routine monitoring of bodyweight and bird condition can be used to determine if the feeding programme requires adjustment for example, if bodyweight deviates from the target bodyweight excessively (more than +/- 5%) then a change in the feeding programme may be required (Aviagen Turkeys, 2024). Excessive bodyweight prompts transitioning to a lower density diet while excessively low bodyweight suggests delaying this transition. An adaptative approach to management of the feeding programme, based on real-time flock data, allows the flock manager to manage the flock to meet the target bodyweight profile and support optimum reproductive performance.

Feed physical quality is another critical variable. The use of high-quality and consistent feed form supports efficient intake of the required nutrients. In flocks fed crumb or poor-quality pellets with high levels of fines (particles less than 1mm in size) allows dominant birds to select larger particles, leaving the fine feed components for sub-ordinate birds to consume. This behaviour can also be encountered when turning off the feeding system a number of times a day to allow birds to consume the fines in the feeders. Stronger birds will consume preferred particle size leaving the remaining component for smaller birds to eat up. This behaviour results in uneven growth within the flock however providing optimum feed form and a consistent particle size profile is a practical step that directly supports flock uniformity ensuring a better start to production.

Furthermore, feeder space and correct ventilation also influence bodyweight development. Overcrowding at feeders creates competition that marginalises smaller birds, permanently widening the weight distribution within the flock. Similarly, thermal stress (both heat and cold) diverts energy away from growth towards thermoregulation, disrupting the growth of the birds (Reed et al., 2022).

A critical consideration in turkey breeder management is bodyweight management as the flock approaches sexual maturity. A common tactic in the field is to force an overweight flock back to target bodyweight in the weeks immediately preceding photostimulation (typically around 20 to 29 weeks), this is usually attempted through aggressive changes in the feeding programme. However, this practice can be harmful to productivity as during this stage of development the bird is undergoing significant physiological transitions in preparation for reproduction, including the development of the reproductive tract (Noetzold, 2025). Better performing flocks tend to avoid excessive weight gain prior to this period. Flocks that are excessively overweight are managed to a recalibrated bodyweight trajectory thus avoiding the need for intervention through aggressive feed changes. This involves accepting the current higher bodyweight as the new baseline and plotting a growth trajectory parallel to the standard curve. This approach supports the bird's physiological transition without imposing the stressor of significant weight loss (Aviagen Turkeys, 2024). The priority at this stage shifts from hitting a specific number on a chart to ensuring that the birds are physically and hormonally primed for the onset of lay.

Conclusion

The genetic progress of the modern turkey demands a constant re-evaluation of rearing management practices. We can no longer view the rearing period as a passive holding phase instead, the first few weeks of life must be treated as a crucial phase of preparation for the laying period. Managing bodyweight in the earlier period of rear programmes seems to be important in setting the bird's biology for long-term performance. Flock data from 2020 to 2025 highlights a direct link between controlled early growth, strong growth in the last 10 weeks of rear and higher egg production.

Equally, an erratic growth pattern, where birds grow too fast and are then forced to reduce growth rate creates metabolic disruption that damages uniformity and reproductive potential. Management strategies must focus on a smooth, consistent growth curve supported by careful environmental control and proactive management of the feeding programme.

Ultimately, we must work with the modern turkey to make sure the bird is properly primed to deliver peak reproductive performance by prioritising controlled weight gain, uniformity.

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Theory and Evolution of Day of Age Poult Treatments Technologies

Andrew Gomer
Nova-Tech, US

Introduction

Nova-Tech Engineering was formed in 1992 and is based in Willmar Minnesota, USA. The Nova-Tech Poultry Division was formed in 2024 to ensure focused support for our hatchery clients based in over seventy countries around the world. Nova-Tech Poultry Division's core business is supporting the application of treatment processes for day of age turkey poults, ducklings, chicken layer pullets, and broiler breeders.

Nova-Tech Engineering developed three main turkey treatment application platforms that are currently in use. Today, we will focus on technologies applied to day-of-age turkey poults which include infrared beak treatment, subcutaneous injection, and prescriptive claw treatment. We will also introduce the concept of direct crop application of ingested products. This device is called the Nutrient Delivery Station and is now commercialized in turkey hatcheries in North America.

The **Poultry Servies Processor (PSP)** was introduced in 1997 and provides loading counting, infrared beak treatment, subcutaneous injection, and box sorting.

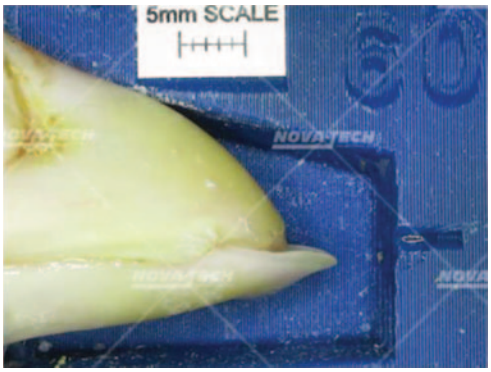


Image to the left is an example of historical industry expectation for turkey beak treatment.

The **Microwave Claw Processor (MCP)** was introduced in 1994 and applies six claw treatment to prevent scratching injuries in hen poults. The depth of treatment can be adjusted by controlling microwave time and toe insertion.

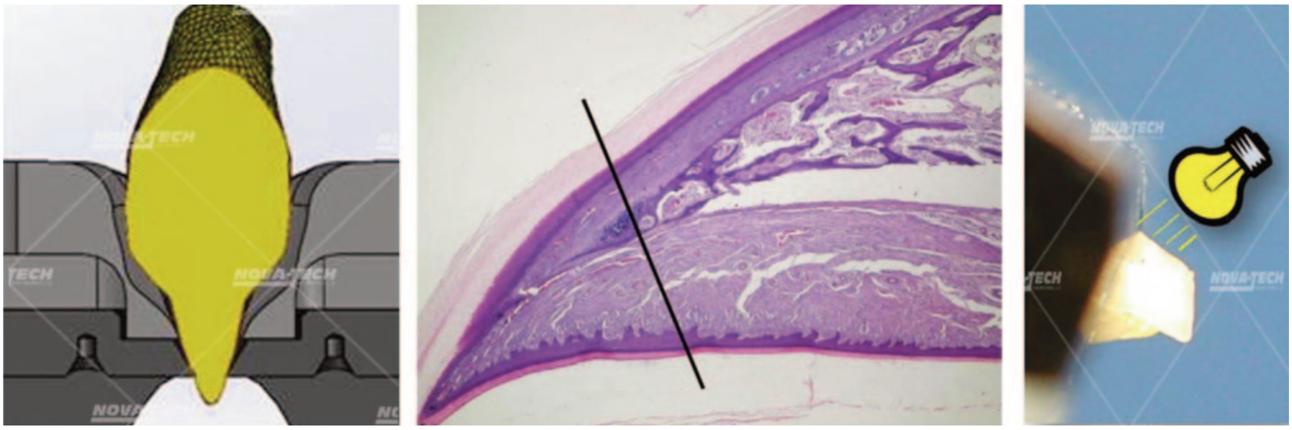
Turkey Claw Treatment on all 4 Toes at 24 Hours

Turkey Claw Treatment on all 4 Toes at 30 Days

The **Modular Poultry Services Processor (MPSP)** was commercialized in 2017 and enables the cradling of turkey poults during treatment. One loader can apply multiple processes such as nutrient delivery (direct to crop application of ingested products), infrared beak treatment, subcutaneous injection, six claw treatment, fourth toe treatment, and sorting. The MPSP system can significantly reduce the number of time poults are handled in a service room improving bird welfare. The MPS used in markets seeking multiple processes that include hen claw treatment.

Theory and evolution of Nova-Tech Engineering's turkey treatment processes.

Infrared beak treatment (IRBT) is a noncontact process applied to manage beak growth in day of age hatchlings. It was initially developed for the turkey industry in 1997 but has undergone a continuous improvement process since inception. Improvements to infrared energy control, software, lamp calibration, and refinement of the head holder hardware has enabled IRBT technology to keep pace with genetics and diverse market needs. Today, infrared beak treatment has been adopted for each of the major poultry species. Our goal is to provide effective day of age treatment for the life of the poultry flock. The infrared beak treatment process can be optimized by genetic line, week of lay and country specific codes of practice.

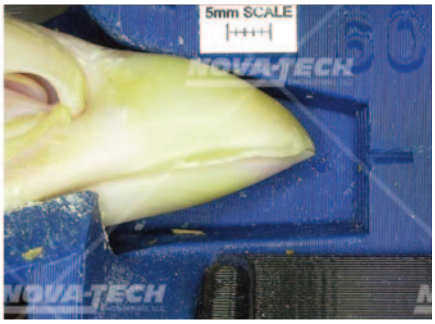


The infrared beak treatment process begins with inserting the poult into a head holder. The tip of the beak will extend through a specialized plate which controls the amount of exposed beak to the infrared energy. The plate also protects non targeted tissues from the infrared energy. The infrared beam is directed at the upper beak. The infrared pulse lasts less than 1.5 seconds provides an effective treatment for commercial turkey poults. The line in the center image designates a generic treatment target for turkey poults.

Nova-Tech has developed different interface plates to provide the less, similar, or more beak exposure as indicated. In 2024, Dr. Jutta Graue of Kartzfehn presented a case study at the Turkey Science and Production Conference which we will summarize. The project goal was to align the irbt process to match German objectives for turkey infrared beak treatment which were: removal of the hook of the beak, symmetrical top versus bottom beak profile at the time of slaughter, no tongue injury, and almost full functionality of the beak after treatment.

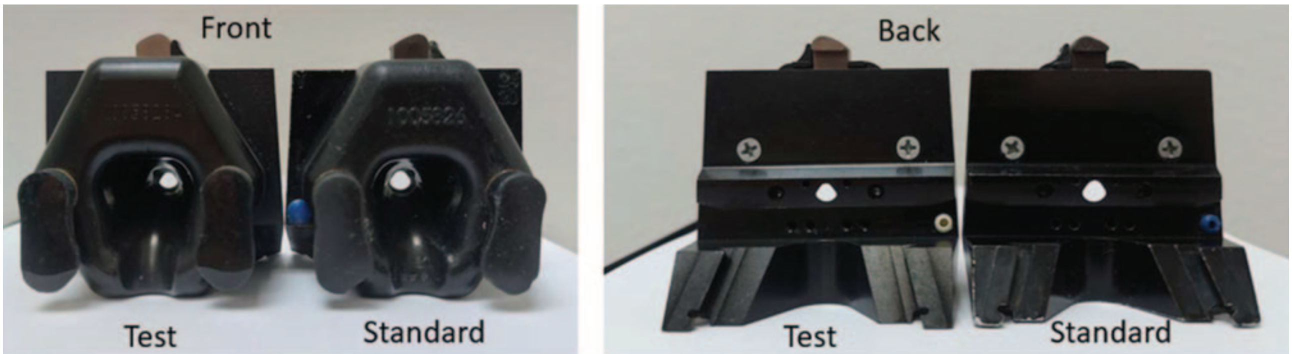
Intact Turkey Beak

Historical IRBT Goal 24/20 Plate



German IRBT Goal 26/23 Plate

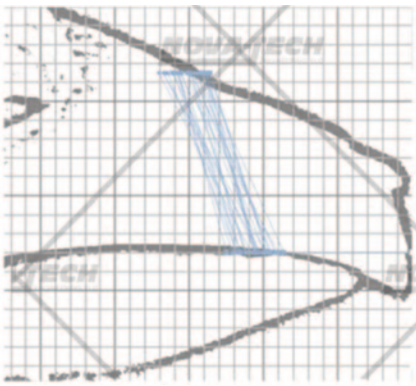
Soley reducing lamp power with prior existing hardware did not yield results consistent with updated German irbt objectives. Nova-Tech Engineering was able to achieve their treatment goal by developing a slightly thicker plate with corresponding smaller beak opening.



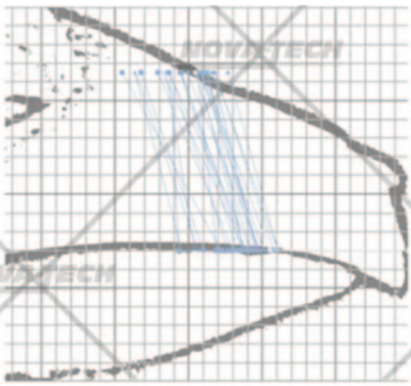
Test is 26/23 Turkey Plate and Standard is 24/20 Turkey Plate

The images below have multiple lines against a beak image background. Each individual line represents one bird in the corresponding treatment group. The center image above shows greater treatment variability when using the 24/20 plate and reducing lamp power to (34) on the Poultry Services Processor 24/20 plate.

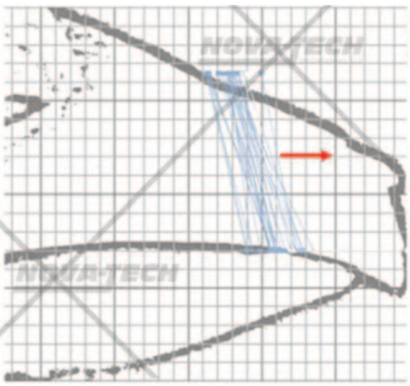
Results after 36 hours



24/20 no shim lamp power 43

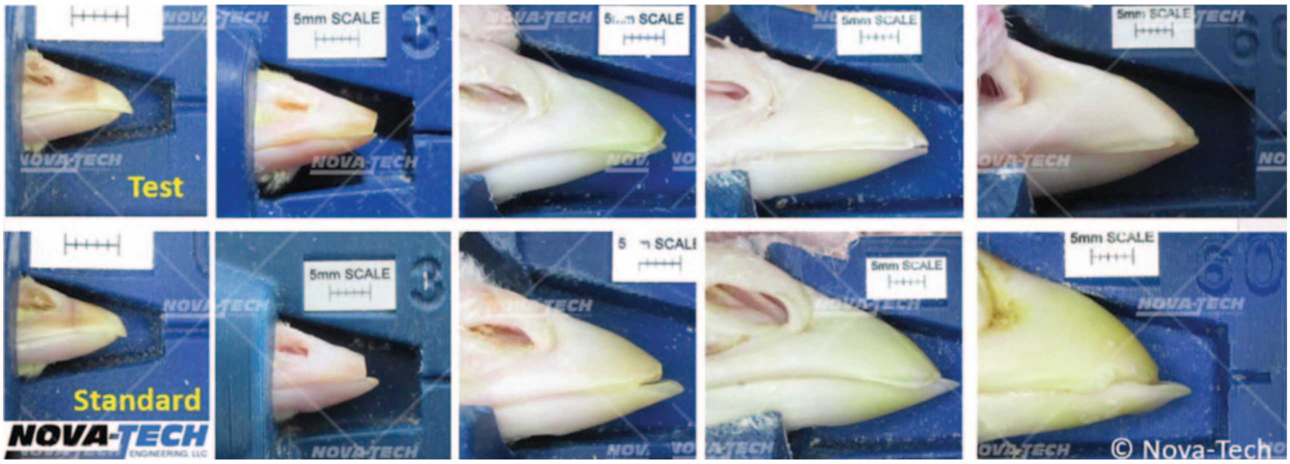


24/20 no shim lamp power 34



26/23 lamp power 43

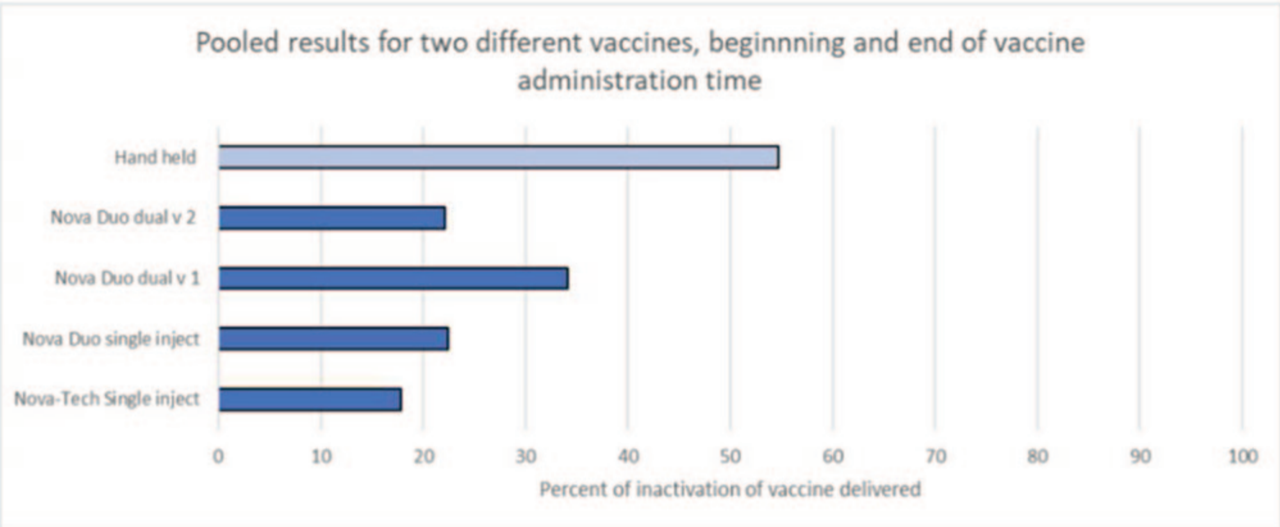
Lamp Power of 43 Used with both Test (26/23) and Standard (24/20) Plates on the images below.



Day 2 Day 15 Day 56 Day 98 Day 146

Subcutaneous Injection

Today Nova-Tech Engineering utilizes peristaltic pumps in our hatchery treatment platforms. The Peristaltic pumps were developed to optimize cell associated vaccine safety. Nova-Tech Engineering recently collaborated with the University of Minnesota to document the effects of different variations of vaccination systems on cell associated vaccine viability on legacy and new hardware.

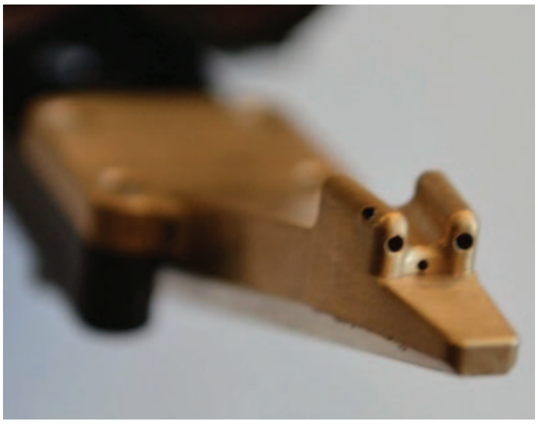


University of Minnesota Vaccine Safety Study

The above chart is pooled data from a trial to compare the efficacy of five different injection devices for the delivery of cell-associated Marek's disease vaccine; two commercial vaccines were evaluated. The active dose of the delivered vaccine was evaluated by plaque assay on chicken embryo fibroblast cells. Nova Tech single and dual injection systems (peristaltic pump) were evaluated; both were able to deliver a greater active dose of vaccine than the semi-automatic handheld (piston pump) vaccination system. The advantage of dual injection systems is that they can simultaneously deliver more than one vaccine, thereby reducing the cost of labor. In conclusion, each of the Nova-Tech automatic systems tested showed higher vaccine titers indicating reduced vaccine damage as compared to the semi-automatic handheld vaccinator.

The **Poultry Services Processor** has been in use in the turkey industry since the 1990's with periodic ongoing updates to the injection system. The primary method for turkey poult vaccination used today in Europe utilizes a single peristaltic pump and restraint system to secure the bird during vaccination.

More recently, Nova Tech Poultry has observed initial trends toward novel vaccine programs. To accommodate shift in market needs, we can provide different options for subcutaneous injections. Hatcheries seeking to inject two separate products through a single needle may utilize the two-pump single needle option. Hatcheries seeking to inject two separate products delivered to two different injection sites may consider turkey dual inject or two pumps two needle option.



Modular Poultry Services Processor (MPSP). Utilizes a roller injection system. The rollers move slightly to create a tent in the skin where the needle is inserted. This enab a highly accurate subcutaneous injection. One or two injection stations can be installe an MPSP to enable single or dual injection.

Nutrient Delivery Station (NDS). In 2024 Nova-Tech Engineering commercialized the Nutrient Delivery Station on the MPSP. This process enables direct to crop application of ingested products in day of age poults. The device can both sense and open the beak. Upon successful opening a probe is inserted and product is automatically administered. Product volume is precisely controlled so each poult receives the same dosage. The NDS can automatically adjust beak opening position by changes in week of lay and loader technique. The application accuracy is over 98% and ensures improved product uptake across multiple trials. In the event of a miss birds can pass by the system again for a retry or be reloaded onto the MPSP. The NDS is primarily used for the application of ingested vaccines such as cocci, salmonella and e-coli. However, it can also apply nutrients, hydrating products, and probiotics into day of age poults.

Below is a case study comparing vaccine uptake data from a Live Salmonella Typhimurium (ST) Vaccine.

Product was prepared using a gel and live ST vaccine at a rate of 30 ml of gel containing one hundred doses. Nutrient delivery station birds (NDS) received the same product and concentration as the gel bar. All crops on the NDS dosed group were visibly distended post processing. Nutrient Delivery Station birds do not require heat lamp and were placed immediately into the pen following application. All gel bar applied poults were exposed to heat lamp for 15 minutes to ensure maximum preening. In all groups, feed was withheld for a duration of 6 hours post application to simulate bird holding and transport time following servicing. All tissue samples were collected 4 days post vaccination, refrigerated and shipped for overnight delivery to the vendor's diagnostic lab.

Live ST-PCR-Percent Positive					
	Cloacal Swab	**Ceca**	**Liver/Spleen**	**Both Ceca + Cloaca**	**Any Organ +**
NDS (T01)	60%	85%	15%	60%	90%
Gel Bar (T02)	40%	65%	5%	20%	85%

This comparison shows that a total of 90% of T01 (NDS) were positive for Live ST compared to 85% of T02 (Gel Bar) birds. The percentage of positive birds was consistently higher in T01 and suggests that the NDS application method resulted in more consistent vaccine takes.

Conclusions

Nova-Tech Poultry Division and Nova-Tech Engineering LLC continue to seek customer feedback and evolve with an ever-changing industry. We continue to refine our legacy treatment processes such as IRBT, claw treatment, and subcutaneous injection. Nova-Tech Engineering continues to develop novel treatment services such as the Nutrient Delivery Station. To date the Nutrient Delivery Station has successfully processed tens of millions of turkey poults across North America. Industry feedback highlights advantages in both product uptake and accuracy of administration across multiple trials.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Can probiotics enhance modern turkey production?

Laura Hoving, MSc
Novonesis, Denmark

Probiotics have been defined by the World Health Organization as "live microorganisms which when administered in adequate amounts confer a health benefit on the host."

They are live microorganisms, such as bacteria or yeast, that can have very beneficial effects on Turkeys, or non-effect at all. This is why it is very important for any Turkey producer to know what probiotic to choose and what it really does to improve health, FCR, Body weight or all the above.

Why strains matter when choosing a probiotic and how a triple strain poultry probiotic can enhance modern Turkey production, will be revealed during the oral presentations.

The Role of Creatine in Cellular Energy Metabolism and the Effects on Turkey Performance

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Introduction

A stable and rapidly available energy supply at the cellular level is essential for growth, health, and high production performance. This is particularly important for modern poultry hybrids with high growth rates and pronounced muscle development, as their cells depend on the efficient provision of adenosine triphosphate (ATP), the universal energy currency for all biological functions including muscle contraction, ion transport and protein synthesis (Wyss & Kaddurah-Daouk, 2000).

In skeletal muscle, rapid and fluctuating energy demands cannot be covered by mitochondrial ATP production alone. Therefore, intracellular buffering systems are required to maintain ATP homeostasis during periods of high and rapidly changing energy requirements. The creatine–phosphocreatine system fulfills this role by enabling the rapid regeneration of ATP directly at sites of energy utilization through the reversible transfer of high-energy phosphate groups between ADP and ATP (Wallimann *et al.*, 1992).

As creatine only occurs naturally in animal tissues, plant-based feed materials do not provide any dietary source of this compound. Consequently, poultry largely depends on endogenous creatine synthesis to meet their metabolic requirements (Tossenberger *et al*, 2016). This synthesis (Figure 1) proceeds via the intermediate guanidinoacetic acid (GAA), formed from arginine and glycine, which is then methylated to creatine primarily in the liver (Brosnan & Brosnan, 2007). This biosynthetic pathway places metabolic demands on arginine, glycine and methyl groups derived from methionine metabolism (Khajali *et al*, 2020).

Dietary supplementation with GAA is a targeted nutritional strategy that increases metabolic creatine availability while partially sparing arginine and glycine for other metabolic functions. Consequently, GAA supplementation has been shown to improve muscle energy metabolism, growth and feed conversion efficiency in poultry (Maynard *et al.*, 2023; Sharma *et al.*, 2022; Majdeddin *et al.*, 2020).

Turkeys differ from broilers in several physiological and production-related aspects, including longer production cycles, higher final body weights, and pronounced breast muscle development. Nevertheless, the fundamental mechanisms of creatine metabolism are conserved across poultry species, suggesting that similar metabolic responses to GAA supplementation can be expected in turkeys. To evaluate this hypothesis, the studies presented here investigated the effects of dietary GAA supplementation on growth performance and carcass traits in turkeys under controlled experimental conditions and under practical production conditions.

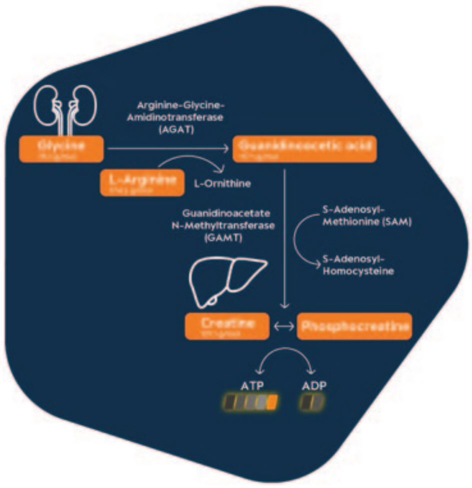

Figure 1: *Endogenous creatine synthesis*

Performance study - the Netherlands

Experimental design
A performance study was conducted from August to October 2024 at Schothorst Feed Research (Netherlands) using male B.U.T. 6 turkey poults. A total of 320 poults with an average initial body weight of 62.8 g were allocated to dietary treatments in a two-phase feeding program (starter: d 0–21; grower: d 22–43). Birds were housed in 8 pens per treatment with 20 poults per pen.

For the present evaluation, two dietary treatments were used:

(i) Control - without GAA supplementation

(ii) GAA - control diet supplemented with 1.2 kg GAA/t feed.

Growth performance parameters included body weight gain (BWG), feed intake (FI), feed conversion ratio (FCR) and breast muscle yield expressed as a percentage of body weight. Pen was considered the experimental unit.

Data were analyzed by direct comparison between the control and GAA-supplemented groups using an independent two-sample t-test (two-sided). Results are presented as means and standard error of the mean (SEM). Differences were considered statistically significant at $P < 0.05$.

Diet composition

Table 1. Composition of basal diets used in the Netherlands study

Nutrient (calculated)	Phase I (d 0-21)	Phase II (d 21-43)
Crude protein (%)	28.5	25.8
Crude fat (%)	5.8	6.8
Crude fiber (%)	2.64	2.57
Ca (%)	1.39	1.34
P (%)	0.94	0.91
Apparent metabolizable Energy kcal/kg	2,825	2,925
Standardized ileal digestibility (SID) Lysine (%)	1.58	1.41
SID Methionine (%)	0.68	0.63
SID Cysteine (%)	0.33	0.30
SID Methionine + Cysteine (%)	1.10	0.93
SID Threonine (%)	0.93	0.83
SID Tryptophan (%)	0.31	0.27

Results

Table 2. Growth performance of male turkeys (d 0-42)
Comparison between control and GAA group (1.2 kg GAA/t feed)

Parameter	Diet	Mean	SEM	P-value
Body weight gain (g)	Control	3032	35.7	0.010
	GAA	3167	28.3	
Feed intake (g)	Control	4144	53.7	0.218
	GAA	4231	39.9	
Feed conversion ratio	Control	1.367	0.004	0.005
	GAA	1.336	0.008	
Breast muscle (% BW)	Control	15.6	0.17	< 0.001
	GAA	16.5	0.12	

Values are means of 8 pens per treatment. Pen was considered the experimental unit.
SEM represents the standard error of the mean (SEM = SD / √n).
P-values were obtained using an independent two-sample t-test (two-sided) comparing control and 1.2 kg GAA/t feed.
Differences were considered statistically significant at P ≤0.05.

As shown in Table 2, dietary supplementation of 1.2 kg GAA/t feed significantly increased body weight gain compared with the control group (P = 0.010) while feed intake was not affected by treatment (P = 0.218). Therefore, feed conversion ratio significantly improved in the GAA-supplemented group (P = 0.005) Breast muscle yield, expressed as a percentage of body weight at day 43, was significantly higher in birds receiving GAA supplementation compared with the control group (P < 0.001).

Performance study - Poland

Experimental design

A performance study was conducted at the University of Warmia and Mazury in Olsztyn, Poland, using 406 male Hybrid Converter turkeys with an initial average body weight of 58.9 g. Birds were reared for 20 weeks (October 2024- February 2025) under standard management conditions representative of commercial turkey production. Birds were housed in seven pens per treatment with 29 poults per pen.

For the present evaluation, two dietary treatments were used:

(i) Control - without GAA supplementation and

(ii) GAA - control diet supplemented with 1.2 kg GAA/t feed.

Performance parameters included final body weight, average daily feed intake (ADFI) and feed conversion ratio (FCR). Performance data were analyzed by direct comparison between the control group and the group receiving 1.2 kg GAA/t feed using an independent two-sample t-test (two-sided). Pen was considered the experimental unit for all analyses. Results are presented as means and standard error of the mean (SEM). Differences were considered statistically significant at $P \leq 0.05$.

Diet composition

Table 3. Composition of basal diets used in the Poland study

Nutrient (calculated)	P1 (1–4 weeks)	P2 (5–8 weeks)	P3 (9–12 weeks)	P4 (13–16 weeks)	P5 (17–20 weeks)
ME (kcal/kg)	2800	2900	3050	3125	3175
Crude protein (%)	27	25	21.5	18	16
Crude fibre (%)	3.2	3.6	3.5	3.5	3.4
Crude fat (%)	3.9	6.3	7.7	7.9	7.7
Arginine (%)	1.77	1.60	1.34	1.07	0.92
Lysine (%)	1.77	1.60	1.35	1.07	0.92
Methionine (%)	0.71	0.62	0.49	0.41	0.35
Met. + Cys (%)	1.15	1.04	0.88	0.76	0.68
Threonine (%)	1.08	0.98	0.84	0.67	0.58
Calcium (%)	1.20	1.10	0.95	0.75	0.55
Av. Phosphorus (%)	0.55	0.52	0.40	0.30	0.26

Results

Table 4. Growth performance of male turkeys (d 0–140)
Comparison between control and GAA group (1.2 kg GAA/t feed)

Parameter	Diet	Mean	SEM	P-value
Final Body weight (kg)	Control	22.98	0.119	0.003
	GAA	23.53	0.084	
Feed intake d0-140(g/d)	Control	462.5	2.93	0.140
	GAA	453.3	4.66	
Feed conversion ratio d0-140	Control	2.673	0.017	0.003
	GAA	2.588	0.015	

Values are means of 8 pens per treatment. Pen was considered the experimental unit.
SEM represents the standard error of the mean (SEM = SD / √n).
P-values were obtained using an independent two-sample t-test (two-sided) comparing control and 1.2 kg GAA/t feed.
Differences were considered statistically significant at $P \leq 0.05$.

Final body weight at day 140 was significantly higher in turkeys receiving 1.2 kg GAA/t feed compared with the control group ($P = 0.003$; Table 4). Feed intake over the experimental period (d 0–140) was not affected by dietary treatment ($P = 0.140$). Feed conversion ratio was significantly improved in the GAA group compared with the control ($P = 0.003$).

Validation under commercial conditions - USA

Experimental design
Performance data were generated from a large-scale field trial on a commercial integrator research farm in the United States of America. A total of 2,976 male turkeys (Nicholas Select toms) were allocated to two dietary treatments and reared until 139 days of age. Birds were housed in 16 replicate pens per treatment with 93 birds per pen. Typical commercial diets containing animal protein were used. Performance and carcass-related parameters were recorded at the end of the production cycle.

For the present evaluation, two dietary treatments were used:

(i) Control - without GAA supplementation and

(ii) GAA - control diet supplemented with 0.8 kg GAA/t feed.

Results

Table 5. Performance and carcass characteristics of male turkeys in the USA (d0-139)
Comparison between control group and GAA group (0.8 kg GAA/t feed) (n = 16)

Parameter	Diet	Mean
Liveability (%)	Control	–
	GAA	+3.7
Final body weight (kg)	Control	21.86
	GAA	22.04
Average daily gain (ADG) (g/d)	Control	156
	GAA	157
FCR	Control	2.48
	GAA	2.45
Breast meat yield (kg/bird)	Control	5.59
	GAA	5.83

Dietary supplementation with 0.8 kg GAA/t feed resulted in a higher final body weight (+180 g per bird). Feed conversion ratio was improved, and breast meat yield increased by approximately 240 g per bird. Livability was higher in the GAA-supplemented group.

Discussion and conclusion

Dietary supplementation with GAA increases creatine levels in the body of the animal. This system plays a key role in buffering adenosine triphosphate (ATP) in skeletal muscle and other tissues, such as the brain, heart and reproductive tract, during periods of high and fluctuating energy demand (Wallimann *et al.*, 1992; Wyss & Kaddurah-Daouk, 2000). In addition to its role in cellular energy metabolism, GAA supplementation benefits amino acid metabolism (arginine and glycine). As poultry lacks a functional urea cycle, arginine is an essential amino acid for them (Wu & Morris, 1998; Khajali & Wideman, 2010). Considerable amounts of arginine and glycine are required for endogenous creatine synthesis (Brosnan & Brosnan, 2007; Tossenberger *et al.*, 2016). By supplying GAA directly, the first rate-limiting step of creatine synthesis is bypassed, thereby sparing these amino acids for other physiological processes. This metabolic relief contributes to improved protein accretion, as evidenced by the increased breast muscle yield observed under commercial production conditions (USA trial) and the higher final body weight reported in the Polish study.

The conversion of GAA to creatine requires a methyl group, which is donated by S-adenosylmethionine. This process is therefore linked to one-carbon (1C) metabolism, and could influence methyl group availability and utilization (Brosnan & Brosnan, 2007). Specifically, GAA could increase methyl group requirement and potentially render their availability limiting to other physiological pathways. However, Sharma *et al.* (2022) demonstrated that additional supplementation with methyl donors, such as betaine, did not result in further performance improvements when GAA was included at levels of up to 2.0 kg/t of feed. This suggests that, under standard feeding conditions that adhere to nutritional guidelines and within the commercially relevant range of GAA supplementation in poultry diets (between 0.6 to 1.2 kg/t of feed), methyl group availability is not limiting.

Results from the experimental studies consistently demonstrated performance benefits of GAA supplementation in turkeys. While higher inclusion levels, such as 1.2 kg GAA/t feed, resulted in pronounced biological responses under experimental conditions, supplementation with 0.8 kg GAA/t feed achieved comparable improvements in performance under commercial production conditions. These findings suggest that a GAA inclusion level of 0.08% provides an effective balance between performance benefits and economic efficiency in practical turkey feeding programs.

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Turkey Haemorrhagic Enteritis: Updated Insights on Epidemiology, Diagnosis and Control

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Abstract
Turkey haemorrhagic enteritis (HE) is a viral disease of continued relevance in turkey production, mainly due to its association with immunosuppression and increased susceptibility to secondary infections. The disease is caused by Turkey haemorrhagic enteritis virus (THEV), a siadenovirus belonging to the family *Adenoviridae*. Although severe clinical outbreaks are currently less frequent, THEV is still widely circulating in commercial turkey flocks, often in subclinical form, and may affect flock health and production performance. This contribution provides an updated overview of the epidemiology, pathogenesis, diagnosis and control of turkey haemorrhagic enteritis, with particular emphasis on recent field observations and molecular studies. Special attention is given to viral persistence, immunopathogenic effects and the use of molecular markers to differentiate vaccine and field strains, highlighting their application in monitoring vaccination programs and virus circulation under field conditions.

Introduction
Turkey haemorrhagic enteritis (HE) is a viral disease affecting turkeys, primarily after four weeks of age, and has been recognized in commercial production systems for several decades. The disease may present with a wide range of clinical manifestations, from acute haemorrhagic enteritis associated with mortality to subclinical infections with no evident clinical signs. In many production settings, the latter form is more frequently observed. The etiological agent, Turkey haemorrhagic enteritis virus (THEV), belongs to the genus *Siadenovirus* within the family *Adenoviridae*. Following infection, the virus shows a marked tropism for lymphoid tissues, particularly the spleen, and is associated with variable degrees of immunosuppression. This condition may favour the occurrence of secondary bacterial infections and negatively influence the response to vaccination against other viral pathogens, with potential consequences for flock health and production performance (Rautenschlein *et al.*, 2020).

Over time, the implementation of biosecurity measures and vaccination programs has substantially reduced the incidence of severe clinical outbreaks of HE. Nevertheless, field observations and longitudinal studies indicate that THEV continues to circulate in commercial turkey flocks, often in the absence of overt clinical disease (Alkie *et al.*, 2017; Giovanardi *et al.*, 2014; Palomino *et al.*, 2020). Viral persistence in recovered birds and environmental resistance contribute to the maintenance of the infection within production systems.

In this context, updated information on the epidemiology, diagnosis and control of turkey haemorrhagic enteritis remains relevant. In addition, recent advances in molecular characterization have provided new tools to investigate viral circulation under field conditions and to differentiate vaccine strains from field viruses. These aspects are of particular interest for the evaluation of vaccination strategies and for a better understanding of THEV dynamics in modern turkey production.

Etiology and Epidemiology
Turkey haemorrhagic enteritis virus belongs to the genus *Siadenovirus* within the family *Adenoviridae* and is classified as *Turkey siadenovirus* A (also known as turkey adenovirus 3) (Benkő *et al.*, 2023). The virus is non-enveloped, with an icosahedral capsid and a linear double-stranded DNA genome of approximately 26.6 kb. Structurally, the virion contains one penton fiber at each vertex, and the hexon protein represents the major antigenic determinant.

Genomic studies have shown a high degree of nucleotide identity among THEV strains, indicating overall genetic stability. However, specific genomic regions, including ORF1, E3, the hexon gene and the fiber knob domain, have been identified as important determinants of virulence and useful targets for molecular differentiation of strains (Beach *et al.*, 2009).

Field observations indicate that most clinical cases occur between 6 and 11 weeks of age, although younger poults may be protected by maternal antibodies. Mortality rates can range from negligible to over 50% in severe outbreaks, depending on viral virulence, immune status of the flock and presence of concurrent infections. Recovered birds may remain persistently infected and continue to shed the virus, contributing to its maintenance within and between flocks.

Pathogenesis and Clinicopathological Features

THEV is a lymphotropic and lymphocytopathic virus, with IgM-bearing B lymphocytes representing the primary target. Viral replication occurs mainly in lymphoid tissues, particularly the spleen, and is associated with marked depletion of B cells during the acute phase of infection. Macrophages also support viral replication and contribute to lesion development. The resulting lymphoid damage leads to a transient but significant immunosuppression, characterized by impaired humoral responses and reduced B- and T-cell reactivity. Following oral exposure, the virus is thought to reach the spleen either through initial replication in intestinal lymphoid tissues or via the bloodstream, where high levels of viral replication trigger inflammatory cell infiltration and splenic hyperplasia. Virus-induced cell death and cytokine-mediated apoptosis of bystander cells further contribute to lymphoid depletion and immune dysfunction. Intestinal lesions and hemorrhages appear to be largely immune-mediated rather than the result of direct viral cytopathic effects. Both virulent and avirulent strains can induce transient immunosuppression, although the effect is more pronounced with virulent viruses, predisposing infected turkeys to secondary infections under field conditions (Rautenschlein *et al.*, 2020). Clinically, acute HE is associated with depression, bloody droppings, and rapid onset of mortality. Gross lesions typically include haemorrhagic content in the small intestine, especially the duodenal loop, congestion and fibronecrotic membranes on the intestinal mucosa, splenomegaly, and hepatic petechial haemorrhages (Figure 1). Notably, affected birds are often in good body condition at death, reflecting the acute nature of the disease.

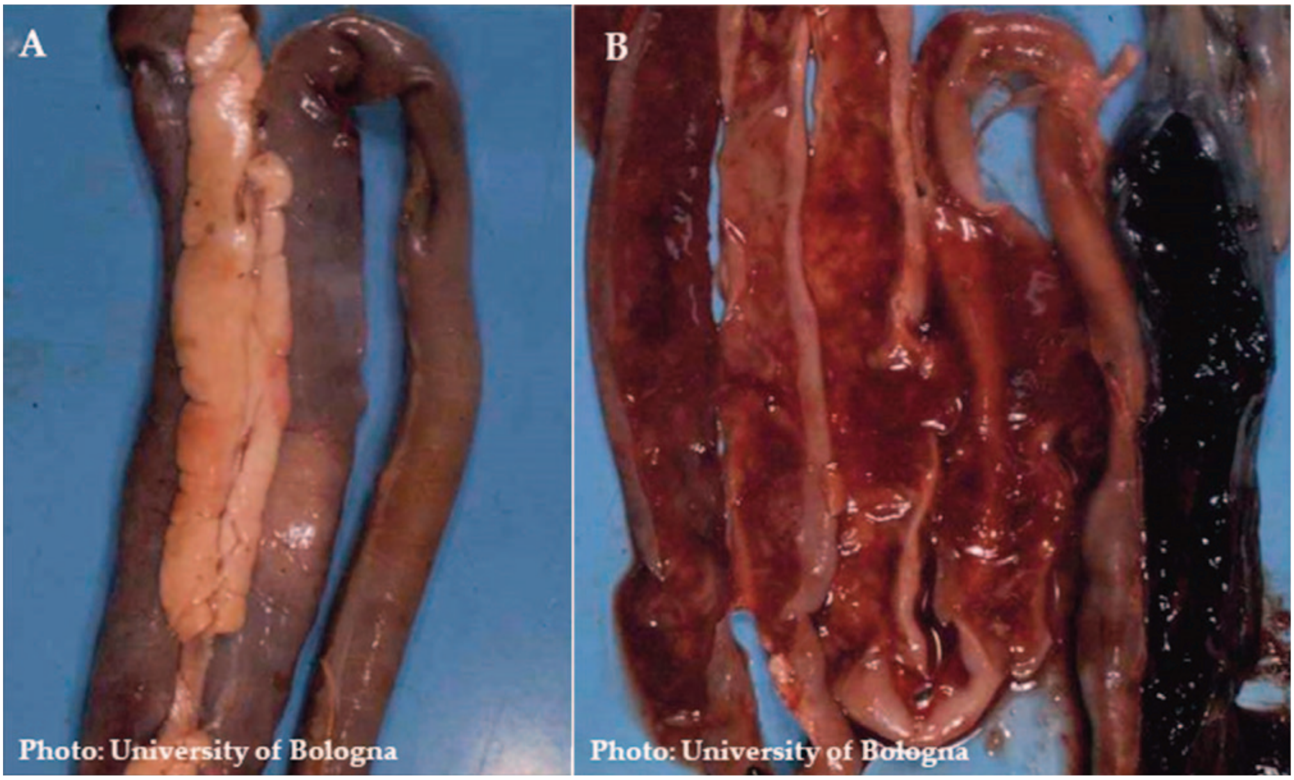

Figure 1. *Small intestine filled with bloody content (duodenal loop); (B) Lesions can be distal in severe cases (Musa et al., 2024).*

Recent proteomic and microbiome studies have demonstrated that natural THEV infection is associated with changes in intestinal mucosal proteins involved in antiviral defense, systemic inflammation and immune regulation, as well as shifts in gastrointestinal microbial populations (D'Andreano *et al.*, 2017; Marques *et al.*, 2019). These alterations may further exacerbate susceptibility to secondary infections such as colibacillosis and reduce vaccine efficacy against other viral diseases, including Newcastle disease.

Co-infections

THEV infection is frequently reported in association with other infectious agents, and its immunosuppressive effects may contribute to increased disease severity in the presence of co-infections. Field studies have shown that THEV circulation may coincide with avian metapneumovirus (aMPV) infection, particularly in flocks experiencing increased colibacillosis-associated mortality, suggesting a possible synergistic effect between respiratory pathogens and immunosuppressive viruses (Giovanardi *et al.*, 2014). Concurrent THEV infection has also been described in association with enteric bacterial diseases, including necrotic enteritis caused by Clostridium perfringens, where THEV infection was considered a potential predisposing factor for severe intestinal lesions and acute mortality (Ramsubeik *et al.*, 2023). In addition, protozoal co-infections such as histomoniasis have been reported in turkey flocks with concurrent THEV infection, in which the virus may exacerbate disease severity and contribute to increased mortality rates (Durairaj *et al.*, 2024).

Overall, these observations support the view that turkey haemorrhagic enteritis should be considered within the context of multifactorial disease complexes rather than as an isolated condition.

Diagnosis

Diagnosis of turkey haemorrhagic enteritis relies on the combined evaluation of clinical presentation, pathological findings and laboratory investigations. In clinically affected flocks, the presence of haemorrhagic enteritis, characterized by blood-filled intestinal content, particularly in the proximal small intestine, represents a relatively characteristic lesion and may strongly suggest infection with THEV. Splenomegaly is a frequent finding in infected birds and reflects the marked tropism of THEV for lymphoid tissues; however, this lesion is not pathognomonic, as spleen enlargement may also be observed following live vaccination or in association with other infectious or immunological conditions. Therefore, pathological findings alone are not sufficient to confirm the diagnosis.

Laboratory confirmation is particularly important in subclinical infections, which are commonly observed in modern turkey production systems and may occur in the absence of overt clinical signs or severe intestinal lesions. In these cases, molecular diagnostic methods play a key role in detecting virus circulation within flocks and in supporting epidemiological investigations. Molecular detection of THEV by polymerase chain reaction (PCR) currently represents the most reliable diagnostic approach. Conventional, nested and real-time PCR assays targeting conserved genomic regions are routinely applied to spleen samples, organ swabs, cloacal swabs or imprints collected on FTA cards (Hess et al, 1999; Palya *et al.*, 2007; Giovanardi *et al.*, 2014; Alkie *et al.*, 2017; Gerber *et al.*, 2022). Cloacal swabs are particularly suitable for longitudinal field studies aimed at monitoring virus circulation at the flock level. Beyond virus detection, molecular characterization has gained increasing relevance for diagnostic and epidemiological purposes. Recent studies have shown that sequencing of selected genomic regions, particularly the 3′ region of the ORF1 gene, may allow differentiation between vaccine-like and field strains of THEV. A PCR-based sequencing approach targeting ORF1, hyd and partial IVa2 genes has been proposed as a useful diagnostic tool to support correct interpretation of PCR-positive results, especially in vaccinated flocks, where the distinction between vaccine persistence and field virus circulation is critical (Quaglia *et al.*, 2023).

Serological assays, including enzyme-linked immunosorbent assays (ELISA), have been used to detect antibodies against THEV and may provide information on flock exposure and immune status. However, their availability and routine application appear to be limited, and serology is currently less frequently used compared with molecular methods. In addition, serological testing does not allow discrimination between antibodies induced by vaccination and those resulting from field infection.

Control and Vaccination Strategies

Complete elimination of THEV from commercial turkey production is considered impractical due to viral persistence, environmental stability and widespread circulation. Consequently, control strategies rely on integrated approaches combining biosecurity, management practices and vaccination. Strict biosecurity measures, including cleaning and disinfection, are essential to reduce viral load and limit horizontal transmission. Nevertheless, vaccination represents the cornerstone of HE control. Both live attenuated and inactivated vaccines are used in different production systems, often according to specific epidemiological and management conditions. Vaccination is commonly performed early in the production cycle, typically between 3.5 and 6 weeks of age, and is usually administered via drinking water to allow mass application at the flock level.

Longitudinal field studies have shown that in flocks vaccinated with inactivated vaccines, THEV may still circulate, although overt clinical haemorrhagic disease is rarely observed (Giovanardi *et al.*, 2014). In contrast, live attenuated vaccines may persist for several weeks after administration and have been shown to reduce circulation of field strains, providing a higher level of protection against infection. These observations underline the importance of understanding vaccine dynamics and viral persistence when designing and evaluating vaccination programs under commercial conditions.

Molecular Characterization and Field Studies

Recent molecular studies focusing on partial sequencing of ORF1, E3, hexon and fiber knob regions have provided valuable insights into the genetic stability and epidemiology of THEV (Quaglia *et al.*, 2023). Analysis of Italian field strains collected between 2009 and 2019 revealed more than 99% nucleotide identity, with only a limited number of mutations. Despite this high similarity, specific nucleotide changes were consistently identified, forming a molecular “fingerprint” of Italian field strains. Phylogenetic analyses demonstrated that these field strains cluster separately from vaccine strains, particularly when analyzing the hexon gene and the 3′ region of ORF1 (Figure 2). These molecular markers are highly useful for differentiating vaccine and field viruses in vaccinated flocks and for monitoring virus circulation over time.

Longitudinal field studies recently conducted in Italy under commercial conditions have further demonstrated the effectiveness of live attenuated vaccination in controlling both disease expression and field virus circulation. In vaccinated flocks, clinical signs and macroscopic lesions were markedly reduced compared with unvaccinated controls, while molecular analyses showed persistent detection of vaccine-like strains and only sporadic detection of field strains. In contrast, unvaccinated flocks exhibited consistent circulation of field viruses throughout the production cycle. These findings indicate that live vaccination not only protects birds from clinical disease but also reduces environmental infectious pressure by limiting field strain circulation.

Figure 2. *Phylogenetic tree based on the partial amino acid sequences of the ORF1 gene of THEV strains analysed in Quaglia et al., 2023 and the reference strains retrieved from GenBank.*

Conclusions and Future Perspectives

Turkey haemorrhagic enteritis remains a disease of relevance in turkey production, mainly because of its immunosuppressive effects and the continued circulation of THEV in commercial flocks. Although severe clinical outbreaks are currently less common, subclinical infections and viral persistence may still influence flock health and favour the occurrence of secondary diseases. Recent field and molecular studies have contributed to a better understanding of THEV epidemiology, highlighting the overall genetic stability of the virus and the presence of specific molecular markers useful for differentiating vaccine and field strains. The application of these tools in longitudinal field investigations represents a valuable approach for monitoring virus circulation and assessing vaccination dynamics under commercial conditions. An integrated control strategy based on biosecurity, appropriate management practices and vaccination remains essential for limiting the impact of haemorrhagic enteritis. Further studies, including full-genome sequencing of circulating strains and in vivo investigations on virus-host interactions, may provide additional information to support the optimization of prevention and control measures in modern turkey production systems.

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Reducing Pathogens, Optimising Performance: The Science Behind Effective Hygiene

Arunee Thanasarasakulpong
Lanxess, UK

Effective hygiene is a fundamental component of biosecurity and disease prevention in commercial turkey production. Poor environmental hygiene has been associated with increased pathogen pressure, compromised flock health, reduced performance, and greater reliance on therapeutic interventions.

While cleaning and disinfection programs are routinely implemented between flocks, their effectiveness can vary considerably depending on how they are designed and executed. In many cases, hygiene is approached as a checklist activity rather than as a scientifically driven process. Understanding the microbiological principles behind pathogen survival, removal, and inactivation is essential if hygiene programs are to consistently deliver measurable benefits at flock level.

This paper outlines the scientific basis of effective hygiene in turkey production, linking pathogen biology and disinfectant chemistry with practical, on-farm application. By combining industry insights with field experience, it aims to support producers in translating hygiene principles into improved biosecurity, flock health, and production performance.

Hygiene as a Tool for Reducing Pathogen Load

Pathogens relevant to turkey production include bacteria, viruses, fungi, and protozoa, many of which are capable of surviving for prolonged periods in the poultry house environment. Organic matter such as litter residues, dust, and biofilms provides protection from environmental stressors and can significantly reduce the effectiveness of disinfectants. An effective hygiene program cuts the pathogen chain of transmission by targeting these environmental reservoirs between flocks. Lower environmental contamination reduces the infectious challenge faced by incoming poults. Even when clinical disease is not evident, reducing subclinical pathogen pressure can have measurable impacts on feed conversion, growth rate, and livability.

From a production perspective, hygiene should be viewed as a preventative investment rather than a cost, contributing to more predictable performance and reduced health risk.

Core Components of an Effective Hygiene Program

- **Removal of Organic Matter**

The removal of organic material is the most critical step in any hygiene program. Manure, litter, dust, and grease not only harbour pathogens but also interfere directly with the action of disinfectants. Without effective cleaning, even high-quality disinfectants are unlikely to achieve the desired level of pathogen reduction.

Dry cleaning should be carried out first to remove loose debris and reduce the overall organic load. Particular attention should be paid to areas where contamination commonly accumulates, including drinker lines, feeders, ventilation inlets, fan housings, and structural joints.

- **Water System Cleaning & Biofilm Removal**

Drinkers, pipelines, and header tanks provide ideal conditions for biofilm formation, which can harbour and protect pathogenic bacteria from both detergents and disinfectants. Once established, biofilms act as persistent reservoirs of microorganisms, creating a continuous source of microbial exposure that can undermine otherwise effective house hygiene. In addition to their role in pathogen survival, biofilms may accumulate within pipes and filters, restricting water flow and potentially compromising water intake and flock performance. Biofilms can also bind medicinal compounds, increasing the risk of under-dosing and reducing treatment efficacy, while simultaneously acting as hotspots for horizontal gene transfer, facilitating the spread of resistance genes to disinfectants and antibiotics.

Effective water system cleaning therefore requires a structured approach, including physical flushing, the use of appropriate detergents or descaling agents to disrupt biofilms, and the application of disinfectants at correct concentrations and contact times. Water quality, temperature, and system design all influence cleaning efficacy and should be considered when developing protocols. Routine cleaning and disinfection of water systems between flocks, and where necessary during production, are essential to minimise pathogen persistence and support flock health and performance.

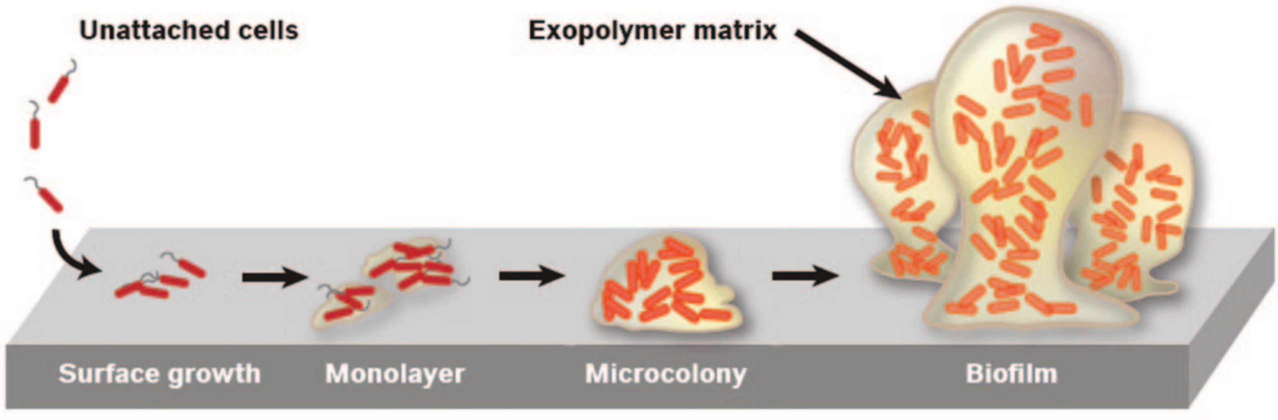

Fig.1: *Schematic of Biofilm Formation on Surfaces*

- **Detergent Application and Wet Cleaning**

Detergents are a critical component of effective hygiene programs, as they break down organic residues and disrupt biofilms that protect pathogens on surfaces. Their surfactant action reduces surface tension, allowing water to penetrate, loosen, and lift organic contamination more effectively, thereby improving overall cleaning efficiency. Detergent selection should take into account surface type, water hardness, and the nature of the organic material present. Adequate contact time and correct dilution are essential to maximise detergent performance, and thorough rinsing is required to remove loosened organic matter and prevent interference with subsequent disinfection steps.

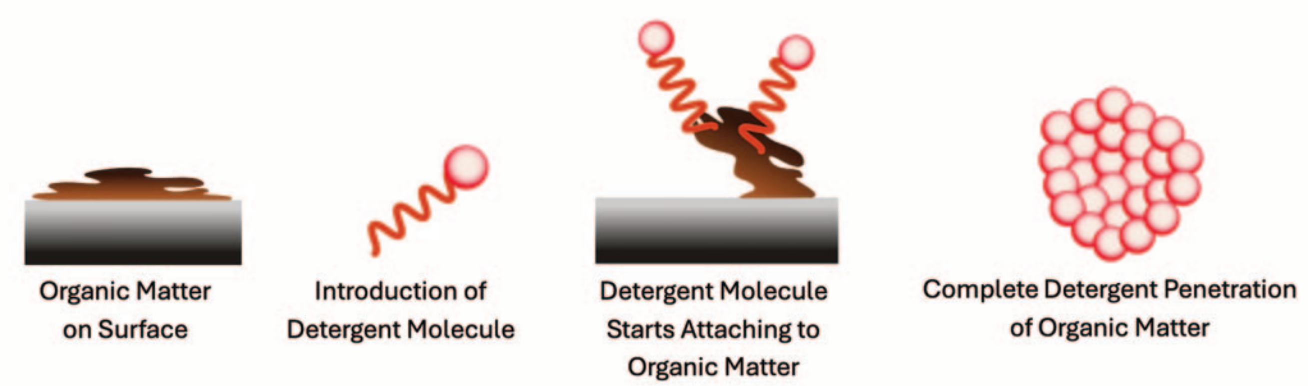

Fig.2: *Mode of Action of Detergent Molecules*

Foam application is recommended for detergent use, as it offers several practical advantages over spraying. Foam adheres more effectively to surfaces, increasing contact time and reducing run-off, particularly on vertical or uneven areas. It also improves penetration into porous materials and enhances visibility during application, allowing operators to verify coverage more easily. From a safety perspective, foam generates fewer fine droplets, reducing operator exposure, and can often be applied more quickly and with less physical effort. For optimal adherence, the foam should be dry and stable rather than excessively thick, with adhesion influenced by application distance and correct adjustment of the foam lance. Foam quality and consistency are strongly influenced by the application equipment used. Foam cannons, which operate as independent mobile units under compressed air, typically produce a more stable and uniform foam compared with foam lances mounted on high-pressure washers. Foam cannons also help maintain a consistent product concentration, reducing the risk of under- or over-dosing and minimising product waste. While foam lance systems may allow faster application over large areas, variations in water pressure and flow rate can affect foam quality and dosing accuracy.

Selecting appropriate equipment and applying foam correctly are therefore key factors in achieving effective detergent performance and reliable hygiene outcomes.

- **Disinfection: Linking Chemistry to Field Performance**

The effectiveness of disinfection depends not only on the product used but also on the type of pathogen present, as different microorganisms vary widely in their susceptibility to disinfectants. Lipid-enveloped viruses are generally the most susceptible, followed by Gram-negative bacteria, Gram-positive bacteria. In contrast, non-enveloped viruses, protozoal oocysts, and fungi and bacterial spores are considerably more resistant. These differences arise from variations in pathogen structure, including the presence or absence of a lipid envelope, differences in cell wall composition, and the ability of some organisms to form spores or other protective structures. As a result, no single disinfectant is equally effective against all pathogen groups, and product selection should be guided by the specific organisms of concern within a production system.

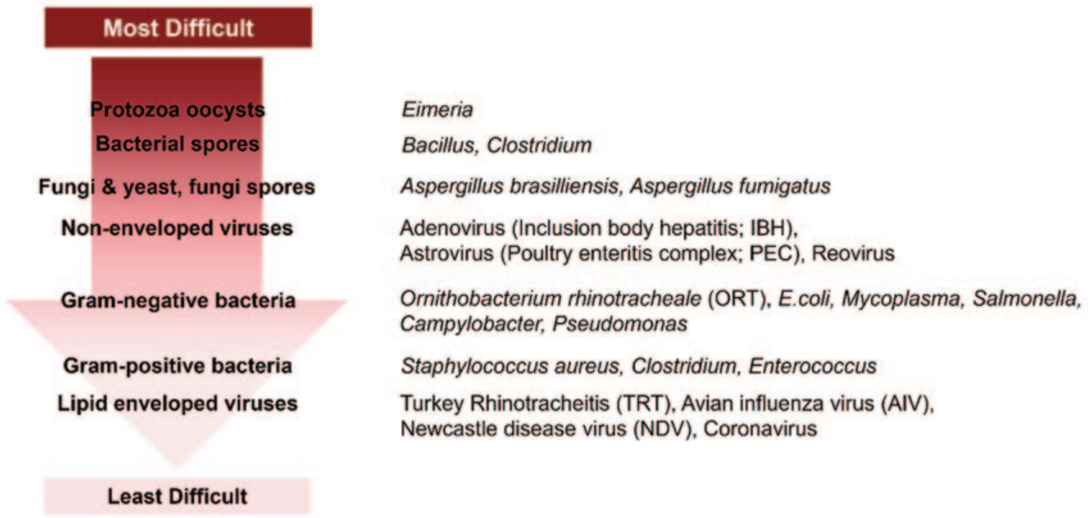

Fig.3: *Relative Susceptibility of Pathogens to Disinfectants*

Disinfection is most effective when applied to visibly clean surfaces, as organic matter can significantly reduce disinfectant activity and shield pathogens from exposure. Disinfectants act through different mechanisms, such as disrupting cell membranes, denaturing proteins, or interfering with essential metabolic processes. Their performance is influenced by several factors, including concentration, contact time, temperature, surface type, and water quality. Under field conditions, reduced efficacy is more often the result of inadequate cleaning, inaccurate dilution, insufficient contact time, or uneven application rather than a lack of intrinsic disinfectant activity. For this reason, clear standard operating procedures, appropriate product selection, and effective staff training are essential to achieve consistent and reliable disinfection outcomes.

From Theory to Practice in Turkey Production

For hygiene programs to deliver consistent benefits, scientific principles must be translated into practical, repeatable on-farm actions. Programs should be adapted to individual farm layouts, available resources, and production schedules, while maintaining adherence to core hygiene principles.

Verification methods such as visual inspection or targeted microbiological sampling can help assess effectiveness and drive continuous improvement. Regular review of hygiene protocols ensures they remain fit for purpose as production systems and disease challenges evolve.

Conclusion

Effective hygiene plays a critical role in biosecurity, disease prevention, and performance optimisation in turkey production. By integrating microbiological understanding with real-field application, producers can implement hygiene programs that reliably reduce pathogen load and support healthier, more productive flocks.

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Adisseo
ADM
Alltech
alzchem group
Anitox
Aviagen Turkeys
Big Dutchman
Biochem
Boehringer Ingelheim
Ceva
CJ Bio
iff Danisco Animal Nutrition & Health
Devenish
dsm-firmenich
emtech Hatchery Systems
for farmers
Hamlet Protein
Hockenhull Turkeys
Huvepharma
Hybrid
innovad.group
invac International
JBT Marel
Kartzfehn
KellyBronze
Kemin
Lanxess Biosecurity Solutions
Mapu
MGH Ag Technologies
NextNest Hatching
Nova-Tech Poultry
novonesis
olmix
Petersime
Premier Nutrition
Putenzucht Miko
Techna

SURVEY

Thank you for participating in our event. We hope you had as much fun attending as we did organising it. We would be grateful to hear your feedback so we can improve your overall experience and content.

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AI INTERPRETATION

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