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Matrix

AFMA
SAFE FEED FOR SAFE FOOD
Animal Feed Manufacturers Association

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Adisseo a global leader in animal nutrition

Managing tight maize supplies • Careers in the feed industry • AFMA Code of Conduct audits
AMR collaboration • Exhibition and sale of farm feeds • Protein utilisation in poultry
Feed efficiency in young beef animals • Mycotoxin contamination in maize
Salmonella species • Antibiotic resistance gene pollution • AFMA IWC round 2 winners

Keeping up with our fast-paced feed industry

By Liesl Breytenbach, executive director, AFMA

It's hard to believe that we are already several months into 2025 – and so far the year has really kept us on our toes! With so many moving parts in our industry, the saying 'time does not wait for anyone' has never been more relevant.

Fortunately, the recent rainfall over key summer grain areas have helped to ease some early concerns, and with the latest Crop Estimates Committee (CEC) figures showing an increase in maize and soya bean production (up from 2024's figures) we now have a clearer picture of what to expect in the months ahead.

While production estimates are higher than in the previous season, stock levels for most summer grains remain tight. The eventual supply-demand situation will depend on export demand from neighbouring countries, which will play a critical role in feed ingredient availability and price trends.

The animal feed industry is never short of challenges, but each one presents an opportunity for innovation, resilience, and collaboration. Whether it is navigating logistical hurdles at our ports or adapting to regulatory developments, one thing remains clear: We are all in this together.

Spotlight on what matters

A key focus in the April issue of *AFMA Matrix* is ongoing port inefficiencies and their impact on the feed industry. Supply chain disruptions have made one thing very clear: Efficient import and export logistics are critical for maintaining feed availability and cost stability. While these challenges are not new, the urgency to address them has never been greater.

We also explore the Animal Feed Manufacturers Association or AFMA's recent introduction of remote audits as part of its Code of Conduct assessment process. This enhancement allows for a more flexible and efficient auditing approach for specific member categories such as traders without warehousing, and certain Southern African Development Community (SADC)-based manufacturers. By integrating remote audits, AFMA continues to uphold high industry standards while streamlining compliance verification in a practical and cost-effective manner.

Perhaps some of the most rewarding developments have been various discussions in our internal AFMA committee meetings. These are invaluable engagement platforms where all members share input, identify challenges, and participate in finding solutions. These meetings are crucial for the entire industry because they give us the space to step back, take stock of our progress, and ensure that projects and strategic focus areas are moving in the right direction.

Value chain issues

AFMA continues to strengthen the value chain through collaboration in the grain value chain network roundtable, addressing key issues such as supply chain efficiencies, market access, and the adoption of innovative technologies to enhance productivity.

Additionally, AFMA is in the early stages of engaging with the livestock value chain roundtable under the Agriculture and Agro-processing Master Plan (AAMP) and is looking forward to contributing to industry-led solutions that drive efficiency and resilience in the livestock sector

As challenges evolve, biosecurity remains a fundamental priority. Preventing disease spread and ensuring feed safety are essential for a resilient and sustainable feed sector. AFMA is dedicated to keeping members informed and updating the industry on key biosecurity initiatives. Strengthening biosecurity across the value chain goes beyond compliance – it is a vital aspect to protecting the long-term future of our industry.

On the topic of global challenges, antimicrobial resistance (AMR) continues to be a significant concern and therefore AFMA is actively engaging with stakeholders in a unified AMR Alliance. Collaboration between regulators, veterinarians, and feed manufacturers is critical in shaping responsible antimicrobial use policies that safeguard both animal and human health.

We know that reliable crop estimates will continue to be invaluable for the feed industry, influencing everything from pricing to procurement strategies. This edition takes a closer look at the CEC's performance of the past seasons with regard to maize, soya bean, and sunflower crops, because accurate data in our industry is not only helpful – it's essential.

Knowledge and collaboration

Beyond the numbers and technical discussions, this issue also shines a light on something that is close to my heart: career development in the feed industry. Whether you are a student looking to enter the field, a feed mill operator seeking to develop practical skills, or a company searching for the right talent, AFMA's training and skills initiatives and collaborations strive to cultivate the next generation of experts.

In this industry, the chicken that stays informed stays at the top of the pecking order. This issue of *AFMA Matrix* is sure to contribute to the knowledge and insights needed to do precisely this.

At the end of the day, what makes this industry special is its people. The dedication, problem-solving, and drive to keep moving forward, despite numerous challenges, are what make our collective efforts so impactful. I encourage you to dive into this issue, reflect on the discussions and, most importantly, join the conversation that is shaping our industry's future.

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NEWS & VIEWS

Creepy crawlies boost feed bioavailability

Researchers from Tomsk State University in Russia have developed a promising technology to improve the biological availability of feed nutrients by using invertebrates such as cockroaches, crickets, and worms. These insects are fed with vitamins, minerals, and nutrients, and their processed biomass shows improved nutrient digestibility compared to the original form.

The study, which tested various enrichment strategies, found that invertebrates, especially cockroaches, could accumulate B vitamins, fat-soluble vitamins, and vitamin C more efficiently. Different species exhibited varying abilities to absorb nutrients, with Achatina and worms showing the most significant changes in mineral composition.

This enriched biomass could be particularly beneficial in the feed industry, especially for young poultry, as it improves nutrient absorption during critical growth stages. The researchers believe this technology could enhance animal health, boost immunity, and provide essential animal protein, thus offering a sustainable solution for the livestock sector. Further trials are needed to refine the approach. – *All About Feed*

Evonik invests in technical upgrade

Evonik is continuing to optimise its global production setup for MetAMINO® (DL-methionine) with a technical upgrade of its European methionine Verbund Antwerp (Belgium)/Wesseling (Germany). The low double-digit million euro investment requires a partial shutdown of these facilities for eight to ten weeks in the period May to July 2025. All existing contracts and supply agreements will be honoured. – *Press release*

A PURRfect *Act* for pets

The Pet Food Institute (PFI) in the United States (US) is advocating for the reintroduction of the *Pet Food Uniform Regulatory Reform Act (PURR Act)*, a bipartisan bill aimed at modernising pet food regulation in the US. If passed, the bill would grant the US Food and Drug Administration (FDA) sole authority over pet food labelling and ingredient reviews, replacing the current state-by-state system.

Dana Brooks, president and CEO of PFI, emphasised the importance of the reform for both pet owners and manufacturers, stating: "This legislation ensures predictable, national standards that encourage progress and speed to market."

The *PURR Act*, introduced on 21 January by representatives Steve Womack, Derek Schmidt, Josh Harder, David Valadao, and Adrian Smith, seeks to eliminate the 'costly and confusing' dual regulatory system that has existed for nearly a century.

The bill proposes centralised federal oversight to standardise ingredient approvals and labelling, addressing the inconsistencies across states that hinder innovation and efficiency. It also includes performance benchmarks for the FDA, ensuring timely reviews and approvals. – *animalfeedmea.com*

Feed enzyme stake changes hands

dsm-firmenich has sold its stake in the Feed Enzymes Alliance to its partner Novonesis for €1,5 billion (US$1,55 billion). The transaction, which represented approximately €300 million in annual net sales for dsm-firmenich last year, strengthens Novonesis' position in the animal biosolutions sector. The companies will continue their long-term commercial relationship, with Novonesis reselling dsm-firmenich's feed enzymes through its animal nutrition and health premix network.

Novonesis president Ester Baiget expressed excitement over the acquisition, noting it would help to address global protein demand and sustainability challenges. dsm-firmenich expects to receive €1,4 billion in net cash, with a book profit recognised upon closing.

The alliance, formed over 25 years ago, has established a leadership position in feed enzymes. dsm-firmenich will continue its separation process from the Animal Nutrition & Health business this year, seeking transaction options for its exit. – *Feed Strategy*

Shoprite feeds 3 000 cattle a day

The Shoprite Group is transforming 1 000 tonnes of food waste into animal feed, providing enough fodder for 3 000 cattle daily. By repurposing food products returned from Shoprite and Checkers stores, the retailer helps reduce environmental impact and supports the circular economy. Non-consumable items such as rice, pasta, chips, and snacks are now used to supplement animal feed, along with hominy chop, a by-product of maize milling.

The company focusses on preventing food waste through improved ordering and data analytics. Surplus food still fit for human consumption is donated to 544 beneficiary organisations, serving 67 million meals annually. Only food deemed unfit for human use is repurposed for animal feed or composted.

With a goal of zero organic waste to landfill in 2025, the Shoprite Group diverted 72 000 tonnes of waste from landfills this year, adopting industry-leading waste management practices to reduce, reuse, and repurpose. – *South Africa: The Good News*

ADM withdraws feed products

ADM Animal Nutrition, a division of ADM (NYSE: ADM), in the US is recalling specific pelleted animal feed products because they may contain elevated levels of copper or have levels of zinc below the represented amounts which could be harmful to cattle.

Possible impacts of chronic copper toxicity include gastroenteritis characterised by anorexia, signs of abdominal pain, depression, lethargy, diarrhoea, and dehydration. Possible impacts of zinc deficiency include decreases in feed intake, feed efficiency, and growth. No illnesses or deficiency impacts have been reported to date.

There are 33 lot numbers in the US involved in the recall. The pelleted products were distributed between 16 January and 27 February, and could have been purchased in Illinois, Missouri, Tennessee, Iowa, Georgia, and Ohio. All of the products listed, except for GROFAST32, have elevated levels of copper. GROFAST32 has levels of zinc below the represented amounts. ADM discovered this issue during routine production. – *US Food & Drug Administration*

Researchers discover natural feed supplement

Occurring across South Africa, Botswana, Namibia and the western reaches of Zimbabwe, the camel thorn (*Vachellia erioloba*) thrives where few others can, extending its roots deep into arid terrain. It is also found in Angola, southwest Mozambique, Zambia and Eswatini, anchoring ecosystems that rely on its resilience.

Now, a team of researchers from the North-West University (NWU) has discovered that supplementing lamb feed with *Vachellia erioloba* leaf meal and ammoniated maize stover significantly enhances growth performance, improves meat quality and enriches fatty acid profiles.

The study, published in the *Meat Science Journal*, was conducted by Dr Getrude Manakedi Chelopo and Prof Upenyu Marume from the School of Agricultural Sciences and the Food Security and Safety research niche area at the NWU, in collaboration with Prof Arno Hugo from the Department of Animal Science at the University of the Free State. The results show that lambs fed this enriched diet exhibited better weight gain, improved meat tenderness, and a healthier fat composition. – *News@NWU*

Rainbow warns government of risks

Rainbow Chicken, a leading South African poultry producer, has reported a significant rise in earnings, with a 119% increase in earnings before interest, taxes, depreciation, and amortisation (EBITDA) to R581,1 million for the six months ending December last year. Revenue also grew by 8,9% to R7,9 billion. The improved performance was driven by operational efficiencies, cost management, and lower commodity prices, alongside a reduction in energy load shedding and avian influenza (bird flu) risks.

However, the company cautioned that bird flu remains a material threat, urging the government to reconsider the prohibitive costs of its vaccination protocol. Rainbow has taken proactive measures, including culling breeder birds, relocating its Midrand breeding facility, and enhancing biosecurity to reduce risks.

Despite the challenges, Rainbow's turnaround strategy continues to show positive momentum, with revenue growth driven by improved sales channels and product mix. The company has opted not to declare an interim dividend, instead focussing on reinvesting in infrastructure for future growth. – *Business Tech*

China bans US soya bean

China has revoked the soya bean import qualifications of three US companies – CHS Inc, Louis Dreyfus Company Grains Merchandising LLC, and EGT – intensifying trade tensions between the world's two largest economies. The suspension follows the detection of ergot and seed coating agents in shipments from the US.

The decision comes just after China imposed new tariffs on US$21 billion worth of American agricultural and food products, in response to the additional 10% duty imposed by the US on 4 March this year. The cumulative tariff now stands at 20%, further straining agricultural trade between the two nations.

The ban is likely to disrupt global soya bean flows, potentially benefiting alternative suppliers such as Brazil and Argentina. As one of the largest buyers of US soya bean for animal feed, China's decision may have significant ripple effects on feed markets worldwide. – *Feed Planet*

Erratum

An article published in the January edition of *AFMA Matrix* starting on page 46 contained an incomplete attribution. The correct and complete attribution should read: This article was originally published in *Applied Animal Science* Vol 40(5) 639-646, MR Beck, VN Gouvêa, JK Smith, JA Proctor, PA Beck, and AP Foote, licensed under the CC BY user license. It has been modified from the original.❖

Manage tight maize supplies head-on

By Petru Fourie, operations manager, AFMA

Maize serves as the cornerstone of South Africa's feed industry, forming the foundation of livestock and poultry nutrition. As the largest single ingredient in animal feed formulations, fluctuations in its supply, pricing, and availability have significant implications for feed manufacturers and livestock producers. The importance of maize in feed production cannot be overstated – it is an energy-dense, cost-effective component in feed rations, making it indispensable in large-scale feed manufacturing.

The past few years have been challenging for the feed industry due to increased maize price volatility, largely driven by the impact of climate conditions on crop production. These factors have tightened maize supplies, prompting feed manufacturers to reassess procurement strategies and adapt to an increasingly uncertain market.

The 2024/25 marketing season has already seen record-high maize consumption levels, with 2025/26 estimates pointing to further supply pressures. Given these realities, feed manufacturers must evaluate strategies to mitigate risks, optimise feed formulations, and ensure supply stability. The purpose of this article is to examine the current challenges associated with the supply of yellow maize, a crucial ingredient in the feed industry.

Local production and consumption

South Africa produces an average of 15 million tonnes of maize annually with white maize primarily consumed as a staple food while yellow maize remains a critical component of the animal feed sector. The local feed industry consumes on average 5,87 million tonnes of maize per year, with 4,57 million tonnes (78%) being yellow maize and 1,3 million tonnes (22%) white maize. During the past five years, an average of 65% of total yellow maize production has been used for feed. However, for the 2024/25 and 2025/26 seasons, this figure is projected to increase significantly to 96%.

Of the total feeds produced, the poultry sector accounts for nearly 40% while the pig, beef, and dairy industries also rely on maize-based feeds. The demand for maize-based feed has steadily increased over the years due to an increase in consumer demand for affordable animal protein, making maize an integral part of the entire agricultural value chain.

As a result of recent drought conditions, maize production has become increasingly unpredictable with major shifts in planting patterns, and the global market also contributing to supply uncertainty. As yellow maize represents a large percentage in feed composition, any disruptions in production or price surges directly impact feed costs, ultimately affecting livestock producers.

Increase demand, tighten supply

According to data by the South African Grain Information Service (Sagis) and the National Agricultural Marketing Council (NAMC), the long-term trends seen in South African yellow and white maize consumption for animal feed showed a steady increase in yellow maize usage alongside fluctuating white maize consumption driven by price and availability (*Figure 1*).

In the 2024/25 marketing year, yellow maize consumption in animal feed reached a record-high level of 6,1 million tonnes. This surge was primarily driven by a tight white maize supply, following drought conditions that severely impacted white maize production. On average, white maize prices traded more than R1 000/ton higher than yellow maize, reinforcing yellow maize as the preferred choice for feed manufacturers.

With poultry remaining the dominant consumer of feed, yellow maize consumption is expected to remain strong throughout the 2025/26 marketing season. This strong demand also has its challenges as the industry faces production shortfalls and price volatility. Feed manufacturers must closely monitor supply trends and adjust procurement strategies accordingly to steer potential market shifts.

> It is important to note that the supply estimates for the 2025/26 marketing year are based on the first production estimates released by the Crop Estimates Committee (CEC) and may change as seasonal conditions evolve, impacting final stock levels and market expectations.

Supply pressure

This section focusses specifically on yellow maize given its dominant role in the animal feed industry. One of the most pressing challenges at the start of the 2025/26

Figure 1: Consumption of yellow and white maize for animal feed. (Source: Sagis, 1997/98 to 2023/24 and NAMC, 2024/25 to 2025/26)

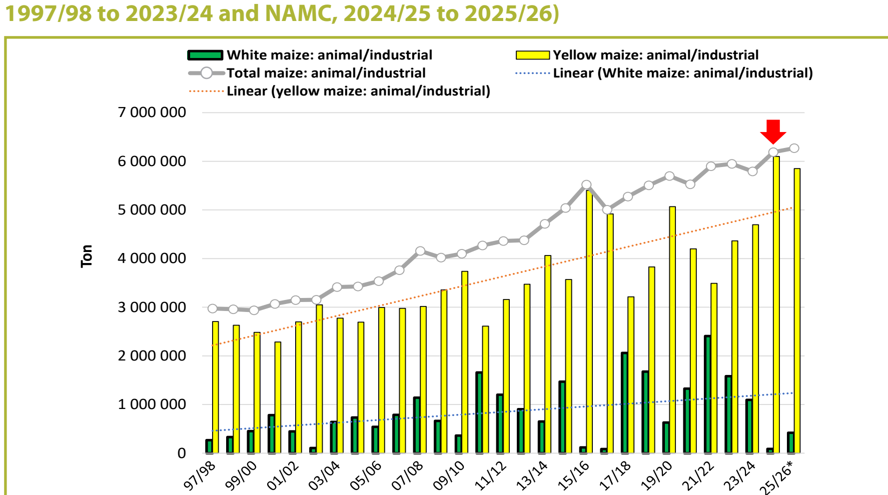
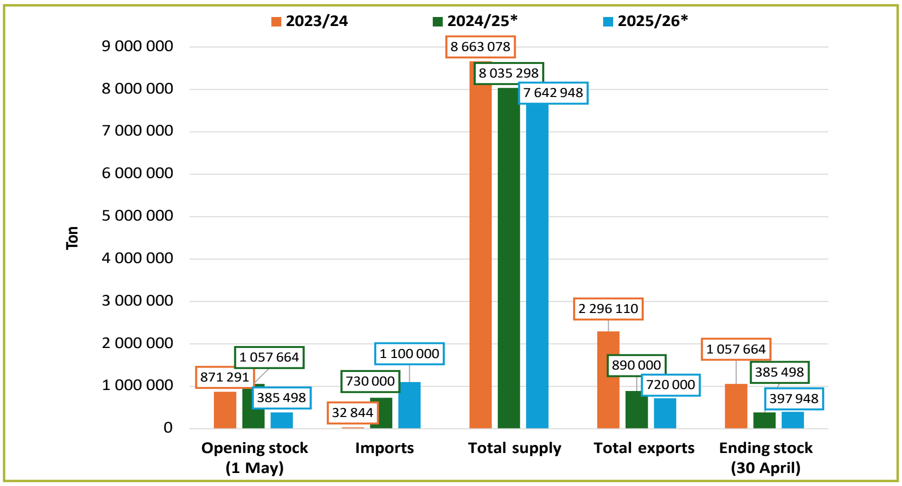


Figure 2 Yellow maize: Opening stock versus ending stock. (Source: Sagis, 2023/24, and NAMC, 2024/25 to 2025/26)



marketing year is the low opening stock levels of 385 498 tonnes – indicating a drastic decline from 1 058 million tonnes in 2024/25. This significantly low stock level creates immediate supply pressures, particularly in a year when the CEC's first yellow maize production estimate is approximately 11% lower than the previous five-year average.

Looking at historical trends, the last time South Africa's yellow maize opening stocks were this low was in the 2014/15 marketing year, a period also marked by severe drought conditions that impacted production. As a result, the current market conditions reflect similar supply constraints, leading to reduced carry-over stocks and market uncertainty.

In order to meet local demand, yellow maize imports are therefore expected to increase significantly – from 32 844 tonnes in the 2023/24 marketing year, with the following season's 730 000 tonnes, to an early projection of 1,1 million tonnes in 2025/26. This shift from being a net exporter of maize to importing puts pressure on feed manufacturers, particularly increasing exposure to currency fluctuations which directly impact the landed cost of imported maize.

Yellow maize exports are projected to decline sharply from 2,3 million tonnes in 2023/24 to only 720 000 tonnes in 2025/26, further highlighting the strain on local supply availability. The ultimate impact on the supply-demand balance will largely depend on demand from neighbouring countries. For feed manufacturers, these dynamics increase uncertainty and cost pressures, requiring proactive procurement and risk management strategies to secure raw materials at competitive prices.

Price volatility

Despite prevailing tight supply fundamentals, yellow maize prices on the South African Futures Exchange (Safex) have declined significantly since 27 January this year. Maize prices across all contract periods – March 2025, May 2025, and July 2025 – have fallen, ranging from more than R1 000 per ton over a five-week period (until the time of writing this article) for the March 2025 contract month compared to almost R400 for the May 2025 and July 2025 contract prices.

While market sentiment and fundamental factors, including low stock levels and increased import dependence, suggest continued price support for the upcoming marketing season, recent downward movements indicate that short-term market forces have temporarily outweighed underlying supply constraints.

While fundamentals still indicate long-term supply constraints, the recent correction suggests that short-term liquidity pressures, improved production outlooks due to the February rains, and a shift in contract focus played a more immediate role in driving prices lower. Although the July 2025 Safex yellow maize contract price is, at the time of writing, trading just above R4 000/t, the prevailing supply constraints indicate that prices could trend towards import parity levels, which are currently approximately R5 100/t.

For feed manufacturers, this sudden price shift presents both risks and opportunities. On the one hand, the decline provides temporary relief on input costs, creating a window for strategic purchasing. However, the fundamental supply outlook remains constrained, and any adjustments in crop estimate figures, unexpected production shortfalls, or renewed global market pressures could lead to a price rebound in the coming months.

With maize accounting for 60 to 70% of total feed costs, such price fluctuations have major implications for the entire feed industry. The ability to analyse Safex trends and anticipate future price movements will be critical in maintaining cost-efficiency and securing raw materials at competitive prices.

Conclusion

As South Africa's feed industry continues to grapple with tight maize supplies, price volatility, and shifting market dynamics, it is crucial for feed manufacturers to remain proactive and adaptable in their procurement strategies. The record-high yellow maize consumption in 2024/25, coupled with historically low stock levels and increased import dependence, highlights the challenges facing the industry as it moves into the 2025/26 marketing season.

As South Africa's feed industry steers towards tight maize supplies, proactive market monitoring and strategic planning are more critical than ever. High maize consumption coupled with lower-than-average stock levels are highlighting the urgency to ensure a reliable and cost-effective maize supply to sustain feed manufacturing – and the broader livestock industry.

It is important to note that the insights shared in this article are based on the first production estimates from the CEC. The transition from being a net exporter of maize to having to import further exacerbates this challenge and exposes feed manufacturers to currency risks and global market fluctuations.

This article was written on 5 March 2025 based on the available information on the day. For more information, send an email to the author at petru@afma.co.za.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Navigating challenges: The impact of port inefficiencies on animal feed manufacturers

By Dr Lucius Phaleng, trade advisor, AFMA

South Africa is recognised as one of the leading shipping hubs globally with a substantial volume of vessels navigating its ports daily. The country has eight commercial ports along its west and east coasts, all of which fall under the jurisdiction of the Transnet National Ports Authority (TNPA), a subsidiary of Transnet.

The seven trading ports serve as vital intermediary points for maritime trade with Europe, Asia, the United States (US), Australia, and both coasts of Africa. Notably, 96% of South Africa's exports are transported by sea, underscoring the importance of these ports as key destinations for imports as well. Among these ports, Durban stands out as the largest container facility in Africa and is often regarded as the busiest port in the country.

This article explores the various inefficiencies that impact animal feed manufacturers, examining the repercussions for production, costs, and overall market competitiveness.

Challenges faced by local ports

In recent years, South African ports have grappled with numerous challenges that have led to operational delays and financial losses. As of this year, the Port of Cape Town has been identified as the most inefficient port for agricultural exports with issues such as backlogs, delays, and outdated infrastructure imposing significant costs on the agricultural sector, especially concerning the importation of essential feed ingredients. Delays in importing key ingredients can result in loss of quality and value.

The situation has become so critical that the World Bank has ranked South African ports among the bottom 400 global docks in its Container Port Performance Index (CPPI). In response to these challenges, the Port of Cape Town has recently acquired new equipment aimed at improving container stacking and ship loading/unloading processes. Ageing equipment and frequent breakdowns have contributed to operational difficulties, particularly as older machinery struggles to endure the strong winds that can affect the area.

Supply chain disruptions

Animal feed manufacturers are particularly dependent on the timely importation of essential ingredients such as grains, protein meals, and additives. Any delays at ports can lead to substantial disruptions in the supply chain. For example, a delay in receiving soya bean meal can halt production lines reliant on that ingredient, leading to immediate financial losses and jeopardising long-term relationships with customers and suppliers.

The just-in-time inventory model that many manufacturers adopt to reduce storage costs becomes unfeasible amid unpredictable port delays. Consequently, manufacturers may be compelled to maintain larger inventories, resulting in increased operational costs and capital being unnecessarily tied up. Furthermore, extended storage times due to delays can compromise the quality and safety of animal feed products, elevating the risk of spoilage or contamination.

Real-time data from GoComet indicates that Durban and Cape Town are currently experiencing six-day delays, while Coega and Gqeberha face delays of two days and one day, respectively.

Conclusion

As the animal feed manufacturing sector evolves within an increasingly interconnected global economy, the significance of port inefficiencies cannot be underestimated. These challenges threaten not only the operational efficiency and financial viability of manufacturers but also the entire agricultural supply chain. By recognising the critical role of port operations and advocating for improvements, stakeholders can collaborate to establish a more resilient and efficient logistics network, ultimately supporting the long-term sustainability and competitiveness of the animal feed industry.

For more information, send an email to Dr Lucius Phaleng at trade@afma.co.za.

Assessing the CEC's accuracy: From first estimate to final crop

By Petru Fourie, operations manager, AFMA

The 2023/24 planting season in South Africa started with adequate early rainfall that enabled timely planting. However, a mid-summer drought in January and February last year led to prolonged heat and dryness, reducing yield potential and resulting in below-average yields.

The impact of these conditions is evident in last year's maize crop which, at an estimated 12,85 million tonnes, marks the smallest total maize crop in five years, making it the lowest since 2019 (11,275 million tonnes). This has direct implications for the animal feed industry, as maize remains a crucial ingredient in livestock feed production. Feed millers rely on stable maize supplies and accurate crop estimates to manage raw material procurement, cost structures, and production planning, all of which become more complex in volatile production seasons.

This article provides an in-depth review of the crop estimation process for the 2023/24 season, analysing how the Crop Estimates Committee (CEC) adjusted its forecasts from the first production estimate in February last year to the final actual estimate in February this year for maize, soya bean and sunflower seed. Accurate and timely estimates are fundamental to market price formation, feed supply planning, and ensuring stability in the agricultural sector, particularly in volatile seasons such as 2023/24.

Progress of the 2023/24 season

Yellow maize

Figure 1 illustrates the monthly production estimates for yellow maize from February to November last year, as released by the CEC. The red line represents the final realised yellow maize production figure of 6,795 million tonnes. The initial estimate in February last year was 7,318 million tonnes, as the season started relatively well, but due to the challenging mid-season drought conditions, the final crop size was adjusted downward by 523 400 tonnes.

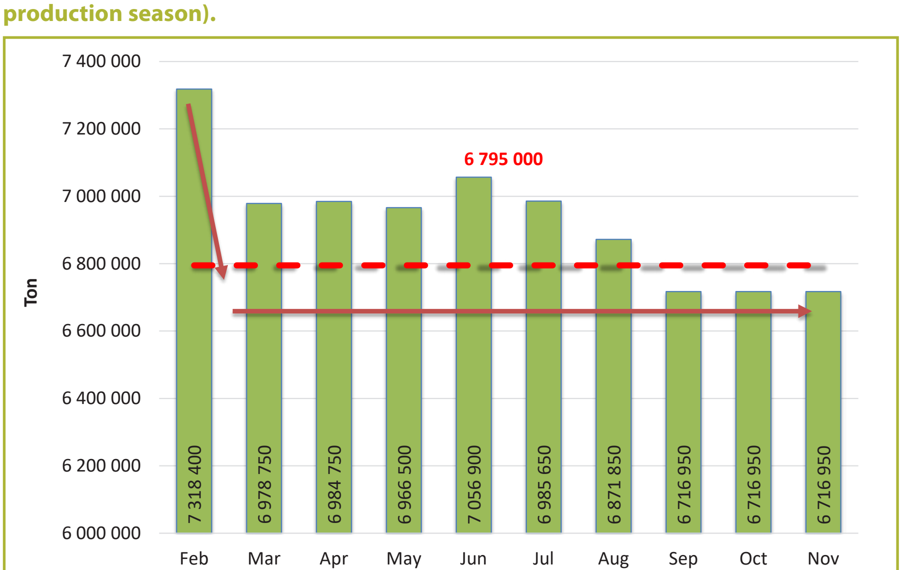
The CEC's swift response to changing conditions and their ability to filter updated information into their estimates is commendable. This is evident in the immediate adjustment of the February estimate to the March estimate. While fluctuations occurred throughout the season, the CEC's projections gradually aligned with the final production figure, demonstrating their commitment to accurate and responsive forecasting.

For feed millers, yellow maize is a critical input in animal feed production, influencing raw material procurement, price volatility, and supply chain planning. A smaller than expected maize crop directly affects feed availability and costs, thus making accurate crop estimates even more essential for planning.

White maize

Figure 2 presents the monthly production estimates for white maize throughout the 2023/24 production season. Similar to yellow maize, the CEC initially estimated a relatively high crop, but its estimates were quickly adjusted to take into account the impact of the drought conditions. As the drought conditions were more severe in the western parts of South Africa compared to the eastern regions, the impact of the drought was more pronounced in white maize compared to yellow maize. The initial estimate in February last year was 7,041 million tonnes, but due to the challenging conditions, the final crop size was revised downward by 985 500 tonnes.

Figure 1: Yellow maize, monthly production estimate vs actual crop (2023/24 production season).

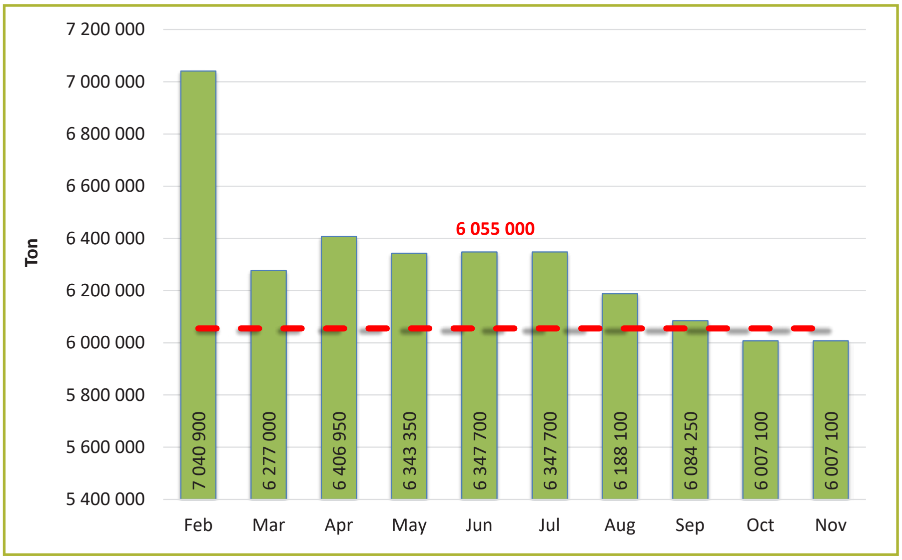


CEC estimate norms

In South Africa, the grain industry has set a standard/norm of accuracy for the CEC within which crop estimates must range. Specifically, from the first to the fourth estimate (February to May), deviations from the actual crop estimate should not exceed 8%, and from the fifth to the final estimate (June to November), deviations should not exceed 5%. The CEC must operate within acceptable upper and lower norms and if an estimate deviates beyond these limits, it may in retrospect be classified as an over- or underestimation.

Yellow maize estimates consistently remained within the acceptable norms, demonstrating a high level of accuracy. However, white maize posed a greater challenge, with the first estimate significantly overestimated. This initial

Figure 2: White maize, monthly production estimate vs actual crop (2023/24 production season).



overestimation of the white maize crop also caused the total maize estimate to exceed the norm during the first round of projections.

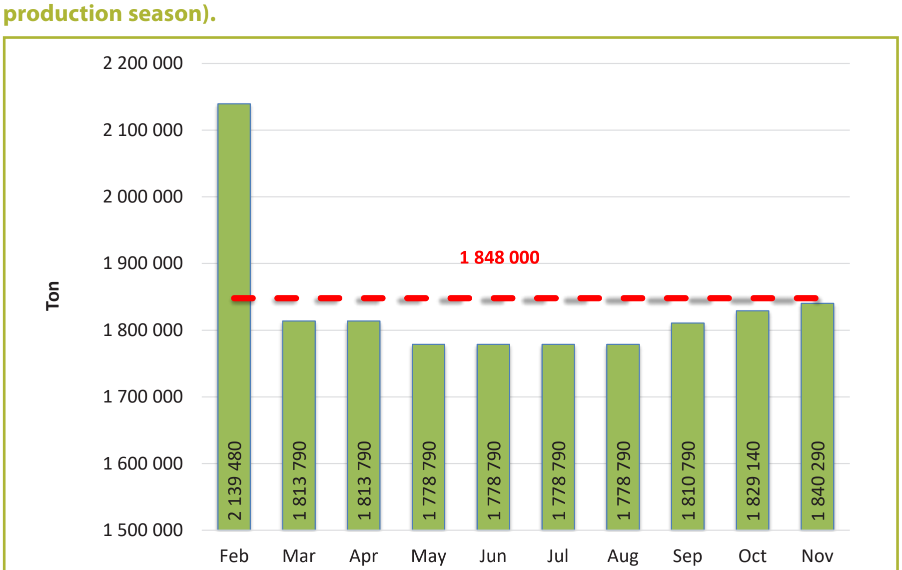
Despite this, the CEC quickly adjusted its estimations, and from the second estimate onward all projections remained predominantly within the acceptable range. This reflects the CEC's ability to refine its estimates as more accurate data became available, ensuring reliable estimations for the industry.

Soya bean

Soya bean plays an increasingly vital role in South Africa's agricultural and feed sectors, particularly as a protein source for animal feed. The accuracy of soya bean production estimates is essential for feed manufacturers to manage soya bean meal supply and price stability.

Figure 3 shows the monthly production estimates for soya bean during the 2023/24 production season. The CEC initially overestimated the soya bean crop in February, with the first estimate at 2,139 million tonnes. However, from the second estimate, the crop size aligned well with the final actual production figure as released on 13 February. This actual production figure indicates a decrease of 291 480 tonnes from the initial February estimate.

Figure 3: Soya beans, monthly production estimate vs actual crop (2023/24 production season).



With the standards and norms already discussed for maize, it is evident that the CEC followed a similar trend for soya bean. The first estimate was overestimated, but subsequent estimates remained within the industry's given norms of accuracy. Overall, the CEC performed exceptionally well, maintaining accuracy and staying within the required limits.

Sunflower seed

The CEC's first estimate for the sunflower seed crop (February last year) was 671 100 tonnes. As the mid-summer drought set in, the CEC lowered its production estimate in March and April last year. However, as the season progressed, the estimates were gradually revised upward before stabilising near the final actual crop figure. Despite initial variations, the estimates remained accurate, aligning closely with the actual crop size.

The CEC performed remarkably well in estimating the sunflower crop the past season, maintaining accuracy within the industry-prescribed norms from the beginning despite a challenging season. Their estimates consistently adjusted towards the final figure, demonstrating reliability in the estimation process.

Conclusion

The 2023/24 season posed significant challenges for agriculture in South Africa, with drought conditions leading to the smallest maize crop in five years. Despite a challenging season, the CEC demonstrated adaptability and accuracy, adjusting estimates as new data became available and predominantly staying within industry norms.

As illustrated in this article, the CEC's strong performance provides a sense of confidence, demonstrating its ability to accurately estimate crop sizes. The timely release of precise crop estimates remains crucial for *inter alia* feed millers and industry stakeholders, as it directly influences raw material prices, procurement strategies, cost management, and production planning in the animal feed sector.

For more information, send an email to the author at petru@afma.co.za or Rona Beukes, a member of the CEC, at RonaB@dalrrd.gov.za

Careers in the feed industry: The journey of a lifetime (Part 1)

By Susan Marais

Animal feed manufacturing is more than simply a job. It is the journey of a lifetime – regardless of your qualification level, says Petru Fourie, operations manager at the Animal Feed Manufacturers Association (AFMA). That is why AFMA and industry role-players work together to ensure that top talent is retained through continued development and opportunities for employees to expand their horizons.

According to Fourie, the best way to build a thriving animal feed industry is to ensure the continuous development of passionate people. In this regard, AFMA and its partners have developed several programmes and courses to ensure that students and professionals already working in the industry can expand their knowledge and expertise.

While 'students' refer specifically to individuals undertaking their tertiary studies, the word 'professional' is not code for somebody with a degree, says Fourie. "All people working in the animal feed industry are highly valued and highly skilled, whether you work on the factory floor, a laboratory or anything in between. And AFMA strives to ensure that all passionate employees reach their full potential."

Ongoing professional development

However, there are certain practical limitations that could prevent a ground-level employee from further developing his or her practical knowledge of feed milling. As a result, the association has introduced its Feed Mill Operator blended learning programme.

"This course rests on two legs, namely a practical side and an online component," says Fourie. The practical segment is conducted at the mill where the person is employed, while the online component can be completed independently. The most important requirement for this course is the involvement of a supervisor who is willing to facilitate the course at the feed mill. The course takes approximately six months to complete because the practical sessions must be incorporated into the normal milling schedule.

At a managerial level, AFMA's annual Feed Miller Short Course needs no introduction. The course is in its tenth year and focusses on students at managerial level. AFMA presents this course annually in collaboration with Nef Feed Milling Consulting. Ernst Nef, former director and specialist teacher at the Swiss Institute of Feed Technology, facilitates the course. The ten-day in-depth programme combines theoretical information with practical, hands-on training to enhance feed mill efficiency and optimise production quality.

"This course is not for inexperienced managers. A person must have a few years' experience and be in a supervisory role to take full advantage of it," says Fourie.

For those with animal science degrees, especially those with a few years' experience, there are new opportunities to expand and apply their knowledge. One such position is that of an independent consultant. Experts in this field are currently in high demand, specifically those who can manage the registration of new products with the Registrar of the *Fertilizers, Farm Feeds, Agricultural Remedies and Stock Remedies Act, 1947 (Act 36 of 1947).*

"Experience lies at the core of this type of position and therefore a few years' exposure to the industry's work environment is critical."

AFMA and its members, Fourie explains, regularly collaborate with AgriJob, a company specialising in agricultural careers, to advertise job openings in the sector on their website *www.agrijob.co.za*. "Advertising careers on this portal is free to our members and therefore is the best place for potential job seekers to see which opportunities await."

This platform posts job opportunities for all careers within the agricultural sector and is ideal for non-animal science job seekers to find the next opportunity to skyrocket their careers. AFMA and many of its members work closely with AgriJob to assist students in finding placements as interns.

Student development

Those starting out on their journey in the animal feed industry might feel overwhelmed by all the available opportunities. The world of animal feed opportunities is forever expanding, and some of these opportunities include:

- Product development (for example, formulator and tester).
- Technical sales representative.
- Laboratory technician/specialist.
- Quality controller.
- Feed specialist (functioning at various levels/positions).
- Research scientist (who focusses on research only).
- Independent consultant.

"Off course we also need other professionals such as economists, but this list is only focussed on the research side of animal feed," Fourie says, adding that AFMA focusses on the development of animal feed scientists and related roles at university level.

All universities offering tertiary courses related to animal sciences are included in AFMA's student development programmes. "We really try to engage with universities as often as possible and specifically target third-, fourth- and final-year students."

Exciting competitions

To encourage the development of the sector at tertiary level, AFMA offers several competitions that honour the best and brightest students. The Koos van der Merwe AFMA Student of the Year award is given to exceptional students in animal nutrition – its aim is to encourage and inspire next generations of professionals to significantly contribute to the animal feed industry. This award includes a cash prize and affords the winner the opportunity to present his or her research during the annual AFMA Symposium.

The Intervarsity Writer's Cup (IWC) competition is open to all final year and postgraduate animal nutrition students. This competition includes a cash prize, and the winning articles are published in *AFMA Matrix* magazine. The winner can present his or her research at the annual AFMA Symposium.

"There are two categories in the IWC competition. One is own research, and the other is a literature review," Fourie says. While prizes are awarded in both categories, only original research is eligible for the award. "It is critical that we stimulate competition among the students and universities because that leads to a stronger, more competitive sector."

Students' papers are graded and evaluated by a group of industry experts, and they must score a minimum of 70% to become eligible for the award. This ensures that the standard of the award remains high.

Another opportunity for students to showcase their research is the AFMA Student Nutrition Poster award. Students can become eligible for this award by submitting an animal nutrition research poster at the South African Society for Animal Science (SASAS) congress.

Top students will be given exposure and recognition on AFMA's social media platforms and there is a crash prize up for grabs.

Besides these competitions, AFMA hosts a technical writing skills workshop specifically aimed at helping scientists write articles for popular agricultural magazines and social media. "This is an excellent opportunity for young people to gain the confidence and skills to distinguish themselves within the industry in order to build a reputation for themselves," Fourie concludes.

In the next issue of *AFMA Matrix*, industry role-players and placement agencies will share their views on current and future career development opportunities in the animal feed industry.

For more information, send an email to Petru Fourie at petru@afma.co.za.

Insight into remote audits for the AFMA Code of Conduct

By Wimpie Groenewald, membership liaison officer, AFMA, and Joe Hanekom, managing director, Afri Compliance

The Animal Feed Manufacturers Association (AFMA) has recently revised its auditing protocol to provide a more functional and logistically flexible auditing process. A key enhancement includes the introduction of remote audits for specific categories of members, namely traders who do not use warehousing and move products directly from the ship to the client; and manufacturing facilities located in neighbouring Southern African Development Community (SADC) countries that do not export feed products to South Africa.

The new provision for remote audits aligns with AFMA's commitment to maintaining a high industry standard with a robust risk-based approach, while offering a practical and cost-effective compliance verification method.

This audit is a self-regulating mechanism that verifies compliance of all AFMA full and associate member facilities with the relevant legal requirements and industry standards related to animal feed and feed manufacturing. The audit process promotes integrity and consumer confidence within the animal feed and food sectors.

The standard audit process

Traditionally, the AFMA Code of Conduct audit requires an on-site assessment conducted every two years by an independent auditor. The process includes:

- Telephonic pre-screening assessment to verify operations at the facility.
- On-site audit to verify compliance.
- Compiling a comprehensive audit report detailing non-conformances.
- Corrective action process to address non-conformances within an agreed timeframe.
- Follow-up verification by the auditor to close findings.
- AFMA Code of Conduct certificate issued upon full compliance.

The industry Code of Conduct was initiated in 2008 and since then, all AFMA feed manufacturers and feed ingredient suppliers have shown continuous compliance with the industry code, creating a responsible industry that provides safe feed for safe food.

AFMA has initiated a modernisation of the Code to ensure its continued relevance, and as part of the re-assessment process, remote audits were adopted as acceptable audit protocols for qualifying members.

How remote audits work

Remote audits use electronic methods to obtain evidence and evaluate conformity to audit criteria, and can include sharing files via email, OneDrive, or Google Drive; video conferencing by using tools such as Microsoft Teams and Zoom; or live video or surveillance video to gather evidence. Remote auditing is useful for any kind of audit where evidence is gathered via documentation review, records evaluation, and interviews with people. This requires certain arrangements for the location of the auditor and safe and reliable technology.

Remote audits are acknowledged by ISO 17065 as a standard auditing process and have been adopted by AFMA as part of its Code of Conduct audit protocol for certain membership categories. These audits are designed to deliver the same outcome as an on-site audit and is based on the same audit criteria. Remote audits are especially efficient for reviewing documents and records at facilities where no product is manufactured and/or stored.

Eligibility for remote audits

AFMA management, in conjunction with the assessment body, thoroughly evaluated the risk of adopting remote audits as part of the Code of Conduct audit protocol, and have identified two membership categories where this will be allowed, as well as a set of criteria to determine eligibility.

***New members*:** It is important to note that the first audit for ALL new (provisional) members will be an on-site audit and determines a risk profile for the business. Subsequent audits during the next audit cycle at trading companies and SADC manufacturers may qualify for a remote audit subject to AFMA approval. SADC manufacturers may only qualify for a remote audit every alternate audit cycle.

***Existing members*:** Traders (without warehousing) may opt for a remote audit in the next renewal cycle following implementation. Eligibility for remote audits will be discussed during the pre-screening assessment with AFMA

Table 1: Membership categories and criteria necessary to determine eligibility.

Membership category	Criteria	Audit frequency*
Traders	Direct delivery of products from ship to client without storage at a warehouse.	First audit = on site Subsequent audits = remote
SADC feed manufacturers	Manufactured feed products are not exported to/traded in South Africa.	First audit = on site Second audit = remote Every alternate audit must be on site

before each renewal, and written confirmation will be given upon approval. AFMA then notifies the assessment body when a remote audit process has been granted, based on the information gathered during the pre-screen process and previous audit risk assessments.

Warehousing

It is often overlooked that farm feed product specifications and safety must be upheld throughout the process, from manufacturing in the feed mill until presentation to an animal for consumption. This also includes the storage and transportation of feed products. The registration holder of a farm feed is therefore responsible by law to guarantee product compliance throughout the supply chain.

The AFMA Code of Conduct was designed to independently verify member compliance across the whole supply chain – from ingredients used in feed manufacturing, its transport and storage, the manufacturing process, to the storage and transport of the finished product to the animal.

It is clear that warehousing is an integral part of the process, and AFMA members have proven to store products under good warehousing practices that support the integrity and safety of animal feed. All warehouses subjected to a Code of Conduct audit are listed on the AFMA certificate issued to compliant member companies. Clients and consumers can obtain assurance that product safety and integrity were maintained during storage at all compliant AFMA members.

Physical verification (on site) is needed to ensure that feed products are stored effectively, and hence the reason why remote audits will only be granted for members that do not make use of warehousing as part of their distribution.

Preparing for a remote audit

Proper preparation for an audit is crucial to facilitate an efficient process. This is also true for remote audits and includes reviewing operational compliance with the AFMA Code of Conduct audit criteria; ensuring all required documentation is organised and available for the audit; preparing staff for virtual assessments; ensuring availability of effective technology to conduct virtual assessments; and co-ordinating with the assessment body in advance.

Implementation

The introduction of remote audits was implemented on 1 March. AFMA is fully committed to enhance the industry's ability to manage risk via the Code of Conduct and to assure our clients and consumers that AFMA members contribute responsibly to the animal agricultural value chain.

Further developments in the modernisation of the Code of Conduct are expected this year, including the introduction of an updated audit scope based on FSSC 22000 principles, and additional assessment bodies that will be approved for auditing against the AFMA Code of Conduct.

For more information regarding the Code of Conduct, audit protocol, and approved assessment body, visit *www.afma.co.za* or send an email to Wimpie Groenewald at admin@afma.co.za.

Quality and standards are king: An auditor's perspective

By Lynette Louw

Dirk Bezuidenhout was involved in the livestock industry for more than 30 years, 15 of which he spent working for Afri Compliance. He was part of a team responsible for conducting specialist audits and verifying quality standards for agricultural establishments. In 2008, the Animal Feed Manufacturers Association (AFMA) adopted the AMFA Code of Conduct (CoC). Afri Compliance was contracted to serve as the independent auditing body to perform the compliance audits relating to the CoC.

Dirk was part of this process from the start. The audits entail ensuring that feed manufacturers meet regulatory requirements and quality standards set out in the CoC. In his role as an auditor, Dirk witnessed first-hand how an industry with a shared goal could succeed in meeting and sustaining the highest of standards.

From concept to conduct

The auditing process ensures that aspects such as transparency, traceability, honest business practices, adherence to regulations, responsible raw material use, respect for human capital, the promotion of sound working conditions, and more are entrenched in feed manufacturing processes. "Ultimately the AFMA Code of Conduct logo became a mark of integrity. The entire process of manufacturing safe feed to ensure safe food means consumers can rest assured that the highest quality standards were met."

Dirk's high school career at Brits Agricultural High School (now Wagpos) in North West laid the foundation for his passion for the livestock industry. When he joined Afri Compliance after serving at Agri Inspec, he learned a lot from his colleagues, especially Herman van Zyl, whose knowledge of the feed industry served as an inspiration and enormous source of information.

Dirk is passionate about the value of maintaining high standards: "It is about much more than adhering to rules and regulations. It is also about an ethical responsibility and ensuring quality as it affects both animal and human health. The CoC assists producers in meeting their ethical obligations. Producers have very little margin for error as almost 70% of their input costs revolve around animal feed and getting their animals market-ready. They have to be able to rely on a trustworthy, well-regulated feed industry."

Independent auditing is key

Third-party auditing, he says, ensures an independent, neutral process. "We know that state organs do not have the capacity to perform all their duties and that is where we can, and certainly do, make a difference. We strive to perform these auditing duties to the highest standards possible, and this is evident in the standard of feed manufacturing witnessed at AFMA members' facilities. AFMA members follow the correct procedures, and they have us to ensure that it remains this way. Nowadays there are even processes in place for producers to talk to their transport suppliers about the quality of the feed delivered to the farm."

During his 15 years with Afri Compliance, Dirk visited numerous sites and had to assist in establishing procedures and quality standards where it lacked. It wasn't always smooth sailing as the process had a cost implication. However, he witnessed a marked change in the attitude towards the third-party audits, and today AFMA's members are industry leaders in their respective fields. "They are proactive and responsible, and this says everything about the CoC and its goals. This is a success story worth telling, and I will always be thankful to have been a part of it."

New technologies are making compliance and audits easier, and make it easier to manage risk, especially given the fact that trade, here and globally, require various stamps of approval before business can be conducted. "So, make AFMA your friend, as the organisation and its members are visibly committed to quality and ethical standards."

Brendon Clement: Rising to the challenge

At 37, Brendon Clement has already made his mark in compliance auditing, and he now steps into a pivotal role at Afri Compliance, succeeding industry veteran Dirk Bezuidenhout.

Brendon's diverse academic background includes a Computer Engineering degree from the University of Pretoria and a Psychology degree (*cum laude*) from the University of Johannesburg. His technical expertise and understanding of human behaviour make him a standout professional. Qualified as an ISO Lead Auditor with a top score of 96%, he exemplifies analytical excellence.

Brendon's career began when he managed the Hanekom family farm before joining Afri Compliance in 2016. He played a key role in pre-export inspections for animal feed companies exporting to Botswana, Lesotho, Namibia, and Swaziland (BLNS markets). Over the past year, he trained under Dirk Bezuidenhout and Herman van Zyl to refine his skills. Earlier this year, he accompanied Afri Compliance's leadership on audits, which confirmed his readiness for this position.

As he takes the reins, Brendon brings a fresh perspective, ensuring that Afri Compliance continues its legacy of excellence in regulatory integrity and industry standards.

For more information, visit *www.africompliance.co.za.*

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Building a unified industry alliance for AMR collaboration

By Bonita Cilliers, technical and regulatory advisor, AFMA, and Margaret Churchill, executive director, SAAHA

Building on the momentum of the 2024 AFMA-SAAHA Antimicrobial Resistance (AMR) workshop, key stakeholders from the animal health and feed sectors convened on 3 February for the first virtual meeting of the AMR Alliance, led by Margaret Churchill, executive director of the South African Animal Health Association (SAAHA).

Participants included veterinarians; producer organisations such as Cape Wools SA, Game SA, the Milk Producers' Organisation (MPO), Milk SA, the South African Poultry Association (SAPA), South African Equine Health and Protocols (SAEHP), the South African Pork Producers' Organisation (SAPPO), Red Meat Industry Services (RMIS) and Wildlife Ranching SA; regulatory representatives; and industry organisations such as the Animal Feed Manufacturers Association (AFMA) and the South African Veterinary Association (SAVA).

Discussions highlighted the need for regulatory clarity and alignment, improved antimicrobial usage, resistance data and information sharing, science-based antimicrobial stewardship, and clear communication to strengthen the industry's collective voice.

Strengthening AMR collaboration

Discussions during the AMR Alliance meeting highlighted several critical focus areas that require collaboration, regulatory engagement, and strategic action.

***Establishing a unified voice*:** A strong, unified industry voice is crucial for effective communication, advocacy, and engagement with regulators. To ensure that industry concerns and strategies are well represented, a collaborative platform was identified as a valuable tool for aligning efforts across sectors.

***Engagement and policy clarity*:** Ongoing dialogue with the South African Health Products Regulatory Authority (SAHPRA), the National Department of Agriculture, and the Ministerial Advisory Committee on AMR (MAC) is vital, particularly concerning veterinary antimicrobial legislation and oversight and the 2025 revision of the National AMR Strategy.

***Usage and data reporting*:** Although AMR is often associated with human healthcare, concerns persist about the role of veterinary antimicrobial use in resistance, despite limited data on specific resistance patterns. Additionally, discrepancies in reported antimicrobial usage data have raised concerns about under-reporting and parallel imports. To address these challenges, regulators propose working closely with industry stakeholders to enhance data collection and strengthen reporting mechanisms; develop species-specific treatment protocols for more precise antimicrobial use; and foster cross-sector collaboration to ensure a balanced, evidence-based regulatory approach.

***Developing treatment protocols*:** Regulatory authorities have emphasised the need for industry collaboration in developing treatment-specific protocols to help standardise antimicrobial use across the sector. While ensuring practical and evidence-based protocols, participants stressed the importance of maintaining veterinary autonomy in treatment decisions.

***Enhancing regulatory engagement*:** To improve data alignment and regulatory co-ordination, the alliance proposed informal meetings with MAC, the National Department of Agriculture and SAHPRA. These engagements will facilitate greater transparency, consistency in reporting, and streamlined communication between regulators, policymakers, and industry stakeholders.

Collaborative platform

To sustain momentum and drive meaningful progress, the AMR Alliance committed to establishing a structured yet flexible AMR collaborative platform. This platform will serve as a central hub for industry engagement, ensuring a coordinated, science-driven approach to AMR-related challenges. The key objectives of the platform include:

- **Facilitating information sharing** among industry stakeholders to enhance collaboration and best practices.
- **Aligning industry efforts** to promote responsible antimicrobial use and strengthen stewardship initiatives.
- **Enhancing data collection** on antimicrobial usage and resistance trends to improve accuracy and transparency.
- **Advocating** for industry representation in policymaking and regulatory discussions, ensuring that the sector's concerns and contributions are recognised.

While SAAHA has volunteered to initiate discussions with regulators, and assume an administrative role, the meeting acknowledged that other industry associations may be better positioned to take on leadership roles within the alliance. By working together, stakeholders can create a unified industry voice to drive effective AMR strategies and promote sustainable animal health practices.

Collective commitment

Closing the meeting, Alan Kloeck of SAAHA emphasised the industry's shared responsibility in addressing AMR: "We cannot ignore AMR – it requires a proactive, collaborative effort to safeguard both animal and human health."

Through transparency, innovation, and open communication, the AMR Alliance aims to unite stakeholders in an effective, collective response to AMR challenges.

As a key partner, AFMA remains committed to working alongside veterinarians, policymakers, producers, and other stakeholders to support responsible antimicrobial use through collaboration, innovation, and adherence to best practices.

For more information, send an email to Bonita Cilliers at technical@afma.co.za, or Margaret Churchill at margaret@saaha.co.za.

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Innovative animal nutrition for sustainable animal production
Using innovative nutritional strategies to produce **nutritious** animal feed in a **responsible** and sustainable way.

Safe feed for safe food
Promoting **good manufacturing practices** in the provision of **safe** feed to enhance **consumer confidence**.

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Guidelines for the exhibition and sale of farm feeds

By Wimpie Groenewald, membership liaison officer, AFMA

With NAMPO Harvest Day and other exhibition opportunities fast approaching, the Animal Feed Manufacturers Association (AFMA) would like to remind registration holders to prepare for these events responsibly.

The exhibition and sale of farm feeds in South Africa is regulated by the *Fertilizers, Farm Feeds, Agricultural Remedies and Stock Remedies Act, 1947 (Act 36 of 1947)*, to ensure product quality, compliance, and consumer protection. Whether displayed at agricultural events or marketed for commercial purposes, all farm feed products must meet specific legal requirements.

This guideline outlines the essential aspects to ensure compliance such as product registration, advertising approval, and adherence to inspection protocols.

Registration and labelling

All farm feeds displayed or sold must be registered and labelled in accordance with *Act 36 of 1947*. In terms of Section 3 of the *Act*, it is illegal to sell fertilisers, farm feeds, agricultural remedies, or stock remedies that are not registered; are not labelled as prescribed; and do not meet the composition, efficacy, and quality standards specified in the registration application.

The definition of 'sell' includes offering, advertising, keeping, exposing, transmitting, delivering, manufacturing for sale, exchanging, or disposing of a product in any manner for any form of consideration.

Registration certificate

The *Act* prescribes that a producer's farm feed registration certificate should always be readily available. A reasonable copy of the product's registration certificate must be accessible upon request by an inspector. This may be a certified hard copy, or an electronic version stored in the company's internal system, and not necessarily the original certificate (refer to Section 4 of the *Act*).

Advertising materials approval

All advertising materials for registered farm feeds must be approved by the Registrar before being displayed or distributed.

***Application deadline for approval*:** Submit materials for approval at least **14 days** before the planned marketing or promotion. Advertisements must include the trademark and trade name (where applicable); the product name as prescribed in regulations; and the product's registration number stated as: Reg no XXX, *Act 36/1947*.

***Additional requirements*:** Advertising must comply with the guidelines of the Advertising Standards Authority of South Africa (Asasa). Misleading or incorrect advertising is prohibited under Section 4(1)(f) of the *Act*. Marketing and sales personnel should ensure that only claims approved via the product registration process (approved label) may be used in advertising campaigns. Generic advertising (for example, 'Our company produces ruminant, poultry, and game feeds') does not require pre-approval. If approval is not received within the prescribed time, provide inspectors with proof of submission.

Inspections and sampling

Inspectors are authorised to enter a premises and examine, analyse, and seize farm feed under Section 15 of the *Act* under the following conditions:

- Entry and inspection may occur at any reasonable time.
- Inspectors may test any fertiliser, farm feed, agricultural remedy, stock remedy, or ingredient thereof.
- Seizure of a product is only permitted if an offense is suspected.

SACNASP-registered scientist

When providing clients with animal nutrition advice, a registered professional natural scientist of the South African Council for Natural Scientific Professions (SACNASP) must be present, as mandated by the *Natural Scientific Professions Act, 2003 (Act 27 of 2003)*.

Conclusion

It is important to uphold responsible marketing practices that comply with legislation. *Act 36 of 1947* sets clear legal requirements for product registration, labelling, advertising, and inspection compliance for all agricultural inputs such as farm feeds, fertilisers, agricultural remedies, and stock remedies. By adhering to these requirements, businesses ensure regulatory alignment, foster consumer trust, and maintain industry credibility.

Proper documentation, transparent advertising, and co-operation with inspectors are fundamental to responsible farm feed marketing. Furthermore, the presence of a SACNASP-registered scientist during client consultations, such as the marketing of animal feed products to the public at an exhibition, is required by law and reinforces the importance of scientific expertise and ethics in the industry.

AFMA is aware of the administrative burden that the approval of advertisements place on the Registrar's office, and that approvals are not always received in time for marketing campaigns. To address this, AFMA collaborated with the pet food industry and submitted a proposal to the Registrar of *Act 36* to allow advertisements via a notification system. The proposal was accepted in principle by the regulator, and expectations are that it will be implemented with the new amended regulations relating to farm feed later this year.

Meanwhile, registration holders must ensure adherence to the current regulations that still require approval of advertising material prior to marketing. They should properly prepare their marketing teams, materials, products, and documentation for exhibitions at agricultural shows according to the guidelines mentioned in the article.❖

For more information, send an email to the author at admin@afma.co.za or visit *www.afma.co.za*.

Bühler reports good financial performance

Last year brought about change, innovation, and uncertainties created by developments on the world stage. In addition, there were the ever-present questions on how to shape the ecological footprint, as well as aspects of food security. "This was the environment our customers, partners, suppliers, as well as ourselves had to navigate last year," said Bühler CEO, Prof Stefan Scheiber, at a press conference in February 2025, discussing the Bühler Group's financial results for 2024.

Bühler increased its profitability, reaching earnings before interest and taxes (EBIT) of CHF227 million (Swiss Francs) and an EBIT margin of 7,6%. The equity ratio improved to 52,8%. Increased cash flow and liquidity further strengthened the company's financial position.

Making things happen

The main contributors to the successes of last year were Milling Solutions, Bühler's largest business area, Leybold Optics, and the customer service business.

Bühler Group's turnover remained stable at CHF3 billion (-0,8%), while order intake stood at CHF2,8 billion (-9,9%). The impact of foreign exchange rates was significant: In local currencies, turnover increased by 2,5% to CHF3,1 billion, and order intake stood at CHF2,9 billion (-7%).

The group's profitability increased for the fourth consecutive year, resulting in the EBIT of CHF227 million (7,6% of turnover; prior year: 7,2%). Net profit rose to CHF189 million, corresponding to a margin of 6,3% (prior year: 5,9%). As a result, the company increased its equity ratio for the sixth year running to 52,8%, up from 51,1% in 2023.

CFO Dr Mark Macus reported that grains and food turnover grew by 2% to CHF2,249 million, strongly driven by Milling Solutions which reported a record year with turnover at an all-time high.

The customer service business experienced strong turnover growth of 9,4% to CHF1 057 million. "This represents a 35,4% share of group turnover (prior year: 32,1%)." Long-term service agreements also experienced strong growth, increasing to more than 4 000. In 2024, Bühler launched 40 new products and services into the market and further expanded its global customer-facing setup, opening three new research and training centres.

Bühler's balanced geographical footprint contributed to the company's stability and reliability. While turnover grew in the Middle East and in Africa, it continued to decline in China. Overall, Bühler's regional share of turnover was balanced: the Americas 28% (prior year: 29%); Europe 27% (28%); Asia 26% (27%); and Middle East, Africa and India 19% (16%).

Outlook for 2025

Building on its order book of CHF1,9 billion, Bühler foresees stable volume development this year.❖

For more information, send an email to Buhler.johannesburg@buhlergroup.com.

Driving excellence in South Africa's pork industry

By Karla Zietsman, general manager, SAPPO

The South African Pork Producers' Organisation (SAPPO) plays a critical role in advancing and supporting the country's pork industry. As the official representative body for pork producers, SAPPO works closely with government, industry stakeholders, and value chain partners to ensure a sustainable and competitive sector.

With a proactive approach, SAPPO focusses on key areas such as biosecurity, consumer education, market development, and producer support. One of SAPPO's core strengths is its commitment to enhancing pork production practices through its Pork 360 consumer assurance programme, which sets high animal health, welfare, and sustainability standards. The programme is designed to give consumers, retailers, and the broader industry confidence in the quality and safety of locally produced pork. By adhering to Pork 360, producers can enhance their market access and build consumer trust while retailers and restaurants can confidently source assured pork.

Industry-wide collaboration

Beyond production, SAPPO actively engages with consumers under the SA Pork brand to promote pork's benefits as a nutritious and affordable protein source. Through strategic marketing campaigns and consumer awareness initiatives, the organisation continues to elevate the profile of pork in South Africa.

SAPPO's work is made possible through the collective efforts of its members, including both individual producers and corporate partners. This year, the organisation introduced its corporate membership, reflecting a stronger commitment to industry-wide collaboration. As corporate members, companies contribute to the growth and sustainability of the pork industry, and this involvement also enables them to stay informed about the latest industry insights, regulatory developments, and networking opportunities.

As the industry evolves, SAPPO remains at the forefront of innovation and advocacy, ensuring that pork production in South Africa continues to meet the highest standards of quality, safety, and sustainability. Businesses eager to play an active role in the growth and sustainability of the country's pork industry are invited to explore SAPPO's corporate membership option.

For more information, send an email to karla@sappo.org.

Protein utilisation in poultry:
Importance, limitations, and strategies to improve

By M Reza Abdollahi

The poultry industry has progressed remarkably over the past 60 years. Constant improvements in the production standards of broilers through genetic selection has turned it into the most successful livestock industry.

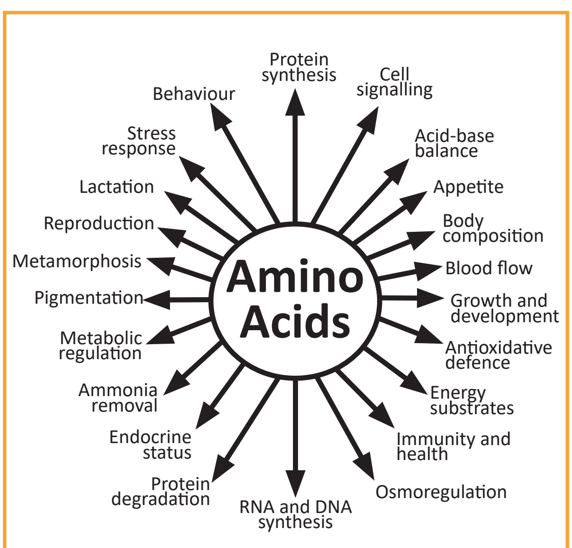
Feed represents 70 to 80% of the total cost of modern broiler production. Protein is the second most expensive component of poultry diets after energy. Protein, a polymer of α-amino acids (AA) linked together by peptide bonds, is the building block of different body tissues. Proteins are involved in a number of functions, but their main role is to supply the AAs for protein synthesis in the body. Dietary supply of correct amounts and ratios of different AAs is essential for optimum growth and productivity in birds.

Accurate knowledge on the digestibility of AAs in raw materials is crucial for the accuracy and efficiency of feed formulation and the sustainable use of feed resources. The digestibility of AAs in poultry can be measured by sampling and analysis of ileal digesta or excreta.

Excreta-based digestibility measurements, however, suffer from the modification and variable effects of caecal microflora on dietary protein utilisation and the contribution of microbial proteins to AA excretion in the excreta. However, with the ileal digestibility method these confounding issues can be avoided (Ravindran and Bryden, 1999). Currently, standardised ileal digestibility (SID) is preferred over the apparent ileal digestibility (AID) method. The calculation of SID involves a correction for the inevitable endogenous AA (EAA) flows from the gastrointestinal tract (GIT).

Animals, including chickens, do not digest or absorb all the ingested dietary protein and AAs, and the undigested portion is a substrate of microbial action in the hindgut. The digestion of protein is a highly complex process that combines hydrolysis and the absorption of proteins. This process involves the recovery of both the exogenous proteins of dietary origin and endogenous proteins secreted within the bird.

Figure 1: Roles of AAs in nutrition and body homeostasis. (Source: Wu, 2010)



The proventriculus is the first site of protein digestion where the ingested dietary proteins are exposed to hydrochloric acid (HCl), denaturing protein, and exposing peptide bonds to enzyme hydrolysis. The first enzyme that initiates protein digestion is pepsin that cleaves the N-terminal of aromatic AA (Phe, Trp and Tyr). The net result of acid denaturation and pepsin hydrolysis is the formation of peptides with smaller molecular weight. These peptides are further degraded in the small intestine by enzymes secreted by the pancreas and the small intestine.

Pancreatic proteinases include trypsin, chymotrypsin, elastase, and carboxypeptidase A and B. The presence of trypsin activates the conversion of chymotrypsinogen to chymotrypsin, proelastase to elastase, and procarboxypeptidase to carboxypeptidase. These enzymes catalyse specific bonds and AAs. For example, trypsin only binds to the positively charged side chains of Lys and Arg residues, facilitating the hydrolysis of these peptide bonds. Elastase binds small side chain AAs such as Gly and Ala.

Limitations to protein digestion

As dietary protein sources are heterogeneous mixtures of proteins, protein is digested at different rates, causing variation in the rates at which different AAs are absorbed. Proteins vary in their chemical composition and have different linkages with carbohydrates, lipids, and other proteins. Therefore, the digestion of dietary protein is affected by these interactions and diet composition (Hughes and Choct, 1999).

The digestibility of protein or AAs depends on the type of feed ingredient. Most feedstuffs commonly used in poultry diets contain antinutritional factors (ANFs) that reduce the digestion and absorption of protein. ANFs include protease inhibitors, lectins, polyphenolic compounds, saponins, phytate, and non-starch polysaccharide (NSP). The three major NSPs found in feeds are cellulose, hemicellulose, and pectin. The indigestible NSP in the cell wall matrix shields the digestion of protein and other nutrients. The ANFs also increase endogenous AA losses, resulting in lower apparent AA digestibility estimates. As an example, raw soya beans contain several ANFs, but these are heat-labile, and most are destroyed by heat treatment.

Non-optimal temperatures during feed processing (under- and over-processing) can reduce the digestibility of or destroy the AA (Abdollahi *et al*., 2011). Under-processing through incomplete deactivation of trypsin inhibitors can hinder AA digestibility. On the other hand, over-processing favours Maillard reaction and the formation of enzymatically undegradable products, reducing AA digestibility (mainly Lys). However, the damage is not limited to Lys; other heat-labile AAs, including Cys, Arg, Thr and Ser, could also be degraded by overheating.

Age is one of the major factors influencing protein digestion in poultry. In newly hatched chicks, the digestive tract and nutrient absorptive functions are not sufficiently developed (Noy and Uni, 2010). Young birds are sensitive to inadequacies in protein digestion as there is a high AA demand for organ and muscle development. Class, gender, and the health status of birds may also affect protein digestibility.

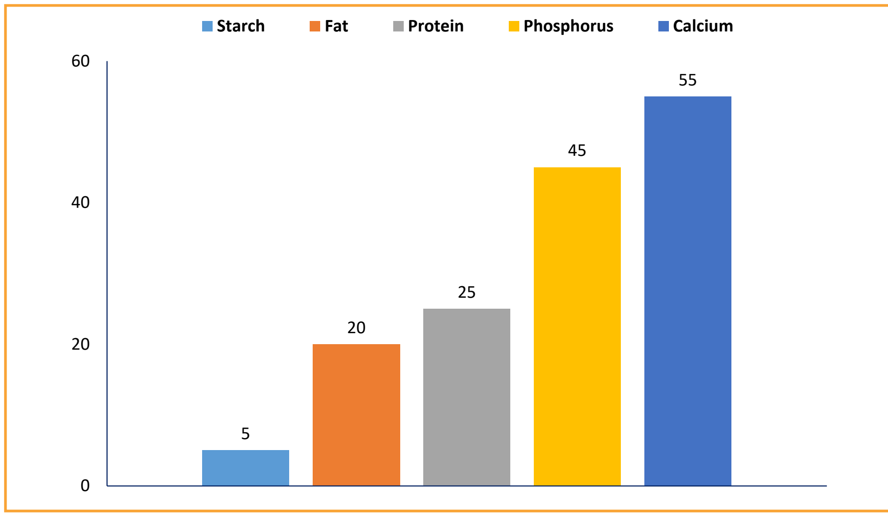
Improving protein utilisation

Dietary nutrients are not fully digested and utilised by poultry. In a typical broiler diet only 70 to 75% of the dietary gross energy is utilised by the bird, and the remaining 25 to 30% is wasted in excreta, causing a significant economic loss. This loss of expensive dietary energy is due to the excretion of undigested carbohydrates (starch and non-starch polysaccharides), lipids, and protein. In a typical broiler diet with no exogenous enzymes, almost 20 to 25% of dietary protein is excreted with huge economic and environmental consequences.

To improve protein digestibility, it is essential not only to increase the protein accessibility in different feed ingredients but also enhance their degradation into small peptides (di- and tripeptides) and AAs. Strategies that are applied to increase protein and AA digestibility should be able to eliminate ANFs in different feed ingredients (Chen, 2017).

Some of these ANFs, such as insoluble or even soluble NSP, originating from plant cell walls, could restrict the accessibility of proteolytic enzymes to dietary protein.

Figure 2: Undigested nutrients (%) in broilers fed cereal-based diets with no enzyme supplementation.



Other ANFs such as trypsin inhibitors could also hinder protein digestion in the GIT by binding to either proteolytic enzymes or dietary protein.

Anti-nutritional effects of phytate on AA utilisation has also been reported. Formation of phytate-protein or phytate-mineral-protein complexes can reduce solubility and digestibility of protein. Moreover, phytate via direct chelation with the enzyme or their cofactors inhibits the proteolytic enzymes such as pepsin and trypsin in the GIT. All these ANFs could increase the secretion of endogenous AAs in the form of mucins, intestinal cells, and pancreatic enzymes. A complete diet can have a combination of all these ANFs.

Hydrothermal processing, which is commonly applied to plant-based protein meals, can increase digestibility of protein and AAs through inactivation of ANFs, such as trypsin and chymotrypsin inhibitors and lectins. Apart from hydrothermal processing, the application of exogenous enzymes through hydrolysing the ANFs could also enhance the accessibility to protein in different feed ingredients and positively affect the extent of dietary protein digestion. Exogenous enzymes are also able to reduce the secretion of endogenous protein/AAs, particularly mucin and increase the recovery or re-absorption of endogenous AAs.

Proteases, also known as proteinases or proteolytic enzymes, represent a large group of enzymes that hydrolyse the peptide bonds in proteins and polypeptides. Proteases are classified by their site of action, enzyme active site, structure, substrate specificity, optimum pH, and specific reaction mechanisms. Based on their site of action, proteases are classified to either exopeptidases that cleave N-terminal (called aminopeptidase) or C-terminal (called carboxypeptidase) peptide bonds, or endopeptidases, which break internal peptide bonds.

Protease enzymes are pH specific, and the efficiency of protease depends on pH conditions in different gut segments. Proteases can be classified into acidic, neutral, and alkaline according to the optimal pH. Acid proteases have a pH optimum in the range of 2 to 5, proteases with pH optima of approximately 7 are neutral proteases, and alkaline proteases have pH optima in the range of 8 to 11. Based on their proteolytic mechanism, proteases can also be divided into different groups such serine proteases and aspartic proteases.

Conclusion

While carbohydrase, phytase and protease have the potential to increase AA digestibility in poultry diets, their modes of action and substrates differ. Moreover, the magnitude of protein/AA digestibility responses to exogenous enzymes depends on the protein quality, inherent digestibility of AAs, and specific AAs.

For more information and references, send an email to M.Abdollahi@massey.ac.nz.

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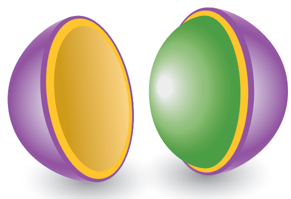

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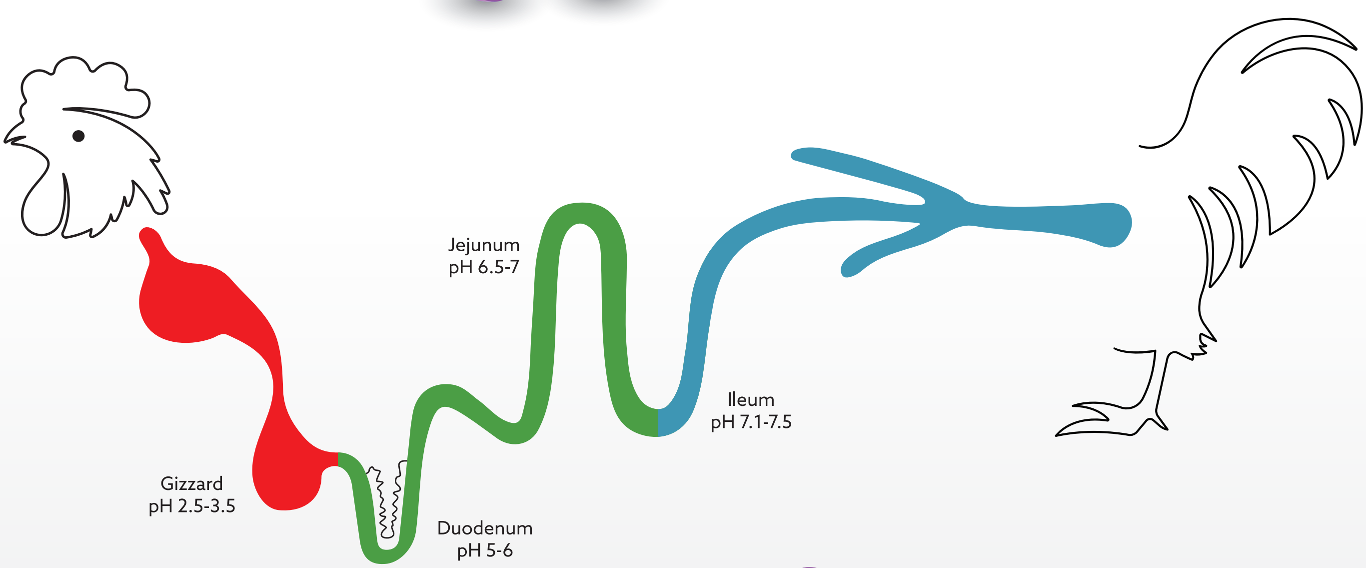

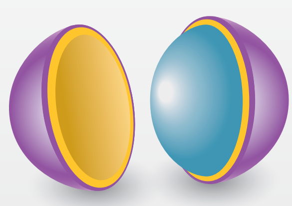

3 ALKALINE PROTEASE

Trypsin like activity
Serene Protease

Thermostable &
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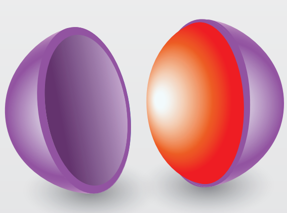

1 ACID PROTEASE

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Impact of feed efficiency on young beef animals on adult resilience: From field challenge experiments to modelling approaches

By P Martin, N Friggens, A Vinet, D Dozias, D Maupetit, G Renand and D Villalba

Over the past decades, feed efficiency has become of great importance. In beef cattle, this is mainly due to the always-increasing feeding costs while the price of calves does not follow the same trend. That poses serious questions for producers' profitability. In this context, it seems increasingly important to understand efficiency in the adult animal as well as during the growing phase, and the link between the two (if any).

Although different mathematical ways of estimating feed efficiency exist, residual feed intake (RFI), first proposed in cattle by Koch *et al*. (1963), is nowadays the most used one in breeding. RFI is defined as the difference between the actual feed intake of an animal and its predicted feed intake based on its performance, measured over a fixed time-period.

It is a complex trait implying various biological functions (Cantalapiedra-Hijar *et al*., 2018; Martin *et al*., 2021) and hard to phenotype as it requires individual measures of intake. Therefore, it is often measured over a short period only and at young ages, disregarding its possible long-term evolution and the associated changes in the biological functions involved (Martin *et al*., 2021).

More recently, another concept has also become a focus of interest of the cattle breeding industry and scientists: resilience. One definition of resilience is the capacity of an animal to be minimally affected by disturbances, or to rapidly return to the unperturbed state observed before exposure to a disturbance (Berghof *et al*., 2019). In more practical terms, it is the cow's ability to cope with environmental disturbances such as pathogens, heat waves, or changes in feed composition and/or quantity (Poppe *et al*., 2020). The complexity of the concept and the number of different biological functions involved make it, as well, hard to phenotype, and various indicator traits have been developed (Friggens *et al*., 2021).

Both efficiency and resilience seem to play a key role in addressing current and future challenges for sustainable livestock production, with the need to find the optimal trade-off between them. In this context, it has been postulated that there is a negative correlation between resilience and efficiency when the latter is measured over short periods but a positive correlation when efficiency is measured over much longer periods, such as lifetime efficiency (Martin *et al*., 2021).

However, even if (short-term) efficiency and resilience are often studied separately, rare indeed are the studies investigating them together, and therefore the link between these two remains largely unquantified. The issue of how resilience and efficiency interact in the long-term, and ideally across multiple environments, is unlikely to be resolved purely from experimental data (given the nature of the experiments needed and the measurement difficulties involved). It is the type of problem where simulation studies have been shown to be of great value (Puillet *et al*., 2021; Villalba *et al*., 2010).

A two-step approach

There are validated systemic models, built on biological principles, that predict lifetime trajectories of intake, performance, and their impacts on other life functions such as resilience (Puillet *et al*., 2016; Villalba *et al*., 2006). These provide powerful tools to extrapolate from the available data and explore the link between efficiency and later life resilience.

Accordingly, in the framework of the GenTORE H2020 project (*gentore.eu*), following work on feed efficiency from one side and resilience on the other side, we now address the interplay between those two. For this, we benefit from an experiment dataset where animals were phenotyped for feed efficiency as heifers and then, later, had to deal with a feed restriction challenge while in lactation to measure their resilience.

A two-step approach is taken, where first the experiment data is analysed to determine if there is an influence of early life feed efficiency on adult resilience. Then, the interplay between efficiency and resilience, and its consequences on lifetime performance and efficiency, are explored using a simulation model calibrated on the experiment data. Accordingly, our objective is to determine if there are, in suckler cows, negative effects of being feed efficient during the growing phase on traits associated with resilience as adults.

Discussion

The results of the experiment have shown that heifers with differences in efficiency during growth react differently as adults in terms of productive and reproductive performance in constrained versus non-constrained environments. The inefficient heifers perform better in terms of milk production, and they produce a heavier weaned calf, particularly under restricted feeding.

In beef cattle, Black *et al*. (2013) found that heifers that were less feed

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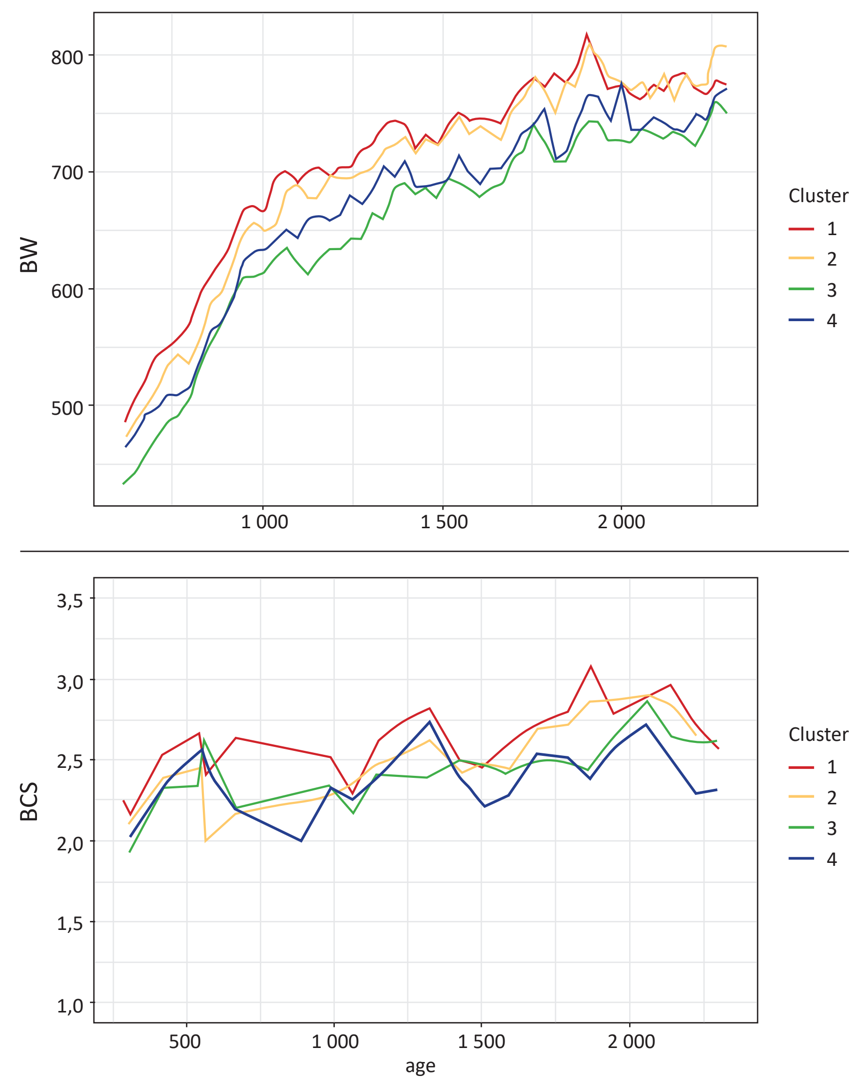
efficient subsequently consumed more feed as lactating cows. A higher intake of cows under the recovery period after the challenge, with *ad libitum* access to high-quality pastures, could explain a higher milk production and therefore a higher weaning weight. In terms of reproduction, under non-constrained feeding, the experiment results showed that efficient heifers became cows that achieve a quicker return to cycling days than inefficient heifers, but this is reversed in a constraining environment.

Basarab *et al*. (2011) also found that efficient cows (i.e., in their case, cows producing low RFI progeny) had worse reproductive performance (calved five to six days later in the year) than inefficient cows. The results of other studies did not find a relationship between efficiency at young ages and reproductive performance but most of them were performed in a non-constrained feeding environment for cows (Callum *et al*., 2019; Hafla *et al*., 2013; Parsons *et al*., 2021).

In our study, despite this difference in return to cycling, there was no difference in rebreeding success. However, this may be due to the design of the experiment with a long calving to calving interval between first and second lactation (about 14 to 15 months) that allowed late recycling animals to recalve anyway. This link between reproductive ability and early efficiency in constrained feeding environment needs to be further explored. If we consider reproductive performance as a proxy of resilience, some doubts could indeed arise about a possible trade-off between later resilience and early efficiency.

Figure 1: Observed body weight and BCS curves for heifer cluster numbers.



Modelling approach

The modelling approach was used to explore the performance of cows with different allocation and acquisition capacities that explain their efficiency at young ages. The calibration of the model parameters on the experiment data was performed in order to mimic the clusters defined not only by RFI, but also from other variables that define heifer performance on test.

Two of these clusters, which have good overlap with efficient and inefficient animals, were selected for the discussion. The animals belonging to the two clusters differed in digestibility and Costa-Roura *et al*. (2020) had found differences in this parameter between high and low RFI fattening calves. The difference in allocation allows the representation of two types of cows in terms of weight (12,5% lighter simulated cows in Cluster 3 than in Cluster 1). Finally, the acquisition parameter differed between clusters because, as commented, intake is one of the key points that differentiate RFI classes in our data and in the bibliography.

The comparison of simulated data with the experiment results and phenotypic data of cows at the experimental farm shows a good fit in most of the variables and so the model is a good tool to explore the *in silico* lifetime performance of cows. The first cluster embodies inefficient heifers, which become larger cows that have greater milk production but at the cost of depleting reserves. In contrast, Cluster 3, comprising efficient heifers, generates lighter cows that effectively maintain reserves, albeit with a trade-off of lower milk production. This analysis extends across diverse feeding environments, showcasing the model's versatility in exploring nuanced scenarios.

Body condition score

In both simulation scenarios, the simulated heifers from Cluster 1 (higher RFI, less efficient) produced heavier cows. Hafla *et al*. (2013) reported a low negative genetic and phenotypic correlation of RFI post-weaning and adult weight but also a medium positive phenotypic correlation between RFI post-weaning and RFI

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as a cow. In our case, the heavier cows are animals with a higher allocation from growth to maintenance, higher acquisition and different pattern of body fat use. The fact that the Cluster 1 animals were both heavier and had higher acquisition is of itself an interesting outcome; this link is not explicitly coded in the model but has been found in some experimental studies (e.g., Walker *et al*. 2015).

The simulated animals from Cluster 3 (low RFI, efficient), despite lower intake, were fatter in both scenarios, especially after second calving. In a non-restricted feed environment, the difference in body fat of the two clusters had no effect on reproduction performance as cows are over the threshold BCS of 2,5 used in the model and thus did not impair resumption of cyclicity (Sanz *et al*., 2004). However, in the conditions of feed restriction imposed by use of mountain pastures, the lower BCS results in a slightly lower reproductive performance of the larger cows from Cluster 1.

The effect of restricted environment in the simulations is cumulative and the BCS difference between clusters is higher with increasing parities. This accentuates the difference in reproductive performance with increasing number of calvings. Thus, as found in the experiment results, our simulations found an interaction between early RFI and resilience (capacity to re-calve) but one that interacts also with parity. In first parity there is a switch between clusters in terms of which one has the highest BCS, but this is not maintained in later parities where Cluster 3 always has the highest BCS regardless of the feeding scenario.

Douhard *et al*. (2014) demonstrated, through simulation of dairy goats, absence of a trade-off between efficiency in youth and adult resilience under favourable conditions. However, in a challenging environment, a pronounced trade-off emerged between survival and production (milk/bodyweight), with differences in body reserves similar to those found in the present study.

In the present study, the simulated weaning weight is higher for Cluster 1 cows (heavier, less efficient) in the two scenarios. Weaning weight has been one of the breeding goals in most of the beef breeding schemes and it is positively correlated, genetically (Meyer, 2005) and environmentally in mountain livestock (Cortés-Lacruz *et al*., 2017), with mature weight. The change in the allocation parameter in the model accounts for these correlations and so heavier cows should produce heavier calves at weaning. Cluster 1 also had higher simulated milk productions and weaning weight of calves both in restricted and non-restricted environments.

> One definition of resilience is the capacity of an animal to be minimally affected by disturbances, or to rapidly return to the unperturbed state observed before exposure to a disturbance.

Callum *et al*. (2019) measured lifetime cow productivity calculated as kilogram of calf weaned per cow culled and found no significant differences between heifers ranked as low, medium and high RFI, but the high RFI cows produced 73kg more of calf weaned than the low RFI cows. This relevant difference (22%) was related with the weaning weight and not to reproductive performance, and is in line with our simulation results. Nevertheless, this better productivity relies on a higher intake. If using the model results, we express kilograms of calf at weaning on a per kilogram of intake basis, beef cows expressing low RFI values tended to produce more than cows expressing high RFI, as in the data presented by Herd *et al*. (1998).

The modelling approach allows the evaluation of the reproductive performance at herd level under a long-term scenario of limiting resources and a short mating season. In this case, the reproductive output is only based on body reserves because all animals had the same inherent parameter value for resumption of cyclicity. The simulation in the mountain scenario showed that reproductive performance is better for lighter efficient cows and this, combined with lower feeding costs at winter, produces a significantly higher income from efficient lighter cows.

No differences in survival were detected during the experiment results that last until third calving. In the case of the modelling approach, no culling rules were applied nor any direct effects of performance on survival, and so only the reproductive performance could be used as a proxy of success of cows.

Environmental impact

In both the experimental and modelling approaches, it seems clear that the answer to the relationship between efficiency at young ages and resilience depends on the environment and on the definition of resilience. Concerning environment and economic resilience, the use of a greater part of forage in diets rather than cereals would be a good way to reduce feeding costs (and limit feed-food competition). However, forage resource availability is dependent on weather conditions and in the context of climate change, more frequent shortages could be expected (Giridhar and Samireddypalle, 2015).

Beck *et al*. (2017) indicates that in limited resource environments the reduced efficiency of large cows may be a limiting factor on economics of production, while in higher rainfall environments mature cow size may not be a significantly limiting factor.

Conclusions

Both the analysis of field results and the modelling approach had showed that the interplay between efficiency at young ages and short- and long-term resilience depends on the environment, especially regarding the effect on reproductive resilience, for which a negative effect of heifer efficiency has been found only in constraining environments. Further, irrespective of the environment, it can be concluded that the selection for efficiency at young ages has a negative impact on a cow's lactational performance.

This article was shortened for publication in *AFMA Matrix*. Visit *www.doi.org/10.1016/j.livsci.2024.105558* to access the full article, or email pauline.martin@inrae.fr.

Small inputs, big results: The power of live yeast

By Dr Elias Bungenstab, global technical manager for ruminants, AB Vista

We can all relate to situations where one small change can have a major impact. Entering one wrong number in a series of calculations can completely alter the final result. Using a drill bit that is one size too big can ruin a project. Missing one key ingredient in a recipe might lead to a change in the dinner menu. You can undoubtedly think of your own examples.

On the positive side, we often have opportunities to fine-tune things in a way that really benefits our efforts. Learning from experience – our own or someone else's – can lead to relatively minor adjustments that significantly improve the way we do something, or what we get out of it.

The fermentation process

This can be particularly true when a certain biological system or process is involved. An excellent example would be fermentation, which all brewers can attest to. Any variation in ingredients, strain of yeast, or brewing conditions is going to seriously alter their batch for good or bad, and the slightest contamination of unwanted microbes will likely ruin it.

We face the same situation with fermentation that takes place inside the rumen. Nutritionists and researchers are focussed on understanding how overall diet, individual ingredients, specific additives, and environmental factors influence the rate, volume, and metabolic pathways related to the fermentative activity of ruminal micro-organisms. This in turn can characterise products and practices that optimise rumen function, leading to enhanced feed intake, efficiency, or animal health.

The rumen of a Holstein cow can hold 57 to 67kg of fluid and digesta (Reynolds *et al*., 2004), and it can sometimes be difficult to get your head around the fact that only a few grams of anything can make a meaningful difference in what goes on there. However, years of research and experience show us that this is the case for several types of feed additives, including ionophores, certain biologic extracts, enzymes, and yeast.

Benefits of live yeast

The value of live yeast, in particular *Saccharomyces cerevisiae*, in the diets of cattle is well-recognised, with targeted peer-reviewed research dating back almost a century (Palmer and Harshaw, 1924). Documented outcomes have included improvements in forage utilisation, milk production, components and efficiency, and various indicators of overall health and immunity.

Multiple modes of action have been evaluated, including impacts on the makeup of the rumen microbial population (which in turn influences the volume, concentration, and proportion of VFA and rumen pH), ruminal redox potential, total dry matter intake, and binding affinity for pathogenic organisms and toxins (Mohammed *et al*., 2018).

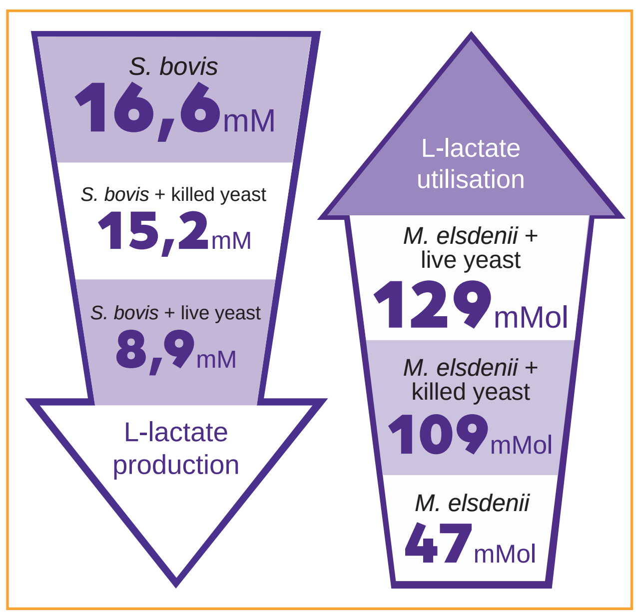
There has been more work done with feeding yeast to lactating dairy cows than any other class of cattle, and the use of yeast and yeast-based additives is fairly widespread in the dairy industry. Much of the published research has focussed on modulation of ruminal pH, as well as dry matter intake and improved utilisation of the fibre portion of the diet. Positive responses to feeding live yeast have been reported for a wide range of metrics, although specific results can vary with product and experimental conditions.

In work done at the University of Guelph in Ontario, Canada (Alzahal *et al*., 2014), lactating cows were exposed to a dietary challenge designed to trigger sub-acute acidosis. Half the animals were fed *Saccharomyces cerevisiae*, 20 billion CFU (colony forming units) per gram. Researchers reported a nearly 8% increased DM intake (23,3 vs 21,6kg/hd/day), 3,1kg of additional fat-corrected milk (29,6 vs 26,5kg/hd/day), and 63% less time spent with rumen pH below 5,6 when *Saccharomyces cerevisiae* was fed in conjunction with the acidotic challenge.

Live vs killed yeast

It has been shown that supplemental yeast has the ability to reduce the activity of lactate-producing bacteria and enhance the activity of lactate-utilising bacteria

Figure 1: The effect of live or autoclaved *Saccharomyces cerevisiae* on lactate production and uptake by *S. bovis* and *M. elsdenii*, respectively. (Data adapted from Chaucheyras *et al*., 1996)



(Monteiro *et al.*, 2022). Lactic acid is approximately ten times stronger than the primary VFA produced during feed fermentation (pKa 3,9 vs 4,9) (Nagaraja and Titgemeyer, 2007) and when it accumulates in the rumen it contributes to a downward spiral in ruminal pH.

Research with *Saccharomyces cerevisiae* at an independent laboratory quantified the *in vitro* shifts in concentrations of *Streptococcus bovis*, a well-known producer of lactate, and *Megasphaera elsdeneii*, an important lactate utiliser, when either live or killed yeast was supplemented (*Figure 1*). In this trial, live yeast reduced *S. bovis* by more than 45%, while *M. elsdenii* concentration increased by approximately 175%. Results were intermediate with the killed product (Chaucheyras *et al.*, 1996).

In a study that evaluated *Saccharomyces cerevisiae* supplementation in a group of 340 high-producing cows under commercial conditions (De Ondarza *et al.*, 2010), the animals receiving the live yeast produced significantly more milk (41,2 vs 42,4kg) as well as milk true protein (1,22 vs 1,27kg/day). These results are in line with more recent farm trials; in one 126-cow comparison utilising two different live yeast, energy-corrected milk yield was 37,58kg for control animals, while being 37,98 and 39,40 for strain 1 and 2, respectively.

A major differentiation between 'yeast' products available on the market is whether they are designed to deliver live yeast to the rumen. If not, they may consist of non-viable yeast cells and possibly the medium they were grown in ('yeast culture'), or very specific fractions of yeast cells (such as mannan oligosaccharides or beta glucans) (Alugongo *et al.*, 2017).

Active yeast is best

A unique benefit of active yeast products is their ability to scavenge oxygen. Killed or fractionated yeast, or yeast culture, is not able to do this simply because they are not living, respirating organisms. This is an important differentiation, since most rumen microbes (especially those involved in fibre digestion) are strict anaerobes, and do not survive in the presence of oxygen. Published research has demonstrated significant reductions in the redox (oxidation-reduction) capacity of rumen contents when yeast is fed (Marden *et al.*, 2008; Pinloche *et al.*, 2013), verifying the ability of live yeast to reduce oxidative stress in that environment.

Other critical attributes to consider include strain selection, CFU concentration and recommended feeding rate, and of course availability of product-specific research that is directly applicable to a given situation. The specific yeast being propagated, as well as the conditions it is exposed to during fermentation, have a significant impact on its ability to favourably influence the ruminal environment or activity; even live yeast additives are not interchangeable equivalents. And meta-analysis confirms that CFU dosages do influence outcomes; if less is fed, lesser results should be expected (Desnoyers *et al.*, 2009).

Yeast additives may be fed in small amounts, but both research and experience show they can provide big results in the dairy.

For more information, send an email to EMEA@abvista.com or visit *www.abvista.com*.

Unlocking nutritional potential in condensed tannin-rich diets: A review

By Zané Orffer, technical representative, Nu3enta

Condensed tannins are secondary plant metabolites present in numerous trees, shrubs, and legumes, produced as a defence mechanism against herbivory and environmental stress, released into the ruminant gastrointestinal tract during mastication. While they can provide some benefits, such as reducing methane emissions and acting as natural anthelmintics, their excessive presence in animal diets can lead to reduced feed intake and impaired microbial activity in the rumen (Beauchemin *et al*. 2007; Fitri *et al*. 2022).

The primary mechanism behind their anti-nutritional effect is their ability to bind dietary proteins, rendering them unavailable for digestion (Adejoro *et al*., 2019; Abioha, 2018). This binding can hinder the animal's capacity to extract essential nutrients from feed, ultimately leading to decreases in productivity and growth (Rivera-Méndez *et al*., 2016; Yanza *et al*., 2021).

Certain herbivores have adapted to condensed tannin-rich diets. Browsers such as goats and many wild ruminants produce proline-rich glycoproteins in their saliva which bind to condensed tannins and neutralise their effects before they reach the digestive tract (Rivera-Méndez *et al*., 2016; Gunun *et al*., 2015). Grazers such as sheep and cattle lack this adaptation, and are therefore more vulnerable to the adverse effects of condensed tannins.

Mitigating adverse effects

Among different PEG variants, PEG 4000 has been shown to be particularly effective in mitigating the negative effects of condensed tannins on nutrient digestibility. Research highlights PEG 4000's ability to improve protein availability and digestion in ruminants such as goats and cattle by reducing condensed tannin interactions with digestive enzymes (Motubatse *et al*., 2007; Kechero *et al*., 2013; Brown and Ng'ambi, 2017).

Additionally, PEG 4000 positively influences rumen fermentation, alleviating condensed tannin-related digestive issues and enhancing animal growth and productivity (Dentinho *et al*., 2018; Gilboa *et al*., 2000; Edwards *et al*., 2012).

Its effectiveness is largely attributed to its hydrophobic properties, which facilitate strong hydrogen bonding with condensed tannins, effectively neutralising their anti-nutritional effects (Kondo *et al*., 2014; Lee and Pan, 2003). Studies link PEG 4000 supplementation to improved nutrient retention and overall performance in ruminants, reinforcing its critical role in optimising condensed tannin-rich diets (Getachew *et al*., 2000; Besharati and Taghizadeh, 2011).

PEG's physical characteristics and interactions with condensed tannins vary based on its molecular weight. PEG 4000 strikes the ideal balance between solubility and binding capacity, making it the optimum molecular size for efficient binding with condensed tannins without being absorbed by the digestive system (Kechero *et al*., 2015, Edwards *et al*., 2012).

Studies have demonstrated that PEG supplementation can significantly improve gas and short chain fatty acid production (Getachew *et al*., 2001), increase NH3-N and nitrogen retention (Getachew *et al*., 2001; Moujahed *et al*., 2000), and overall protein digestibility (Moujahed *et al*., 2000; Bhatta *et al*., 2002, Moujahed *et al*., 2004).

Supplementation has furthermore proven to positively influence the performance of goats fed a diet containing condensed tannin-rich *Acacia karroo* leaf meal and *Setaria verticillata* grass hay, leading to enhanced weight gain and energy intake (Brown and Ng'ambi, 2017). Similarly, the addition of PEG increased gas production in sheep, indicating improved ruminal fermentation, which is crucial for nutrient absorption (Lima *et al*., 2017). Hlatini *et al*. 2018 emphasised the role of PEG in enhancing the utilisation of leguminous leaf meals in livestock diets. The beneficial effects of PEG are particularly pronounced in diets containing high levels of condensed tannins.

Other studies in grazing systems found the inclusion of PEG to significantly improve the digestibility of crude protein (CP) and overall feed efficiency. For instance, Xie *et al*. (2021) demonstrated that adding PEG to rations containing sorghum condensed tannins increased CP digestibility and shifted nitrogen excretion from faeces to urine, indicating enhanced nitrogen utilisation.

PEG can improve the overall growth performance of beef cattle in pasture-based systems. Addis *et al*. (2021) highlighted the importance of optimising feed demand and pasture utilisation for young beef cattle, suggesting that the inclusion of PEG could enhance productivity and profitability in such systems. By improving nutrient availability, PEG supplementation can lead to increased average daily gains and better feed conversion ratios, which are critical for the economic viability of beef production.

PEG can help reduce methane emissions in beef cattle diets supplemented with condensed tannin-rich legumes, contributing to more sustainable beef production practices (Suybeng *et al*., 2021).

Conclusion

In essence, PEG 4000 is a valuable tool for optimising ruminant nutrition by neutralising the negative effects of condensed tannins, enhancing protein digestibility, and improving overall animal performance. Its application in both grazing and feedlot systems can lead to increased growth rates, better feed efficiency, and potentially lower methane emissions.

By integrating PEG 4000 into ruminant diets, producers can maximise the utilisation of condensed tannin-rich forages, ultimately improving the profitability and sustainability of animal production systems.

For more information, send an email to Zané Orffer at zane@nu3enta.co.za.

Mycotoxin contamination and the nutritional content of maize targeted for animal feed

By Anthony Pokoo-Aikens, Callie M McDonough, Trevor R Mitchell, Jaci A Hawkins, Lincoln F Adams, Quentin D Read, Xiang Li, Revathi Shanmugasundaram, ElsiAnna Rodewald, Pratima Acharya, Anthony E Glenn, and Scott E Gold

Cereal grains, especially maize, are a primary source of calories in animal diets worldwide (Dubey *et al*., 2020). Approximately 70% of the world's cereal grain is used in animal feed (Oliveira *et al*., 2014). Although production of crops has increased over the years, about 25% of the world's cereal grain harvest is wasted due to mycotoxin contamination making it unsafe for consumption (Marin *et al*., 2013).

Maize is more susceptible to mycotoxin contamination by a variety of colonising fungi than other animal feed commodities such as wheat, barley, oats, and soya beans (Magnoli *et al*., 2019). An estimated 60 to 80% of agricultural products are contaminated with mycotoxins (Eskola *et al*., 2020) with an estimated 61% containing multiple mycotoxins (DSM, 2023).

Mycotoxins are a class of secondary metabolites produced by fungi that exert toxic effects on animals, including humans (Liu *et al*., 2020). In the agricultural industry, mycotoxins cause losses in animal production due to reduced growth rates, decreased immunity and fertility, reduced egg, meat and milk production, and increased mortality (Thipe *et al*., 2020).

The major mycotoxins that contaminate cereal grain are aflatoxin (AFB1), fumonisin (FUM), deoxynivalenol (DON), zearalenone (ZEA), T-2 toxin, and ochratoxin (OTA). The United States (US) has regulatory guidance levels established for AFB1, DON, and FUM but not for ZEA, OTA, or T-2. Limits for concentrations of these mycotoxins in various animal feed products are given in *Table 1* (FDA, 2011). DON, ZEA, FUM and T-2 are considered to primarily be field mycotoxins whereas AFB1 and OTA are considered to be primarily storage mycotoxins (Munkvold *et al*., 2019). However, the 'field mycotoxins' have also been observed to increase in concentration when grain is stored under favourable conditions for the fungi.

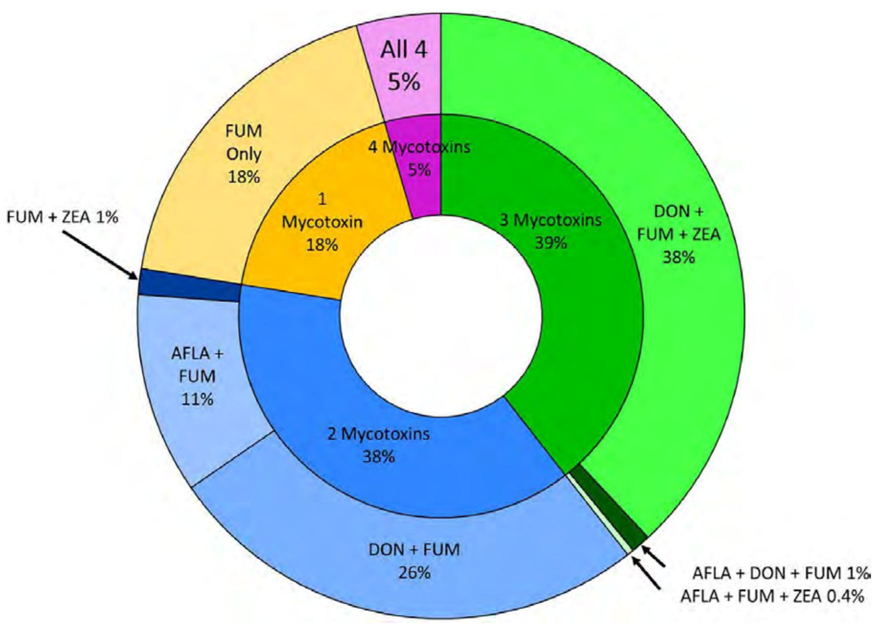
In addition to fungal growth on maize leading to mycotoxin contamination, it also, by necessity, results in changes in nutritional content of the kernels as the fungus selectively consumes components of and develops in the maize kernels. Fungi consume specific plant nutrients changing the nutrient content of the colonised plant biomass (Vieira, 2003). Maize entering storage is frequently contaminated with fungal spores from the field, potentially leading to fungal growth (Vieira, 2003).

Factors potentially affecting maize during storage include high moisture content (above 13%), high relative humidity (70 to 75%), prolonged conducive temperature exposure (15 to 20°C for *Fusarium*, 25 to 30°C for *Aspergillus*), physical damage to kernels (such as mould and insect infestation), storage methods, and storage duration (Hossain *et al*., 2011; Rosentrater, 2022). Fungal growth in stored maize frequently leads to a measurable reduction in carbohydrate and fat levels (Vieira, 2003). These changes in the nutrient profile are predicted to have negative impacts on the

Table 1: Mycotoxin regulatory limits for animal feed. (Source: *FDA Mycotoxin Guidelines, 2011*)

	Mature animals	Breeding animals	Immature animals
Aflatoxin (µg/kg)	Beef cattle – 300	Beef cattle – 100	All – 20
	Dairy cattle – 20	Dairy cattle – 20	
	Swine – 200	Swine – 100	
	Poultry – 100	Poultry – 100	
Deoxynivalenol (µg/kg)	Cattle – 10 000	Cattle – 10 000	Cattle – 10 000
	Swine – 5 000	Swine – 5 000	Swine – 5 000
	Poultry – 10 000	Poultry – 10 000	Poultry – 10 000
Fumonisin (µg/kg)	Beef cattle – 60 000	Cattle – 30 000	Cattle – 10 000
	Dairy cattle – 30 000	Swine – 20 000	Swine – 20 000
	Swine – 20 000	Poultry – 30 000	Poultry – 100 000
	Poultry – 100 000		
Zearalenone	N/A	N/A	N/A

Figure 1: Distribution of the number of mycotoxins detected in individual maize samples (inner ring) and (outer ring) the distribution of specific combinations of mycotoxins (aflatoxin [AFB1], deoxynivalenol [DON], fumonisin [FUM], and zearalenone [ZEA]) making up the co-contaminations indicated.



poultry feed conversion ratio if not taken into consideration during feed formulation.

Fungal growth can change other aspects of the maize kernels, including colour. If colour data can be correlated to mycotoxin content, this could be another avenue by which grains could be cheaply screened for mycotoxin contamination. Poultry producers routinely screen incoming grain for mycotoxins, especially AFB1, but do so less frequently for other major mycotoxins such as FUM and DON. Concentration levels of DON in grains have been shown to change during storage; this creates the possibility that grain which passed inspection can have increased toxin levels when later removed for use (Venslovas *et al*., 2022).

Additionally, FUM and DON are frequently found in the same grain source and at levels below regulatory thresholds (Weaver *et al*., 2021). Recent studies indicate that sub-regulatory levels of multiple mycotoxins in the same feed can have negative synergistic effects on poultry gut health, performance, and food safety (Shanmugasundaram *et al*., 2022).

Although several surveillance papers have examined the occurrence and co-occurrence of mycotoxins, most use small sample sizes. Here, we analysed 328 maize samples obtained from grain elevators, feed mills, and farms in the Southeastern US, a major producer of broiler meat, for four major mycotoxins of poultry production concern and examined their co-occurrence.

Mycotoxin analysis

Of the 328 samples, 82,93% were below the level of detection (LOD) on the HPLC-MS/MS and were thus recorded as having no AFB1 (*Figure 1*). The remaining 17,07% of samples were found to contain concentrations of AFB1 between 0,6 to 939µg/kg: 6,40% were below the 20µg/kg regulatory action level for young animals, 7,62% contained between 20 and 100µg/kg, and 3,05% showed amounts greater than the 100µg/kg regulatory action level for chickens (*Table 1*).

All 328 samples had detectable levels of one or more fumonisins ranging from 19 to 47 300µg/kg. FB1 was detected in all samples and ranged from 19 to 24 680µg/kg. A total of 2,44% of the samples had no detectable levels of FB2 while samples with detectable levels of FB2 positive samples ranged from 2 to 15 320µg/kg. FB3 in positive samples ranged from 1 to 9 540µg/kg with 1,22% of the samples having no detectable FB3. All samples were under the 100 000µg/kg guidance level (*Table 1*).

Of the 328 samples, 69,82% had detectable levels of DON ranging from 15 to 9 640µg/kg. None of the samples were above the 10 000µg/kg advisory level (*Table 1*). A total of 43,60% of the samples tested had detectable levels of ZEA. Samples that had ZEA ranged from 4 to 8 093,5µg/kg. There are currently no regulatory guidelines for ZEA (*Table 1*).

A total of 81,71% of the 328 samples were contaminated with multiple mycotoxins. The most common number of mycotoxins in a sample was two. Of the 328 samples, 4,88% had all analysed mycotoxins present (AFB1, FUM, DON, and ZEA) (*Figure 1*). Most of the samples that had three or more mycotoxins present (120 out of 126) had DON, ZEA, and FUM present.

FUM was the most frequently occurring mycotoxin and was present in all samples. DON was the second most frequent mycotoxin and was present in 69,82%

Table 2: Maize NIR proximate/nutritional analysis.

	Protein (%)	Fat (%)	Starch (%)	Fibre (%)	Moisture (%)
Average ± SEM	7,05 ± 0,03	3,41 ± 0,01	63,12 ± 0,06	1,90 ± 0,00	13,76 ± 0,05
Minimum	5,98	2,07	57,61	1,73	10,95
First quartile	6,74	3,37	62,5	1,86	13,19
Median	7,00	3,47	63,24	1,90	13,58
Third quartile	7,27	3,52	63,82	1,94	14,27
Maximum	9,05	3,77	66,51	2,09	17,77
# of samples	328	328	328	328	328

of samples. ZEA was the third most frequently occurring mycotoxin and was present in 43,60% of all tested samples. AFB1 was the least frequently occurring mycotoxin and was present in 17,08% of the 328 samples, with an average level in the positives of 82,4µg/kg. This is below the 100µg/kg level for mature poultry, but above the 20µg/kg level for young animals.

Proximate analysis of maize

Protein ranged from 5,98 to 9,05% with a standard deviation of 0,46%. Fat content ranged from 2,07 to 3,77% ± 0,24% (*Table 2*). Moisture content was more variable with a range of 10,95 to 17,77% ± 0,93%. The fibre content ranged from 1,73 to 2,09% ± 0,06%. Starch ranged from 57,61 to 66,51% ± 0,05%.

Nutritional content and colour

Correlation analyses of nutritional content with mycotoxins are shown in *Table 3*. AFB1 was negatively correlated with fat content ($P = 0,007$; slope = 0,033) and negatively corelated with the L* (lightness) colour value ($P = 0,007$; slope = -0,842). DON was positively correlated with starch ($P < 0,001$; slope = 0,037). FUM was positively correlated with protein ($P = 0,008$; slope = 0,072) and moisture ($P = 0,019$; slope = 2,353) and negatively correlated with starch ($P < 0,001$; slope = 0,026). ZEA was negatively correlated with starch ($P = 0,034$; slope = 0,034).

More studies are necessary

A more thorough understanding of the effects of mycotoxin levels on the nutrient content of maize will allow animal feed formulators to account for the changes in nutrient content caused by mycotoxin contaminated maize when formulating feed. Comparing the results of multiple studies on this effect can contribute to a more thorough understanding of how individual mycotoxins affect the nutrient content of feed components.

It is also important to note that the cultivar, grade, harvest, and storage time of maize can have an effect on the nutrient content of maize (Mut *et al*., 2022). However, this data was not available for the samples collected in this study due to the samples being obtained from sources that store maize in bulk from multiple fields.

Previous studies have examined potential correlations between mycotoxins and various visual characteristic of maize. Some of the methods that have been used to analyse the colour of maize include using RGB values of pixels in computer images (Steenhoek *et al*., 2001). Also, BGY fluorescence is a common test for AFB1 contamination in maize (Chavez *et al*., 2020). Other methods such as near-infrared spectra, X-ray images, colour images, and physical properties have been used alone or in combination to try to determine fungal infestation in maize (Pearson *et al*., 2006).

Less work has been published on examining the international Commission on Illumination (CIE) values and mycotoxin levels. In our study, we found a strong negative correlation between the CIE lightness (L) value and AFB1 contamination. This shows another potential avenue of visual analysis to detect mycotoxin contamination in maize.

Conclusion

These results demonstrate that mycotoxins are associated with a change in the nutrient profile of maize. This can affect animal health and performance even before mycotoxicosis affects animals directly. Co-contamination with multiple toxins seems to be very common, with FUM being the most common co-contaminant, in this study. Further research is needed to better understand the relationship between mycotoxins and the nutrient properties of maize, to quantify the effects of mycotoxin co-contamination in feed, and to develop methods to reduce mycotoxin accumulation in grain/feed storage.

Table 3: Mycotoxin and nutrient correlations of maize samples.

Mycotoxin[1]	Median slope	Slope lower/ upper limits	P-value[2,3]
Protein			
AFB1	0,033	(–0,059, 0,124)	0,480
DON	–0,112	(–0,168, –0,056)	**<0,001**
FUM	0,072	(0,019, 0,125)	**0,008**
ZEA	0,008	(–0,097, 0,112)	0,890
Fat			
AFB1	–0,145	(–0,249, –0,040)	**0,007**
DON	0,028	(–0,036, 0,092)	0,390
FUM	0,000	(–0,061, 0,061)	1,000
ZEA	0,002	(–0,119, 0,122)	0,980
Fibre			
AFB1	0,029	(–0,040, 0,099)	0,410
DON	0,035	(–0,008, 0,077)	0,110
FUM	–0,017	(–0,057, 0,024)	0,420
ZEA	0,015	(–0,064, 0,094)	0,710
Starch			
AFB1	–0,018	(–0,042, 0,005)	0,130
DON	0,037	(0,022, 0,051)	**<0,001**
FUM	–0,026	(–0,039, –0,012)	**<0,001**
ZEA	–0,029	(–0,057, –0,002)	**0,034**
Moisture			
AFB1	0,020	(–0,079, 0,119)	0,700
DON	–0,039	(–0,100, 0,022)	0,210
FUM	0,069	(0,012, 0,127)	**0,019**
ZEA	0,015	(–0,099, 0,128)	0,800
L colour			
AFB1	–0,842	(–1,453, –0,230)	**<0,001**
DON	–0,041	(–0,255, 0,174)	0,710
FUM	–0,056	(–0,238, 0,126)	0,540
ZEA	0,016	(–0,359, 0,392)	**0,930**

[1]Aflatoxin (AFB1), deoxynivalenol (DON), fumonisin (FUM), zearalenone (ZEA). [2]P-values associated with the average slope for each mycotoxin, holding all other mycotoxins constant at their average values. In the model, the y variable is on the log scale and the x axis is such that 0 is the lowest concentration and 1 the highest. In the table, the 95% confidence intervals of the slopes are given in parentheses. The P-values are based on a z-test. [3]Significant relationships are shown in bold.

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Utilising tributyrin to improve histomorphology and the performance of broilers: **Introducing SpeoCare™ T60**

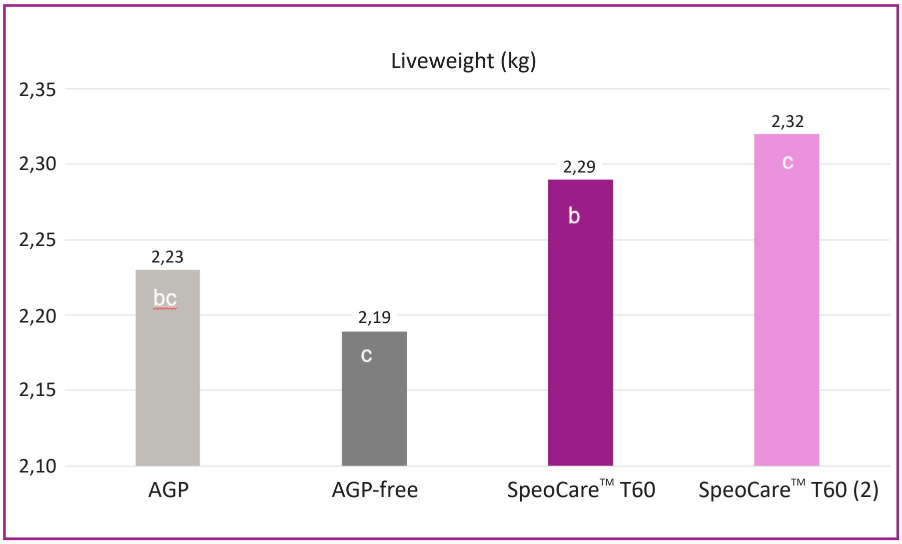
By Natasha Davison

Butyric acid is a short-chain fatty acid (SCFA) which is the main energy source for colonocytes. Colonocytes are vital in the absorption of electrolytes and water from the hindgut and have a very energy intensive, high turnover rate of every three to four days.

Butyric acid encourages the growth and differentiation of epithelial cells and acts as a cell mediator, regulating gene expression, immune modulation, and oxidative stress. The low pH of butyric acid also reduces the pH in the hindgut, preventing the colonisation of pathogenic bacteria and, as a result, it can modulate intestinal bacteria (Bedford and Gong, 2018).

Butyrate glycerides come in various forms, including mono-, di- and tributyrins. SpeoCare™ T60 is a new, innovative tributyrin product produced by Evonik. A tributyrin contains three butyric acid molecules bound to a glycerol backbone, enabling the butyrate molecules to only be released from their glycerol bonds in the small intestine in the presence of lipase. Tributyrins are the most efficient source of butyrate esters as they contain approximately three times the amount of butyric acid molecules compared to butyrate salts.

Figure 1: Liveweight of broilers supplemented with an AGP vs SpeoCare™ T60.



[a, b]*: values with differing superscripts are statistically significant (p < 0,05).*

SpeoCare™ T60 trial

A broiler trial was conducted at the Institute of Poultry Management and Technology where birds were either supplemented with an antibiotic growth promoter (AGP) (positive control), without an AGP (negative control), or with SpeoCare™ T60.

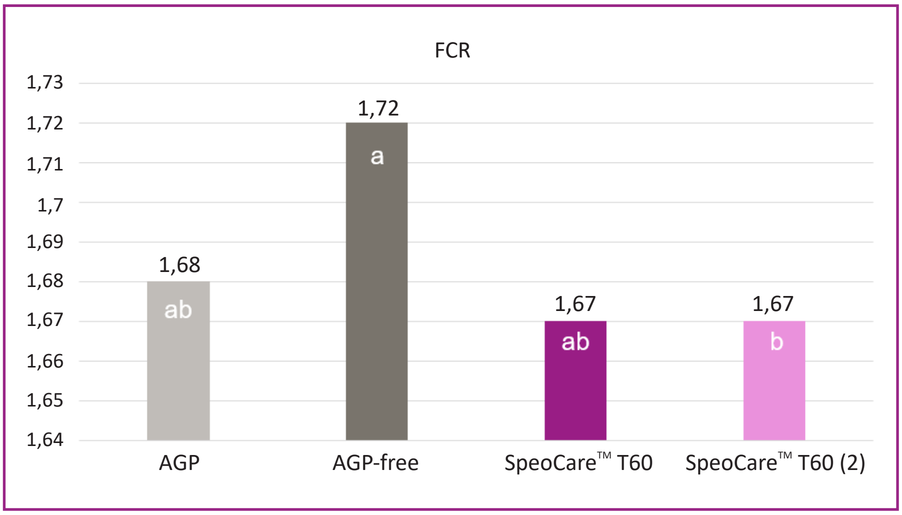
The open-sided house environment in which a total of 4 400 broilers were kept until day 42 provided the ideal challenge model. In such conditions, one would expect lower performance than breed standards, leaving room for improvement.

The broilers were fed a control maize-soya bean meal diet as well as two treatment diets: SpeoCare™ T60 and SpeoCare™ T60 (2). The SpeoCare™ T60 diet contained 500g/t of SpeoCare™ T60 in the starter diet and 250g/t in the grower and finisher diets; the SpeoCare™ T60 (2) diet contained 500g/t of SpeoCare™ T60 in the starter and grower diets, and 250g/t in the finisher diet.

Remarkable results

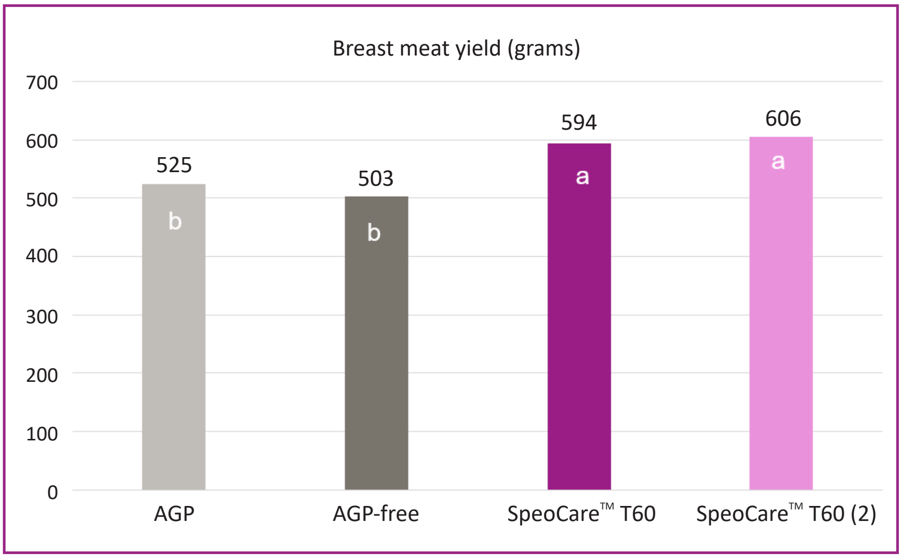
There were marked improvements in performance and histomorphology with the supplementation of SpeoCare™ T60 to broilers. From *Figure 1* it can be observed that liveweight is reduced when AGPs are removed from the diet (NC); however, when SpeoCare™ T60 is added, there is an improvement over and above the

Figure 2: FCR of broilers supplemented with an AGP vs SpeoCare™ T60.



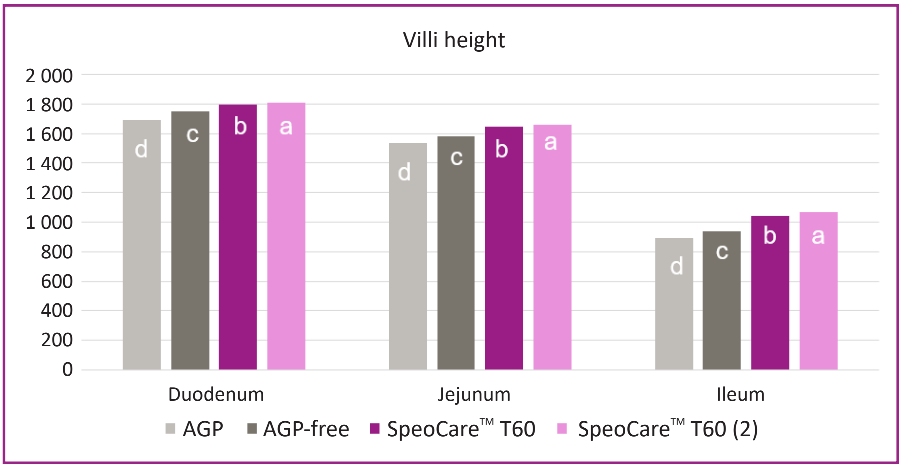
a, b: values with differing superscripts are statistically significant (p < 0,05).

Figure 3: Breast meat yield of broilers supplemented with an AGP vs SpeoCare™ T60.



a, b: values with differing superscripts are statistically significant (p < 0,05).

Figure 4: Villi height of broilers supplemented with an AGP vs SpeoCare™ T60.



a, b: values with differing superscripts are statistically significant (p < 0,05).

AGP (PC) diet. Interestingly, increasing the supplementation to 500g/t in the grower diet saw a further improvement in performance.

A similar trend is noticeable in *Figure 2* when FCR is considered. The FCR worsens when the AGP is removed, which is to be expected, but improves drastically when SpeoCare™ T60 is added.

In addition to growth performance, carcass composition was also measured to assess the effect of tributyrin supplementation on breast meat yield. Again, in *Figure 3*, we see a depression in yield when we remove AGPs from the diet, but when adding SpeoCare™ T60 at lower or higher levels, we observe a significant increase in breast meat yield (even higher than the AGP level). This is potentially indicative of improved absorption and utilisation of nutrients in the diet with improved histomorphology.

Lastly, histomorphology was measured and villi height was compared between treatments. As discussed, butyric acid has a considerable influence on gut structure and function. There were some interesting findings as can be observed in *Figure 4*. Villi height increased in the duodenum, jejunum, and ileum when AGPs were removed, and a further increase is observed with the addition of SpeoCare™ T60.

Conclusion

It can be concluded that although AGP addition in poultry diets keeps the pathogen levels in the gut at sub-clinical levels, they do not necessarily improve histomorphology. This could be due to the suppression of butyrate-producing bacteria.

Exploring alternatives to AGPs in broiler production can be a challenging task, especially when producers cannot afford to compromise on performance. Supplementing butyric acid in poultry diets in the form of tributyrin is an opportunity to significantly improve performance through strengthening the gut barrier and histomorphology in broilers, especially under challenging conditions.

For more information and references, send an email to Natasha Davison at natasha.davison@evonik.com.

Antibiotic resistance gene pollution in poultry farming environments and approaches for mitigation: A system review

By Yun Chen, Yujia Liu, Cuiyan Zhao, Jinge Ma and Jing Guo

Since the discovery of aureomycin in the 1940s as a growth promoter for animals, various antibiotics have been proven effective in promoting growth at sub-therapeutic levels (Castanon, 2007). It is estimated that antibiotic use in livestock accounts for 70% of the total global antibiotic consumption, which is projected to increase to 107 472 tonnes by 2030 (Mulchandani *et al*., 2023).

Approximately 73% of these antibiotics are used in livestock, primarily in countries such as China, Brazil, India, the United States (US), and Australia, which account for 58% of global antibiotic consumption (Mulchandani *et al*., 2023). Even with the cessation of selective pressure, the overuse of antibiotics over an extended period has resulted in the emergence of antibiotic-resistance genes (ARGs) and resistant bacteria, which persist in the environment (Martinez, 2008; Li *et al*., 2024).

Livestock and poultry waste, including manure, sewage, and soil surrounding farms, are considered hotspots for ARG pollution. ARGs are primarily transmitted through horizontal gene transfer (HGT) and vertical gene transfer (VGT), spreading through agricultural soils, crops, and food chains to humans, thereby reducing the efficacy of antibiotic treatments (Tong *et al*., 2022). By 2050, the annual global death toll due to antibiotic resistance is expected to reach ten million (Huemer *et al*., 2020).

The pollution of ARGs in poultry farming environments differs significantly from that in livestock farming environments, including farming practices, physiological characteristics, manure management, and environmental transmission pathways (Korver, 2023). First, there are notable differences in the farming practices between poultry and livestock. Poultry is typically raised in confined or semi-confined environments, such as cages or barns, often poorly ventilated with concentrated feed, water, and manure, leading to a high-density accumulation of pathogens and resistance genes (Yan *et al*., 2023).

In contrast, livestock (especially ruminants) are often raised in open or semi-open pasture environments with more exposure to the external environment, resulting in more diverse and complex transmission pathways for resistance genes (Peng *et al*., 2022). Additionally, poultry farming environments are generally of higher density, implying a higher risk of cross-contamination, thereby accelerating the dissemination and spread of resistance genes.

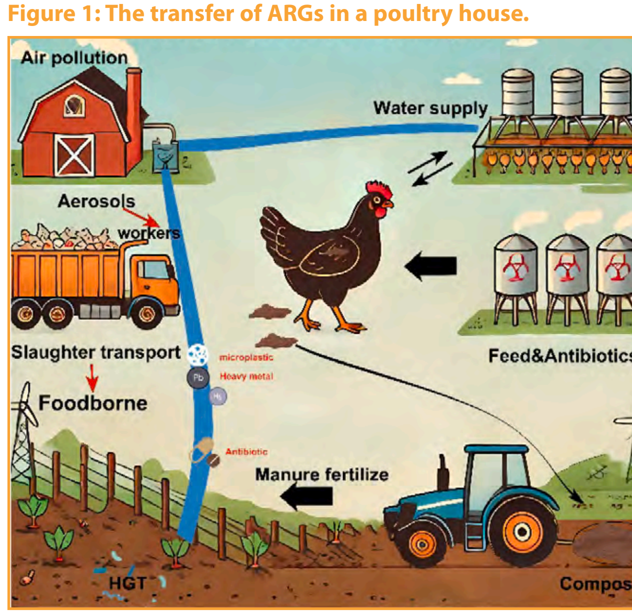
Secondly, the physiological characteristics of poultry also influence the transmission of resistance genes. The gut microbiota of poultry differs from that of livestock, and due to lower absorption efficiency, 70 to 90% of antibiotics are excreted into the environment through faeces and urine in their original form or as metabolites (Wickramasuriya *et al*., 2022; Liu *et al*., 2024). Notably, poultry's relatively short intestinal length may affect the colonisation and dissemination patterns of resistance genes.

Certain unique bacterial species in the poultry gastrointestinal tract, such as *Bacteroidaceae* and *Lactobacillaceae*, may play critical roles in resistance genes' horizontal transfer and selection pressure (Zhou *et al*., 2020; Qiu *et al*., 2022). Furthermore, the high metabolic rate and shorter lifespan of poultry mean that the dynamic changes in resistance genes within their bodies are more rapid, accelerating the accumulation and spread of resistance genes.

Additionally, there are differences in manure management between poultry and livestock. Poultry manure is often used as organic fertiliser and applied directly to agricultural fields, increasing the risk of resistance genes entering the environment through soil (Drozdz *et al*., 2020; Rizzo *et al*., 2022). In contrast, livestock manure (such as cow and pig manure) is usually subjected to composting or anaerobic digestion before being applied to fields, which can reduce inactivate resistance genes to some extent, thereby reducing the risk of their spread (Zubair *et al*., 2023).

Lastly, the transmission pathways of resistance genes in poultry farming environments also have unique characteristics compared to livestock farming. Poultry feathers, respiratory droplets, and dust in farming facilities are all potential carriers of resistance genes (Gao *et al*., 2022; Xu *et al*., 2022).

Figure 1: The transfer of ARGs in a poultry house.



Compared to livestock, poultry is more prone to spreading pathogens and resistance genes through the respiratory tract. Moreover, wastewater and feed residues in poultry farming can also serve as sources of resistance genes, further increasing the complexity of environmental contamination (Di Francesco *et al*., 2021; Rui and Qiu, 2024).

Antibiotic resistance gene pollution in poultry farming environments is characterised by high density, complex transmission pathways, and rapid environmental accumulation compared to livestock. These differences affect the modes and rates of resistance gene transmission and impose higher demands on their environmental management and control strategies.

Alternatives to antibiotics

Probiotics and prebiotics have garnered increasing attention as alternatives to antibiotics in poultry farming. Probiotics, such as lactic acid bacteria, enhance animal health by competitive exclusion, strengthening the host immune system, and inhibiting pathogen colonisation. Studies have shown that administering *Lactobacillus* strains in poultry diets can effectively reduce *Salmonella* colonisation in the gut, improving overall bird health and reducing the need for antibiotics (Abdel-Raheem *et al*., 2024; He *et al*., 2024). Prebiotics, such as fructooli gosaccharides, stimulate the growth of beneficial gut bacteria, indirectly lowering pathogen populations (Qiu *et al*., 2021).

Research suggests that the combined use of prebiotics and probiotics, termed synbiotics, can significantly reduce disease incidence in poultry, thereby lowering antibiotic usage (El-Shall *et al*., 2024). In addition to these biotic interventions, plant extracts and essential oils have emerged as natural antimicrobial agents that are effective against various pathogens. Garlic, oregano oil, and curcumin are widely incorporated into poultry diets due to their antibacterial, antiviral, and antioxidant properties. These natural products suppress the growth of harmful pathogens, enhance gut health and improve feed efficiency, reducing the reliance on antibiotics in poultry farming (Jimoh *et al*., 2024; Popov *et al*., 2024).

Furthermore, preventive vaccination is another critical approach to reducing antibiotic use. Vaccines can effectively prevent common bacterial and viral infections in poultry, decreasing disease incidence and reducing the demand for antibiotic treatments. By enhancing immunity, vaccines reduce the incidence of diseases such as avian influenza, salmonella, and coccidiosis, thereby decreasing the need for antibiotic treatments. This not only lowers the reliance on antibiotics but also helps in controlling the spread of antimicrobial resistance.

Vaccines provide a more sustainable approach to disease prevention, improving animal health and reducing the economic burden associated with antibiotic use. Advances in DNA and genetically engineered vaccines have led to the development of multivalent vaccines that protect against multiple pathogens, providing a comprehensive disease control strategy in poultry production. These multifaceted approaches represent a promising shift toward sustainable poultry farming practices, mitigating the spread of antibiotic resistance while maintaining animal health.

Manure treatment technologies

Composting is a traditional method for treating poultry manure, utilising microbial degradation to break down organic matter and pathogens effectively (*Table 1*). By carefully controlling key parameters such as temperature, oxygen supply, and moisture content during the composting process, it is possible to maximise the degradation efficiency, thereby reducing antibiotic residues and the dissemination of ARGs.

Recent advancements have shown that incorporating biochar into composting can further enhance this process by improving nutrient retention and reducing the release of harmful substances. Biochar-amended composting has demonstrated the ability to mitigate ARGs more effectively, as it adsorbs and immobilises pollutants, thereby limiting their environmental spread (Akdeniz, 2019; Cao *et al*., 2020).

Anaerobic digestion is another promising technology that transforms poultry manure into biogas and fertiliser while simultaneously reducing the levels of antibiotics and ARGs. By optimising anaerobic digestion parameters such as temperature, pH, and organic loading rate, the process can improve the degradation of harmful substances but also the recovery of energy, making it an eco-friendly solution to manure management (Awasthi *et al*., 2019; Efremenko *et al*., 2023).

Furthermore, pyrolysis, a thermal conversion process, involves the high-temperature treatment of poultry manure to produce biochar and pyrolysis gas. This technology offers a comprehensive pathogen and ARG elimination approach while generating valuable by-products like soil amendments. Pyrolysis has also significantly reduced greenhouse gas emissions during manure treatment, offering both environmental and economic benefits (Drozdz *et al*., 2020; Lataf *et al*., 2024).

Together, these advanced manure management strategies present practical ways to mitigate the environmental impact of poultry farming, reduce the spread of ARGs, and contribute to sustainable agricultural practices.

Water purification methods

Physical filtration techniques, such as ultrafiltration, nanofiltration, and reverse osmosis, are highly effective in removing organic matter, pathogens, and ARGs from poultry farm wastewater. These membrane-based technologies act as physical barriers that separate contaminants from the water, offering a robust method for wastewater purification. Despite the higher operational costs associated with membrane filtration, its efficacy in mitigating water pollution is well documented, making it a valuable option for addressing environmental challenges in poultry farming (Gao *et al*., 2023; Shanthini *et al*., 2024).

In addition to physical filtration, biological treatments like constructed wetlands and biofilters have gained attention for their ability to remove pollutants and ARGs through the synergistic action of plants, micro-organisms, and substrates. In constructed wetlands, plant root systems play a critical role by adsorbing and degrading organic pollutants, while microbial communities facilitate the biodegradation of ARGs. Similarly, biofilters leverage the microbial activity in filter media to degrade contaminants, thus providing a sustainable and efficient solution for wastewater treatment (Soliman *et al*., 2021).

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Table 1: Removal of ARGs contamination in poultry houses.

Method	Principle	Source	Type of ARGs	Dominance	Removal efficiency	Reference
Two-stage combinations of constructed wetlands	Inhibit bacterial growth; promote the establishment of anammox	Goose wastewater	Tilmicosin-TMS and doxycycline-DOC, seven *tet* genes (*tet*O, *tet*Q, *tet*W, *tet*A, *tet*C, *tet*G, and *tet*X), three *erm* genes (*erm*B, *erm*F, and *erm*C) and *intI*1	Low maintenance costs and environmentally friendly features	>98%	(Huang *et al.*, 2019)
Industrial composting and anaerobic digestion	Absorb antibiotics and heavy metals, reduce mobility	Chicken manure	Aminoglycosides, β-lactam, quinolones, sulfonamides, and tetracyclines; *bla*CTX-M, *intI*1, aac6'-Ib, *aad*A and *oqx* B	Highly effective		(Riaz *et al.*, 2020)
Microbial fuel cell	Uses micro-organism as biocatalysts to decompose organic compounds in wastewater	Livestock wastewater	Tetracycline, sulfonamide and chloramphenicol	Green treatment	>60%	(Zhang *et al.*, 2022)
Hydrothermal pretreatment followed by anaerobic digestion	Stabilise animal waste and simultaneously generate biogas; increasing the contact surface of lignocellulosic matrices	Poultry litter	Tylosin-resistant bacteria and the antibiotic resistance genes (*erm*B, *bla*TEM, *sul1*, *qnr*B and *tet*A)	Increase the contact surface of lignocellulosic matrices	91,6%	(Paranhos *et al.*, 2023)
Rice straw biochar and mushroom biochar	Regulate moisture content, accelerate organic matter degradation and ammonium formation, and enhance nitrification	Chicken manure	*sul* genes (*sul1* and *sul2*); chloramphenicol resistance genes (*fex*A, *cfr*, *cml*A and *flo*R); *tet* genes (*tet*A, *tet*B, *tet*L, *tet*M, *tet*W, *tet*Q, *tet*O and *tet*X)		0,86 log units	(Cui *et al.*, 2016)
Bamboo charcoal	Increases the temperature, thereby prolonging the thermophilic phase to accelerate the degradation of organic matter during composting	Chicken manure	*tet*C, *tet*G, *tet*W, *tet*X, *sul2*, *drf*A1, *drf*A7 and *erm*B	Easily accessible resources	21,6 to 99,5%	(Li *et al.*, 2017)
Clay	Reduces the bioavailable concentrations of toxic metals while enhancing composting efficacy	Poultry manure	*mfd*, *mac*B and *bcr*A		52 to 56%	(Awashti *et al.* 2019)
Zeolite and superphosphate	Preserve nitrogen, increase sludge porosity, and remove phosphorus	Chicken manure	Sulfonamide: *tet*M, *tet*O and *tet*B; *sul1*, *sul2*, *tet*G and *tet*L	Improving the removal of ARGs from composting processes	0,4 to 99,9%	(Peng *et al.*, 2018)
Surfactants	Have strong effects on the surface tension between liquids and solids	Chicken manure	Sulfonamide and quinolone: *tet*C *tet*G, *tet*M, *tet*Q, *tet*W, *tet*X, *sul1*, *sul2*, *dfr*A7, *erm*B, *erm*F and *erm*X		Decrease two times	(Zhang *et al.*, 2016)
Hydrothermal carbonisation	High temperatures and humification	Chicken manure	*tnp614*, *intI1*, *IS1216*, *IS26*, *IS6100*, *IS613* and *ISEcp1*	Saves time, energy and more cost-effective	40,13 to 55,33%	(Shan *et al.*, 2023)
Combined inoculation of *Bacillus subtilis* with biochar	*Bacillus subtilis*: inhibits the growth of pathogenic bacteria; Biochar: regulates microbial growth in compost, reduces nutrient loss, improves end-product quality, and reduces the bioavailability of antibiotics	Chicken manure	*tet*X, *tet*G, *tet*M, *tet*O, *tet*W, *erm*B and *Tn916/1545*	Fast reproduction, easy cultivation, no toxicity, and high adaptability to the environment	97%	(Wu *et al.*, 2024)
Chitosan as additive	Absorbs and flocculates antibiotics, heavy metals and inhibits bacterial pathogens	Chicken manure	*amp*C/*bla*DHA, *bla*CTX-M-02, *bla*CTX-M-04, *bla*CTX-M-05, *bla*CTX-M-06, *bla*CMY, *bla*GES, *bla*PAO, *bla*SHV-02, *mec*A, *ndm-1* (beta-lactamase), *ade*A, *mex*A (multidrug), *tnp*A-03 (MGEs), *tet*D-01, *tet*K, *tet*L-01, *tet*U-01, *tet*V, *tet*E (tetracycline), *van*A (vancomycin), *qnr*A, *qnr*D (fluoroquinolone)	Biodegradable, non-toxic, disease management, and stress resistance management	23,33 to 30%	(Liu *et al*, 2021)
Aerobic composting	Kills pathogens, worm eggs, and weed seeds in manure	Broiler manure	Tetracycline resistance genes (*tet*W, *tet*U, *tet*O, and *tet*M), glycopeptide resistance genes (*van*F, *van*VB, and *van*L), MLS resistance genes (*lnu*C, *mef*E, and *vat*F), and phenicol resistance genes (*cat*Q and *cat*L)	An economical and environmentally friendly approach	<48,98%	(Xu *et al.*, 2022)
Semi-permeable membrane covered hyperthermophilic composting	The transfer of bioaerosols from the air environment to the compost was prevented, so as to avoid the rebound of the abundance of ARGs in the mature phase	Chicken manure	Tetracycline resistant genes (*tet*M), MLSB resistant genes (*erm*X, *erm*Q, *erm*B, *erm*O and *lnu*B), and aminoglycoside (*aph3-III*, *aac6*[1] and *sat4*)	The ARGs could be removed more effectively than conventional composting without abundance rebound in the mature phase	90%	(Sun *et al.*, 2024)

Furthermore, chemical oxidation processes, such as advanced oxidation technologies using ozone, hydrogen peroxide, and Fenton reactions, generate highly reactive oxidising agents (e.g., hydroxyl radicals) that rapidly degrade organic pollutants and ARGs in water.

These methods are known for their fast reaction rates and high removal efficiencies. However, the potential formation of harmful by-products requires careful monitoring and management to ensure safe and effective treatment. Together, these physical, biological, and chemical approaches offer complementary strategies for improving poultry farm wastewater quality and reducing ARG dissemination's environmental impact.

Emerging technologies

As the poultry farming industry continues to evolve, the application of emerging technologies is expected to play a pivotal role in mitigating ARG pollution. One promising area is developing and deploying precision agriculture tools, such as Internet of Things-based sensors and data analytics platforms. These technologies allow for real-time monitoring of environmental conditions and antibiotic usage, facilitating optimised antibiotic administration to minimise ARG generation while offering early warnings of potential disease outbreaks (Leishman *et al*., 2023).

In addition, next-generation sequencing technology enables a more detailed analysis of the microbial communities in poultry farming environments, allowing for the identification of high-risk resistance genes. This information can be utilised to formulate more targeted mitigation strategies and to provide real-time monitoring data on ARG dissemination (Goossens *et al*., 2022; Brown *et al*., 2025).

Another promising approach is the development of novel antibiotic alternatives, such as CRISPR-Cas-based gene-editing systems, which can precisely target and eliminate pathogens carrying ARGs. The application of these technologies reduces the reliance on antibiotics and effectively curtails the spread of resistance genes within the environment (Pandey and Vavilala, 2024). Collectively, the integration of IoT-based precision farming tools, NGS-driven microbial surveillance, and CRISPR-Cas gene editing holds significant potential for addressing the growing challenge of ARG contamination in the poultry industry.

Future research directions

Despite the progress made in recent years in the study of ARGs, numerous unresolved knowledge gaps remain, particularly concerning the mechanisms of ARG migration and dissemination in poultry farming environments. For instance, it is still unclear how varying environmental conditions and coexisting pollutants influence the environmental processes of ARGs, as well as the specific mechanisms by which these factors affect both horizontal gene transfer and vertical gene transfer. Future research should focus on several key areas.

First, the construction of a comprehensive regulatory system is critical. Susceptible and stable intelligent monitoring devices should be developed using multi-source data fusion technologies to establish an ARG surveillance platform. This platform would enable long-term monitoring of ARG abundance and diversity in poultry farming environments across different regions.

Second, research must prioritise identifying key environmental processes and molecular mechanisms. Detailed investigations into the distribution patterns and migration dynamics of ARGs in different environmental media are needed, as well as studies on the impact of various environmental factors on ARG dissemination mechanisms. Identifying high-risk ARGs and clarifying their transmission routes and molecular mechanisms in poultry farming environments is essential.

Third, the development of efficient pollution mitigation technologies is necessary. Innovative and environmentally friendly treatment technologies should be developed for environments already contaminated by ARGs. This could involve combining physical, biological, and chemical approaches to create novel, biodegradable functional materials that enable coordinated soil, wastewater, and air remediation in poultry farms. Finally, the establishment and sharing of a global ARGs database is vital. By drawing on the policies and measures implemented in different countries and regions, we can explore more rational management practices for livestock waste to control the spread of ARGs effectively.

In summary, future research must continue developing emerging technologies and mitigation strategies for ARGs and address current knowledge gaps, particularly regarding the migration and dissemination mechanisms of ARGs and pollution control technologies. These efforts will provide a stronger scientific foundation for the sustainable development of the poultry industry and help mitigate the threat of antibiotic resistance to public health.

Conclusion

The pollution of ARGs in poultry farming environments is a pressing issue that poses significant risks to both ecosystems and public health. The persistent use of antibiotics in animal husbandry has accelerated the proliferation and spread of ARGs, facilitated by horizontal and vertical gene transfer. The complexity of this issue is compounded by the specific farming practices, manure management methods, and physiological traits of poultry, with manure, wastewater, and air being major vectors of ARG dissemination.

While current waste treatment technologies offer some mitigation, they are insufficient to fully address the scale of the problem. To effectively curb the spread of ARGs, it is crucial to reduce antibiotic usage, enhance waste management, optimise farming practices, and strengthen regulatory measures. Additionally, further research is needed to fill existing knowledge gaps and develop more efficient pollution control technologies. By implementing these strategies, we can safeguard environmental and public health in poultry farming contexts.

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The effects of garlic as a feed additive on ruminal fermentability and ruminant performance: A meta-analysis

By Rima Shidqiyya Hidayati Martin and Abdul Shakoor Chaudhry

Enhancing rumen fermentation and digestibility is crucial in optimising animal performance and reducing methane (CH_4) emissions to improve energy efficiency and mitigate environmental impact. Numerous strategies have been explored to achieve these objectives, such as providing high-quality feed, adjusting feed formulations, and incorporating feed additives. Among these additives, antibiotics have proven effective and are commonly used in ruminant nutrition.

Non-therapeutic doses of antibiotics can modulate rumen microbial populations by suppressing methanogenic bacteria and promoting carbohydrate- and fibre-degrading bacteria. However, prolonged antibiotic use raises concerns about antibiotic resistance in humans due to the potential contamination of ruminant-derived food products with antibiotic residues. As a result, many countries have banned the use of antibiotics as feed additives. Consequently, research has shifted towards exploring natural alternatives to enhance rumen function and livestock performance.

Antibiotic substitutes should ideally have similar or superior properties, such as antimicrobial and antibiotic effects that can alter rumen fermentation and enhance the nutrient content of animal products such as milk and meat. These desirable properties can be found in plant products, making natural feed additives a potential replacement for antibiotics. Callaway *et al*. suggested that antibiotic substitutes are phytonutrients, natural chemicals, or compounds produced by plants.

Garlic meta-analysis

One such plant that contains phytonutrients is garlic (*Allium sativum*). Garlic and its derivatives contain bioactive organo-sulphur compounds, including allicin, alliin and allylsulfides. These compounds confer garlic products with antimicrobial, antioxidant, anti-inflammatory, immunomodulatory, antihypertensive, cancer-preventive, and lipid-lowering effects. The antimicrobial properties present in garlic make it suitable for use as a rumen modifier as it can modify rumen fermentation, increase nutrient digestibility, alter rumen microflora populations, and reduce CH_4 emissions.

Garlic has been extensively studied as a feed additive for ruminants but a comprehensive quantitative summary and meta-analysis of garlic's impact on rumen fermentability and ruminant performance are lacking. Although Ding *et al*. reviewed garlic's potential in ruminant diets, the review did not quantify the results. To update the understanding of garlic's impact on ruminants, further analyses using statistical meta-analysis techniques are necessary, combining data from related studies. Conducting a meta-analysis could address current ambiguities and provide new perspectives, particularly concerning the application of various garlic products in ruminants.

Interestingly, there is a distinct lack of meta-analysis that specifically investigates the increased levels of garlic products. This gap in research underscores the importance of conducting such a meta-analysis to advance understanding in this field.

This article hypothesises that incorporating garlic as a feed additive can enhance ruminal fermentation efficiency and ruminant performance. Additionally, it is hypothesised that garlic can positively alter the microbial population in the rumen, thereby reducing methane emissions. Hence, this study aimed to assess various garlic products as ruminant feed additives on rumen fermentability and ruminant performance by analysing their importance through meta-analysis.

Discussion

The CH_4 emission can reduce efficiency of feed utilisation for ruminants, resulting in energy loss. These energy losses can range from 2 to 12% of digested feed energy. To reduce CH_4 production, manipulation of rumen fermentation is required, one of which is using natural feed additives. Garlic, one of the natural feed additives,

Table 1: Effects of garlic on ruminal fermentation and *in vitro* digestibility.

Variables	NC	Estimate	Lower bound	Upper bound	Std error	p-value	τ2	Q	Het p-value	I^2
Rumen fermentability										
pH	100	-0,181	-0,396	0,035	0,110	0,100	0,806	359,196	<0,001	72,438
Gas production 24h	47	-0,466	-1,217	0,285	0,383	0,224	5,845	732,679	<0,001	93,722
CH_4 24h	35	-4,401	-5,353	-3,450	0,485	<0,001	6,654	341,096	<0,001	90,032
NH_3	84	0,215	-0,079	0,509	0,150	0,152	1,389	379,446	<0,001	78,126
Total VFA	78	0,052	-0,289	0,392	0,174	0,767	1,854	545,321	<0,001	85,880
C_2	107	-1,435	-1,841	-1,028	0,207	<0,001	3,491	982,574	<0,001	89,212
C_3	107	1,052	0,656	1,449	0,202	<0,001	3,366	972,519	<0,001	89,100
C_4	111	0,457	0,036	0,878	0,215	0,033	3,857	1 085,854	<0,001	89,870
C_5	82	0,608	0,290	0,926	0,162	<0,001	1,483	404,078	<0,001	79,954
$IsoC_4$	57	0,454	0,059	0,848	0,201	0,024	1,599	345,584	<0,001	83,796
$IsoC_5$	74	0,033	-0,317	0,384	0,179	0,853	1,722	424,133	<0,001	82,788
$C2/C_3$	76	-1,185	-1,579	-0,790	0,201	<0,001	2,496	630,939	<0,001	88,113
***In vitro* rumen digestibility**										
IVDMD	50	-0,397	-0,959	0,166	0,287	0,167	2,719	378,418	<0,001	87,844
IVOMD	33	0,060	-0,395	0,515	0,232	0,795	1,354	184,825	<0,001	82,686
IVNDFD	41	-1,043	-1,444	-0,641	0,205	<0,001	1,235	182,572	<0,001	78,091
IVADFD	15	-0,538	-1,324	0,249	0,401	0,180	1,875	114,989	<0,001	87,825
Rumen microbial population										
Total bacteria	41	0,151	0,007	0,296	0,074	0,040	0,000	34,156	0,730	0,000
Total protozoa	46	-0,355	-0,622	-0,088	0,136	0,009	0,517	132,837	<0,001	66,124

NC: number of comparisons; τ2: estimate of variance between studies in a random-effects meta-analysis; Q: study homogeneity; Het: heterogeneity; I^2: percentage of variation across studies due to heterogeneity; TVFA: total volatile fatty acids; IVDMD: in vitro dry matter digestibility; IVOMD: in vitro organic matter digestibility; IVNDFD: in vitro neutral detergent fibre digestibility; IVADFD: in vitro acid detergent fibre digestibility.

significantly reduced CH_4 gas production in the meta-analysis. This was consistent with the results of an *in vitro* rumen experiment in batch culture for 24 hour-observation.

Although the current meta-analysis was not conducted on long-term studies, studies using the rumen simulation technique system (RUSITEC) or respiratory chambers reported linear results. Garlic contained sulphur-containing compounds that were associated with antimicrobial and anti-methanogenic effects such as allicin. In the rumen, methanogenic archaea – responsible for CH_4 production – could be inhibited by allicin or its derivatives, leading to a reduction in CH_4 emissions.

Notably, the *Methanobacteriaceae* family, which predominantly included CH_4 producers in the rumen, experienced decreased microbial population numbers. The reduced population of methanogenic archaea in response to garlic consumption could be attributed to the toxic effects of organo-sulphur compounds such as diallyl sulphide and allicin. These compounds inhibited specific sulfhydryl-containing enzymes that played a crucial role in the metabolic activities of methanogens. However, the mechanism by which organo-sulphur utilises excess hydrogen (H_2) remained unclear. Takahashi *et al*. explained the possible mechanism for organo-sulphur in inhibiting rumen methanogenesis. It could block methanogenic activity by either binding to their metal co-factors or acting as a H_2 sink.

Rumen microbial populations

Furthermore, the reduction in CH_4 emissions was associated with a significant decline in the total number of rumen protozoa, as demonstrated in *Table 1*. This finding is aligned with the results reported by Kewan *et al*. These ciliated protozoa within the rumen played a crucial role in methanogenesis, serving as major H_2 producers and maintaining symbiotic relationships with methanogenic archaea. Specifically, members of the *Methanobacteriaceae* family utilised the H_2 produced by rumen protozoa, whether inside the protozoal cells or on their external surface, forming an association.

Additionally, the toxic properties of allicin impacted ciliated protozoa in the rumen. The use of garlic products in combination with other essential oils (EOs) resulted in a decrease in the number of rumen protozoa. For instance, the addition of citrus EOs containing flavonoids did show such effects. Allicin and flavonoids synergised in inhibiting protozoan defaunation, although studies on the specific mechanism remain limited. The primary mechanism that likely involved medium-chain fatty acids (MCFAs) found in garlic and garlic oil, which exhibited antimicrobial properties. These MCFAs

selectively inhibited rumen protozoa, resulting in defaunation.

In addition to reducing CH_4 production, the decline in total protozoa also influenced the overall bacterial population in the rumen (*Table 1*). Protozoa acted as predators for several types of rumen bacteria, capable of engulfing bacteria in the rumen as their primary protein source. Research conducted by Ma *et al*. revealed a similar phenomenon – an increase in total bacteria and cellulolytic bacteria. Notably, the *Prevotellaceae* and *Veillonellaceae* families exhibited an increase in their rumen population.

These families were known for their role in degrading carbohydrates into volatile fatty acids (VFAs), primarily contributing to the breakdown of complex substrates into C_3 and, to a lesser extent, C_4. The results of this study concerning C_3 and C_4 improvement aligned with the findings from previous studies that investigated the use of garlic powder and garlic oil as ruminant feed additives.

In the CH_4 formation process, methanogenic archaea and ciliated protozoa utilised H_2 to decrease CO_2 levels and generate CH_4. When the population of methanogenic archaea and protozoa decreased, there was an unutilised H_2. The available H_2, which was not utilised by methanogenic archaea and protozoa, was instead utilised by *Prevotellaceae* to produce C_3 during carbohydrate fermentation.

In contrast, the increasing C_3 was not followed by increasing C_2 (*Table 1*). Existing evidence supported the positive correlation between CH_4 formation and C_2 production, while an inverse relationship existed with increased C_3 production. This decrease was attributed to organo-sulphur compounds – allicin – in garlic that inhibited CH_4-producing micro-organisms. Thus, methanogens utilised C_2 as a crucial substrate, a process known as acetogenic methanogenesis. Due to the significant increase in C_3 and decrease in C_2, there was a noticeable reduction in the C_2/C_3 ratio.

Despite the increase in total rumen bacteria, the meta-analysis of *in vitro* neutral detergent fibre digestibility (IVNDFD) showed a significant decrease. This finding was different from the results of the systematic review conducted by Sari *et al*., which stated an increase in IVNDFD followed by an increase in organic matter digestibility (OMD) and acid detergent fibre digestibility (ADFD). Ma *et al*. and Manasri *et al*. mentioned that the bacterial groups that were increased were cellulolytic bacteria, such as *F. succinogenes*, *R. flavefaciens* and *B. fibrisolvens*, in sheep fed allicin-supplemented diets. However, the reports of Patra and Yu were consistent with the results of this meta-analysis. The garlic oil significantly reduced the fibre degradability of feed in an *in vitro* rumen mixed culture after two, ten and 18 days of incubation.

Effect on DM and CP intake

Garlic, when used as a ruminant feed additive, influenced dry matter intake (DMI) and crude protein intake (CPI). The results indicated that garlic increased DMI and CPI. Its flavour and aroma could affect palatability, and the ruminants might find it appealing. Furthermore, the bioactive compounds in garlic could enhance gut activity through their antimicrobial effects and garlic positively influenced the cation-anion balance, which affected rumination activity. The decrease in CH_4 gas due to organo-sulphur compounds might also contribute indirectly to the increase in DMI and CPI.

Additionally, the elevated crude protein content in garlic might contribute to CPI; specifically, garlic powder contained 16,3 to 22,9%, garlic skin contained 13,10 to 13,65%, garlic leaves contained 11,83 to 24,80%, and garlic straw contained 5,73 to 9,56% protein. Yet, the mechanism related to the increase in DMI with the addition of garlic remained unclear. Although DMI and CPI increased, the meta-analysis did not find a significant improvement in dry matter digestibility (DMD) and crude protein digestibility (CPD). This lack of significance could be due to the consistent efficiency of nutrient extraction from the consumed feed.

With the DMI and CPI increases, this meta-analysis revealed that the garlic products did enhance average daily gain (ADG). This was consistent with previous studies that explored various garlic products, including garlic skin, garlic extract, garlic leaves and garlic powder. Research indicated that lambs infected with gastrointestinal nematodes experienced significantly increased ADG when fed garlic powder. This improvement was attributed to garlic powder's antiparasitic properties.

By incorporating garlic powder into their diet, ruminants benefited from enhanced feed palatability, leading to increased appetite and nutrient intake. Additionally, garlic powder contained sulphur compounds with antioxidant and antimicrobial effects, safeguarding feed ingredients against oxidation and microbial contamination during storage, ultimately improving the overall feed palatability.

Furthermore, ADG was increased due to the rise in C_3 levels. Here C_3, a short-chain fatty acid produced in the rumen, played a crucial role in ruminant body weight gain by contributing to energy metabolism. The liver efficiently removed C_3 from portal blood. Within the liver, C_3 served as a major substrate for gluconeogenesis – a critical process for ruminants due to limited glucose absorption in the small intestine. The C_3 molecule after conversion into glucose via gluconeogenesis can provide a source of energy for growth and maintenance for tissues and thus contribute 24 to 61% of the total energy needs in ruminants. Additionally, when glucose was abundant, it could be transformed into fatty acids and stored as fat, indirectly supporting fat deposition.

Conclusion

Based on the results of the meta-analysis, the utilisation of different forms of garlic as ruminant feed additives positively affects *in vitro* rumen fermentability and rumen microbial population. Garlic supplementation leads to a reduction in CH_4 gas production, C_2 percentage, C_2/C_3 and total protozoa, while increasing the percentage of C_3, C_4, C_5, IsoC_4 and total bacteria in the rumen. The addition of garlic in feeds increases DMI and CPI and improves ruminant performance. Furthermore, garlic oil, garlic powder and garlic bulb all suppress CH_4 production, whereas garlic powder and garlic bulb enhance the C_3 percentage.

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Prevalence and characterisation of *Salmonella* species on US swine sites as part of the NAHMS 2021 swine enteric study

By Stephanie C Hempstead, Catherine A Gensler, Charles A Haley, Alyson M Wiedenheft, James B Robertson, Paula J Fedorka-Cray, and Megan E Jacob

Salmonellosis is known to cause gastroenteritis, sepsis, and death in many animal species, including swine (Quinn *et al*., 2011; Stevens *et al*., 2009). In pigs, like other hosts, *Salmonella* can be carried asymptomatically and be nonpathogenic. The strain or serovar, and host and environmental factors determine whether *Salmonella* is a cause of production-limiting diseases (Quinn *et al*., 2011).

Salmonella enterica serotypes Chloleraesuis and Typhimurium have historically been considered host-adapted and associated with severe intestinal salmonellosis in swine. While many other serotypes are frequently isolated, most are associated with less severe disease or asymptomatic carriage (Burrough, 2022). Of those *Salmonella* serotypes which are carried by pigs asymptomatically, several are of public health importance, causing illness in humans (Tassinari *et al*., 2019).

Broadly, an increasingly important aspect of managing bacterial disease in both animal and human health is antimicrobial resistance (AMR). Infections caused by AMR bacteria have been associated with increased morbidity and mortality (AVMA, 2022; Murray *et al*., 2022). Because antimicrobials have been used in agricultural settings, including metaphylactically in the swine industry for many years, AMR occurrence in these populations has been well studied.

Antimicrobials are particularly beneficial in younger pigs, especially at the nursing stage (Bosman *et al*., 2022), and the continued availability of these important management tools is important for swine health and production. As public perception of AMR and demand for antibiotic-free (ABF) and organic products have increased, pork producers have limited the use of antimicrobials, and the impact on the occurrence of bacterial disease and AMR in that setting is still being studied.

Adaptive features of bacteria

Bacteria readily acquire new traits, including antibiotic resistance genes, through horizontal gene transfer; this acquisition is commonly through the transfer of conjugative plasmids (Doublet *et al*., 2005). Plasmids are associated with the carriage of genes that can provide additional advantages to the bacteria, including antimicrobial resistance and virulence in *Salmonella* (Lavigne and Blanc-Potard, 2008; Lindsey *et al*., 2009; Carattoli, 2013; Glenn *et al*., 2013).

Plasmids are typed based on their inability to be maintained together within the same cell line, which are defined by the incompatibility of replication mechanisms or replicons (Novick *et al*., 1976); this typing helps predict susceptibility and virulence properties and study evolutionary trends. Plasmids with the IncA/C replicon have previously been associated with MDR in *S. enterica* serotypes from animals, retail meat, and humans (Glenn *et al*., 2013). Plasmid replicons associated with MDR in *Salmonella* from other sources include B/O, HI1, HI2, I1, N, F, and P, many of which reportedly co-occur in some MDR *Salmonella* (Poole *et al*., 2009).

Another adaptive feature of bacteria, including *Salmonella*, is the ability to produce biofilms. Biofilms have been described on a variety of abiotic surfaces in agricultural settings, including on surfaces at operations and meat production facilities (Steenackers *et al*., 2012; Barilli *et al*., 2018). Biofilm formation is a useful adaptation mechanism for bacterial survival in harsh conditions, such as UV light exposure, pH changes, host immune responses, and antimicrobial agents (Hall-Stoodley *et al*., 2004; Smirnova *et al*., 2010).

The role of biofilm in *Salmonella* persistence and AMR characteristics is not well known; however, in *Escherichia coli*, biofilm and antimicrobial resistance have been reported as an inverse relationship. National programmes have aided pork producers in efforts to control *Salmonella* through clean feed, biosecurity, judicious antimicrobial usage, and disinfection protocols between production cycles (Andres and Davies, 2015; Martelli *et al*., 2017). While many cleaning and disinfection practices are effective in reducing contamination, *Salmonella* can persist in pens, feeders, water sources, and floors (Andres and Davies, 2015).

The association between biofilm occurrence, serotype, and antimicrobial resistance characteristics of *Salmonella* has not been described in a swine production setting. Periodic sampling for *Salmonella* at the farm level identifies the potential for animal and public health risks and allows the industry to understand the impact of various production changes. Therefore, the objectives of this study were to determine *Salmonella* prevalence, serotype distribution, and assess antimicrobial resistance and biofilm characteristics of

Table 1: Demographic data and *Salmonella* outcomes for the NAHMS swine 2021 study.

	Number of *Salmonella* positive samples			Number of *Salmonella* positive sites[A]		
	Total	%[B]	Fishers exact test p value	Total	%[B]	Fishers exact test p value
Total	41/1 043	3,93	–	13/39	33,3	
Region[C]			0,0131			0,2951
Upper central	33/643	5,13		10/24	41,67	
Other	8/400	2,00		3/15	20	
Site size (head)			0,0674			0,6211
1 000 - 1 999	9/297	3,03		4/11	36,36	
2 000 – 4 999	6/268	2,24		2/10	20,00	
5 000+	26/478	5,44		7/18	38,89	
Facility type[D,E]			0,5055			0,7281
Total confinement	29/666	4,35		9/24	37,50	
Open building	12/362	3,31		4/14	28,57	
Gender[E]			0,6458			
Gilts	1/30	3,33				
Barrows	1/15	6,67				
Mixed	39/983	3,97				
Evidence of diarrhoea in pen[E]			0,2520			
Yes	0/45	0,00				
No	38/883	4,30				

[A]Gender and evidence of diarrhoea were identified at a sample level, not site level. [B]Percentage of total or subset. [C]Upper central: Iowa, Michigan, Minnesota, Nebraska, and South Dakota; Other: Illinois, Indiana, Ohio, Pennsylvania, Kansas, Missouri, North Carolina, and Oklahoma. There was no biologic collection participation in Michigan, South Dakota, Kansas, North Carolina, or Oklahoma. [D]Total confinement means solid exterior wall and often mechanical ventilation. An open building generally has open sides or the potential for sides to be opened weather permitting. [E]Variable sample numbers that do not equal the total sample number are due to missing fields on the collection form.

Table 2: The prevalence of *Salmonella* by associated questionnaire data on *Salmonella* vaccine status or sites disclosing prior *Salmonella* presence in the six months prior to study sampling (December 2020 through May 2021).

No of sites included in sampling			No of positive *Salmonella* samples		
Total	Total	%[A]	Total	%[A]	Fishers
	39		13		
Declaring *Salmonella* present					
Breeding females	1/9	11,11	0/1	0,0	1,0
Prewean pigs	0/9	0,00	–	–	–
Nursery aged	1/26	3,85	0/1	0,0	1,0
Grower/finisher aged	5/38	13,16	3/5	60,00	0,419
Declaring *Salmonella* vaccine use					
Breeding females	1/9	11,11	1/1	100,00	0,333
Nursery aged	3/26	12,28	1/3	33,33	0,600
Grower/finisher aged	4,38	10,53	2/4	50,00	0,738

[A]Percentage of subset.

Salmonella isolated from swine faeces in the United States (US) at a national level.

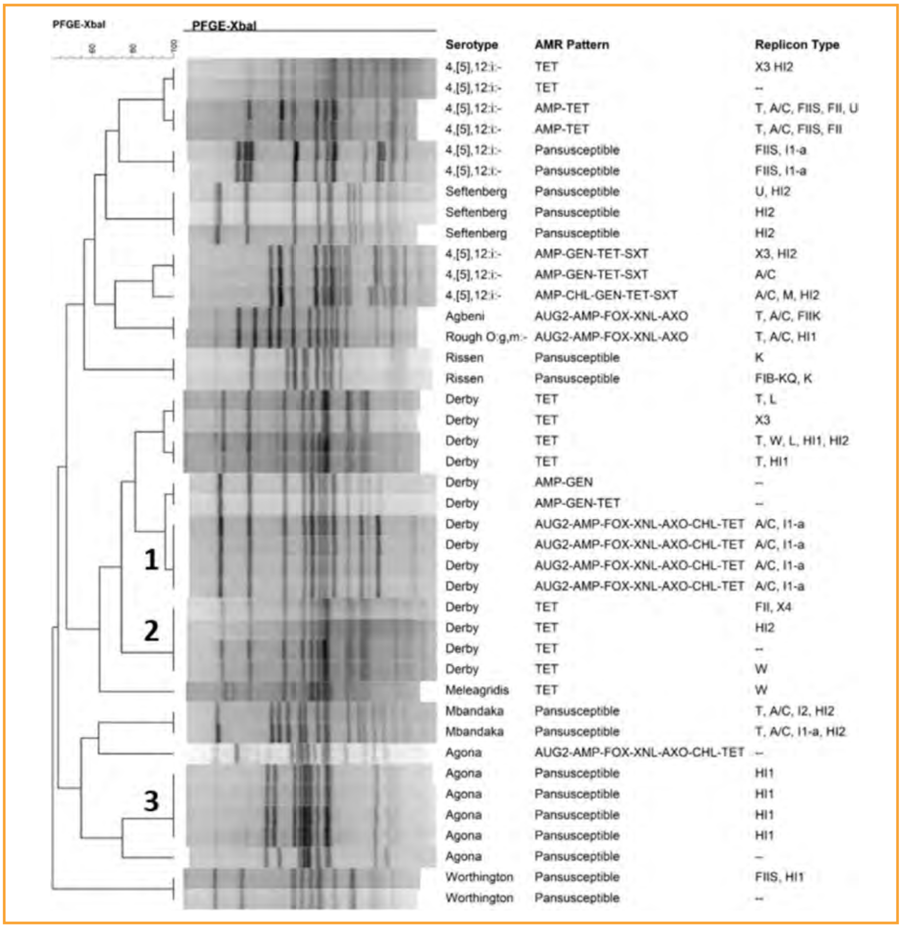
Prevalence of *Salmonella*

Thirty-nine swine sites across the US had a maximum of 30 faecal samples taken from up to six pens for a total of 1 043 samples as part of the NAHMS 2021 Swine enteric study (*Table 1*). The overall prevalence of *Salmonella* isolated was 3,9% (41 of 1,043). At least one *Salmonella*-positive faecal sample was found on 33,3% (13 of 39) of sites tested, with prevalence ranging from 3,3% to 23,3% (mean of 12,19%) on each positive site. One operation, consisting of two sites, had 13 (31,7%) of the total *Salmonella* isolates. Serotypes that were identified from the study include Agbeni (2,4%, 1 of 41), Agona (14,6%, 6 of 41), Derby (34,1%, 14 of 41), Meleagridis (2,4%, 1 of 41), Mbandaka (4,9%, 2 of 41), Rissen (4,9%, 2 of 41), Rough O:g,m:- (2,4%, 1 of 41), Senftenberg (7,3%, 3 of 41), Worthington (4,9%, 2 of 41), and 4,[5], 12:i:- (22%, 9 of 41).

While three serotypes were represented by only one isolate each, serotype Derby was identified in 14 samples from four separate sites; serotype 4,[5],12:i:- was found in nine samples from four sites, and serotype Agona in six samples from three sites. Serotypes Mandak, Rissen, Senftenberg, and Worthington were only found on one site each. Select characteristics of sampled sites, including demographics, region, site size, facility type, and the evidence of diarrhoea in the pen from which the sample was obtained, are broken out at the sample and site levels and shown in *Table 1*. Of these, only the region of collection showed a statistical difference.

Questionnaire data collected from farms were available to make associations with *Salmonella* outcomes, although few were evaluated with such low prevalence. *Table 2* shows the number of sites, by pig type (breeding, nursery, grower/finisher) that reported *Salmonella* on their site in the previous six months (December 2020 through May 2021). Seven of 39 sites (17,9%) reported previous *Salmonella* presence. Of these, three (42,9%) tested positive, all from grower/finisher sites. Eight of 39 sites (20,5%) reported using a *Salmonella* vaccine in the previous six months; four of these sites (50%) were positive for *Salmonella* (one in breeding females, one in nursery, and two

Figure 1: Dendrogram demonstrating the genetic diversity, serotype, antimicrobial susceptibility, and detected replicons among *Salmonella* isolates from US swine faeces. Three clusters of significant similarity are indicated: Cluster 1 includes 4 S. Derby fingerprints, Clusters 2 and 3 each include 4 S. Derby fingerprints.



in grower/finisher). None of these associations were statistically significant.

Resistance to any antimicrobial was observed in 61% of samples; 390% were pan-susceptible. The most common resistance across all serotypes (*Table 2*) was towards tetracycline (53,7%, 22 of 41). No isolates demonstrated resistance to azithromycin, ciprofloxacin, nalidixic acid, or sulfisoxazole. Additionally, 26,8% (11 of 41) of all isolates demonstrated a pattern of multidrug resistance (MDR; ≥3 antimicrobial classes). *Table 3* denotes the antimicrobial susceptibility patterns and prevalence by *Salmonella* serotype. The MDR isolates represented five sites and five different serotypes.

As mentioned, over half (53,7%) of *Salmonella* isolates demonstrated phenotypic resistance to tetracycline (*Table 2*). Further genotypic characterisation showed tetracycline resistance genes were more prevalent, however. The *tet*(B) gene was most frequently identified and present in 78% of all *Salmonella* isolates (32 of 41) regardless of phenotypic resistance. This was followed by *tet*(A) in 70,7% of *Salmonella* isolates (29 of 41). The combination of both *tet*(A) and *tet*(B) was observed in 48,8% of isolates (20 of 41); however, 17 of the 20 isolates with this genotype were phenotypically susceptible. In total, 18 of 19 *Salmonella* isolates phenotypically susceptible to tetracycline were positive for tetracycline-associated resistance genes.

Pulsed-field gel electrophoresis (PFGE) fingerprinting of the 41 *Salmonella* isolates revealed 18 unique isolate profiles with 14 clusters (>80% similarity), as shown in *Figure 1*. Serotypes Mbandaka, Senftenberg, Agbeni, Rissen, and Worthington each fall into single clusters and are from single sites, respectively. Major Cluster 1 is composed of four Derby isolates, each from the same site, and demonstrating the same antimicrobial resistance profile. Major Cluster 2 also includes four Derby isolates, all from the same site and with phenotypic tetracycline resistance. Major Cluster 3 is made up of four Agona isolates from the same site, while the two remaining Agona show differing fingerprints and are from different sites, both from one another and the primary cluster.

Table 3: The distribution of antimicrobial susceptibility patterns by *Salmonella* serotype.

Susceptibility profile and *Salmonella* serotype	Number of isolates	Percent of isolates	Count
Pan susceptible	16	39	
4,[5],12:i:-			2
Agona			5
Mbandaka			2
Rissen			2
Senftenberg			3
Worthington			2
TET	11	26,8	
4,[5],12:i:-			2
Derby			8
Meleagridis			1
AMP-TET	2	4,8	
4,[5],12:i:-			2
AMP-GEN	1	2,4	
Derby			1
AMP-GEN-TET	1	2,4	
Derby			1
AMP-GEN-TET-SXT	1	2,4	
4,[5],12:i:-			2
AMP-CHL-GEN-TET-SXT	1	2,4	
4,[5],12:i:-			1
AUG2-AMP-FOX-XNL-AXO	2	4,8	
Agbeni			1
Rough 0:g,m:-			1
AUG2-AMP-FOX-XNL-AXO-CHL-TET	5	12,2	
Agona			1
Derby			4

Prevalent replicons and isolates

A PCR-based replicon typing commercial assay was used for detecting 30 different plasmid incompatibility (Inc) types on all isolates. In total, 73 plasmid replicons were detected, with a range of zero to six detected per isolate. The mean replicons were 1,8 per *Salmonella* isolate, and the median was 1. The most prevalent replicons observed were H12 and A/C (24,4%, 10 of 41 each), though they only co-occur in three isolates. The isolates containing both H12 and A/C replicon types were *Salmonella* Mbandaka (two isolates) and a single *Salmonella* 4,[5],12:i:-. No replicons of types I1-ɣ, X1, R, HIB-M, X2, N, N2, FIA, FIB, P, FIB-M, or B/O were detected.

The four Agona isolates in major Cluster 3 of the PFGE fingerprint each contain a single replicon: HI1, and two *Salmonella* 4,[5],12:i:- isolates from the same site had identical replicon patterns of FIIS-I1-α. All four *Salmonella* Derby isolates from major Cluster 1 have identical replicon types of A/C-I1α and identical AMR patterns AUG2-AMP-FOX-XNL-AXO-CHL-TET, while the remaining two Derby isolates from that site with a resistance pattern of AMP-GEN and AMP-GEN-TET contained no replicons. The distribution of all replicon types can be seen in *Figure 1*.

Finally, the potential for *Salmonella* to form biofilm (as measured by biomass) under laboratory conditions was observed in 85,4% of isolates (35 of 41). Based on the categorisation of biofilm formation as weak, moderate, and strong using a normal distribution and positive control strain, only 11,4% (4 of 35) were found to be strong biofilm formers. Far more biofilm-positive isolates formed a moderate 45,7% (16 of 35) or weak 42,9% (15 of 35) biofilm.

Conclusions

The enteric biologic component of the 2021 Swine NAHMS study estimated the prevalence of important swine health pathogens and antimicrobial resistance in the US to inform the swine industry; this includes *Salmonella*. In this study, 33,3% of sites sampled had at least one *Salmonella*-positive faecal sample. This is similar to the site prevalence in the 2000 NAHMS swine study (35%); both the 2006 and 2012 NAHMS swine studies reported higher estimates (52,6 and 50,4%, respectively) (USDA-APHIS, 2009). The number of operations participating in both the 2006 and 2012 studies was higher (135 and 117, respectively) than the 39 participating in the 2021 study.

Compared to previous NAHMS studies, which have shown a higher prevalence of *Salmonella* detected in swine, both at the farm and animal level, this study reports a lower rate of *Salmonella* detected in US swine populations. In addition, we showed a reduced prevalence or resistance and replicon frequency compared to similar studies or from other surveillance programs.

The reduced prevalence could be an artifact of the small sample size; small samples have insufficient power to detect changes representative of behaviour happening in the national population. The lower rate may also indicate the cumulative impact of efforts by production manager, veterinarians, public officials, and site operators to decrease antibiotic use, increase vaccination rate, and the increasing implementation of all-in-all-out production systems (Bearson, 2022).

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Factors affecting bone health in laying hens

By Jorja Ashford

Leg bone health in laying hens has recently come under the spotlight, driven by the alarming statistic that 30% of caged laying hens experience bone fractures at some point during their production cycle (Farm Animal Welfare Council, 2010).

One of the contributing factors predisposing laying hens to bone health issues is the dual-purpose nature of bones. Bones provide structural support for mechanical loading, while also acting as an auxiliary calcium (Ca) reservoir for eggshell production. Bones are a living tissue and their weight changes throughout the hen's lifetime due to the highly regulated action of the structural units, osteoclasts, and osteoblasts.

These structural units balance the formation and resorption of medullary bone, allowing for the alteration of bone mass in times of high Ca demand, such as during eggshell formation. The high rate of Ca deposition required for eggshell formation places significant stress on the skeletal system, potentially leading to conditions such as osteoporosis and bone fractures.

This review aims to evaluate bone health in layers, and the factors influencing it, including nutrition, genetics, management practices, and housing systems as a tool to reduce future incidence.

Bone dynamics

Laying hens have three types of bone structure, namely cortical, trabecular, and medullary bone (Wang *et al*., 2022). Medullary bone serves as an auxiliary Ca reservoir for eggshell formation (Yamada *et al*., 2021), while cortical and trabecular bones provide structural support.

After the onset of sexual maturity, when there is an increase in circulating oestrogen, there is a change in the function of osteoblasts – from forming cortical bone to producing medullary bone through osteoclastic resorption (Jung *et al*., 2019). During the early laying period, there is a loss of trabecular bone due to this medullary formation. Once the laying period commences, the medullary bone is used to resorb Ca to be utilised for eggshell formation.

During periods of high Ca demand, usually at night during eggshell formation, the supply of Ca from the digestive tract is low. Thus, there will be a surge of osteoclastic resorption, and the medullary bone is utilised to meet this Ca demand. Once the egg is laid, there will be a corresponding surge of osteoblastic formation where the medullary bone that was lost is regenerated via Ca in the diet (Eriksen, 2010).

The interplay between these bone types and tightly coupled opposing processes determines overall skeletal health (Whitehead, 2004a). When there is a shift in bone remodelling, the bones become brittle and weak, resulting in bone disorders such as osteoporosis (Yamada *et al*., 2021).

If, at any point, the hen runs out of Ca reserves in the medullary bone, the deficiency will lead to skeletal disorders such as osteoporosis. Osteoporosis means 'porous bone' and occurs when there is

Table 1: Methods of evaluating bone health in laying hens.

Method	Mechanism
Bone ashing	This method allows for the burning off of all organic material in order to evaluate the total mineral content of a given known dry weight of the bone. This gives a measure of bone mineral content (BMC), which has an advantage over the other techniques due to the inclusion of soft tissue, which would account for the medullary bone volumes as well as the cortical bone (Kim *et al*., 2012; Robison and Karcher, 2019).
Desitometric techniques	Techniques such as dual-energy X-ray absorptiometry (DEXA) and peripheral quantitative compound tomography (CT) are commonly used in assessing BMC as well as bone mineral density (BMD) (Kim *et al*., 2012). DEXA and micro-CT are, however, not widely available and are expensive. This has led to their limited use in laying hens (Chen and Kim, 2020).
Mechanical testing of bone	These techniques provide information on BMC and BMD with its key focus on bone strength and resistance to fractures. An Instron universal testing machine with a known load is used to measure the breaking strength of the bone. However, this is a destructive test, and so caution should be exercised to collect all the fragments of the bone if ashing is going to be performed following this test (Harash *et al*., 2020).
Histomorphometry	Visualising the microarchitecture of the bone allows a closer look at growth and bone development, together with bone mineralisation and use of the medullary bone throughout the production cycle. This method is one of the only methods in which the rate of bone formation can be evaluated (Kim *et al*., 2012).

a net resorption of structural bone. It is characterised by a progressive loss of structural bone mass, resulting in increased fragility and susceptibility to fractures. This is highly prevalent in modern high-yielding layers due to the continuous Ca mobilisation required for egg production (Whitehead, 2004b).

Along with this, the modern layer has been genetically selected to increase egg production per hen lifetime due to high population demand. The current commercial standard is being extended to 100 weeks, with an expected lifetime production of 500 eggs (Sinclair-Black *et al*., 2023). These high production demands increase Ca utilisation, affecting the structural integrity and leading to a higher prevalence of skeletal disorders.

This further highlights the need to have an in-depth understanding of the factors affecting bone health. However, there is also a need to understand how to measure bone health (*Table 1*).

Hormone regulation

Bone health is a multifaceted problem with many contributing factors such as hormonal regulation, which plays a vital role in maintaining the balance between bone formation and resorption. Oestrogen has been identified as a critical hormone in preserving bone density by inhibiting osteoclast activity and promoting osteoblast function (Yamada *et al*., 2021).

During the laying cycle, fluctuating oestrogen levels influence Ca mobilisation and bone turnover. In addition, research has highlighted the potential use of calcitonin, a hormone that suppresses osteoclast-mediated bone resorption, as a therapeutic agent to counteract osteoporosis (Regmi *et al*., 2016). Similarly, analogues of parathyroid hormone have been used to stimulate bone formation and enhance Ca retention. These hormonal interventions, combined with precise dietary adjustments, could offer comprehensive solutions for improving skeletal health in laying hens.

Nutritional factors

Bone health deteriorates with age as structural bone mass is progressively replaced by medullary bone. Peak egg production phases further exacerbate Ca depletion, highlighting the need for targeted nutritional strategies during these periods (Alfonso-Carrillo *et al*., 2021).

The minerals Ca and phosphorus (P) are fundamental to bone mineralisation and hence, egg production. Due to the medullary bone being a Ca reserve for the hen to use during eggshell formation, each bird requires 2,3g of Ca per day for egg production (Farm Animal Welfare Council, 2010). An egg contains approximately 10% eggshell by weight, meaning there is approximately 6g of shell per 60g egg (Bello and Korver, 2019). The main source of Ca is supplemented in the form of limestone in plant-based layer diets (Hervo *et al*., 2023); however, there is great variation in the Ca content due to the chemical and physical characteristics of limestone.

Dietary P, in the form of phytic acid, is known to be poorly available to poultry. This is due to the complex interaction between phytic acid and multivalent cations in the diet. Ca is the dominant chelator due to its abundance in the diet, forming insoluble complexes, and reducing the availability of Ca, P, and various other nutrients. Supplementing diets with phytase is common practice in broilers and is becoming more common in laying hen diets.

Phytase enhances the availability of phytate-bound minerals, improving the utilisation of Ca while also improving egg production (An *et al*., 2016). Along with this, phosphates are supplemented, mainly in the form of MCP and MDCP, in the diet to meet the daily requirements (Hervo *et al*., 2023). Phytase alone will not reach the birds' requirements and results in the supplementation of inorganic P to meet the requirements.

The balance between Ca and P is critical for optimising skeletal structure and integrity. When supplementing P, one should be cautious to not overfeed, as this will lead to a higher prevalence of cracked eggs. Similarly, the supplementation of excess Ca will cause an increase in Ca excretion, leading to the production of more dirty eggs. Excess Ca reduces the absorption of P through the production of insoluble complexes (Ribeiro *et al*., 2016). Furthermore, the use of phytase plays a critical role in meeting these requirements using lower levels of Ca and P in the diet, while maintaining skeletal structure.

Vitamin D also plays a pivotal role in Ca and P metabolism by regulating their absorption in the intestine and mobilisation in the bones. Studies have shown that dietary supplementation with partially active forms of vitamin D improves bone quality and eggshell strength compared to traditional vitamin D3 (Sinclair-Black *et al*,. 2023; Świątkiewicz *et al*., 2015).

Housing systems

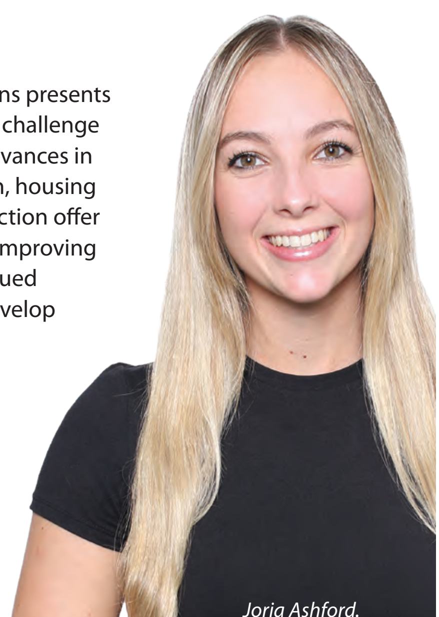
Heavily driven by public perception and large supermarket monopolies, welfare is a major concern for the poultry industry. Therefore, there are now both caged and free-range systems that provide the consumer with a clear ability to choose how they want their eggs produced.

This, however, has provided a challenge for the industry, as conventional cages restrict movement, leading to reduced bone strength. Movement and mechanical stress stimulate bone remodelling by activating osteoblasts, forming new bone tissue (Silversides *et al*., 2012; Rodriguez-Navarro *et al*., 2018).

In contrast, enriched cages with perches allow for greater physical activity, promoting better bone density and reducing fracture rates (Lay *et al*., 2011). The provision of perches encourages natural behaviour such as roosting and jumping, enhancing bone strength. However, poorly designed perches can cause keel bone deformities, emphasising the need for ergonomic designs (Heerkens *et al*., 2015)

Conclusion

Bone health in laying hens presents a complex, multifaceted challenge to poultry producers. Advances in dietary supplementation, housing design, and genetic selection offer promising solutions for improving skeletal integrity. Continued research is needed to develop holistic strategies that enhance bone health while maintaining high production efficiency along with finding methods for evaluating bone health in laying hens.



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Chemistry Analysis: "Guaranteed Analysis"	Microbiology Analysis:
- Crude protein - Moisture - Ash - Crude Fat and Fibre - Minerals (Sodium, Phosphorus, Calcium) - Aflatoxin Total (B1, B2, G1, G2) - Zearalenone - DON (Deoxynivalenol)	- Total Plate Count - E.coli - Coliforms - Staphylococcus aureus - Salmonella spp. - Yeast and Mould - Listeria monocytogenes - Enterobacteriaceae - E.coli O157 - Bacillus cereus - Clostridium perfringens - Campylobacter spp.

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AFMA INTERVARSITY WRITER'S CUP 2025: WINNER ROUND 2 / OWN RESEARCH

Supplementing pasture-based dairy cows with *Aspergillus oryzae* fermentation product

By C Basson, L Steyn, and R Meeske

In many countries, the sub-therapeutic use of antibiotics or ionophores in livestock production systems is prohibited due to health concerns associated with these products. This created a demand for non-antibiotic alternatives to increase feed efficiency in livestock production (Sallam *et al*., 2020).

Direct-fed microbial feed additives are commonly used in dairy farming to increase nutrient intake and utilisation, boost production efficiency, and reduce the risk of metabolic disorders (Vieco-Saiz *et al*., 2019). These additives are particularly beneficial during periods of physiological stress (El Jeni *et al*., 2024). The mechanism by which these feed additives exert their effects, differ.

Aspergillus oryzae fermentation product (AOFP; Amaferm – BioZyme Inc., St. Joseph, MO, US) is a feed additive derived from a dried fermentation extract of the fungus *Aspergillus oryzae* NRRL458. It contains metabolites and fibrolytic enzymes produced by the fungus (Zhang *et al*., 2022).

Previous research reported that AOFP supplementation stabilises rumen pH by enhancing lactate uptake (Bercovitz *et al*., 1990; Nisbet and Martin, 1990; Sallam *et al*., 2020), boosts rumen microbial activity (Sallam *et al*., 2020), increases fibre degradability (Schmidt *et al*., 2004; Wubah, 2004), and increases dry matter intake or DMI (Cantet *et al*., 2019). These effects collectively increase the energy available for milk and milk fat synthesis in cows. *Figure 1* provides a summary of the mode of action of AOFP, as reported in previous studies.

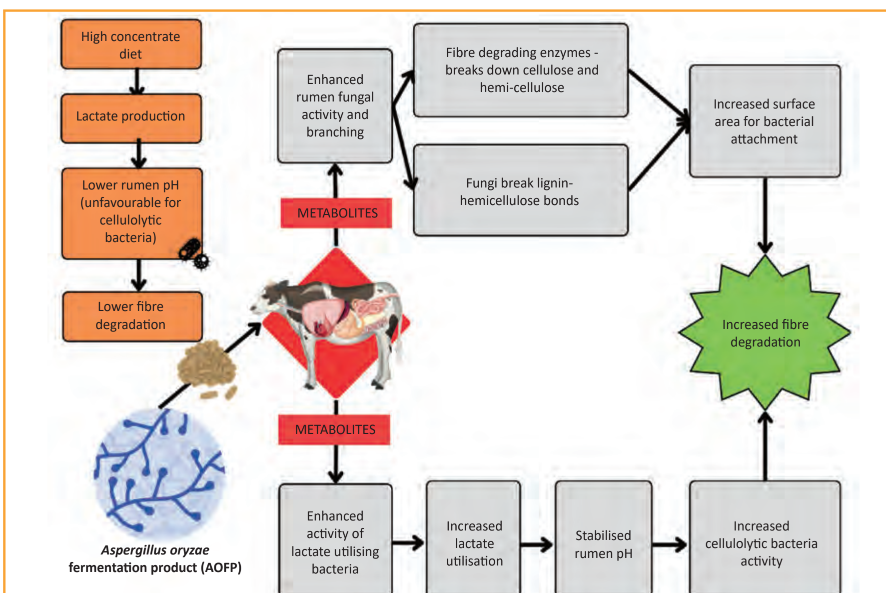
Most research on AOFP has been completed on total mixed ration (TMR) systems, while research in pasture-based systems is lacking. Therefore, the aim of this study was to determine the impact of AOFP supplementation on milk composition, milk production, rumen environment, and fibre degradability in Jersey cows grazing perennial ryegrass (*Lolium perenne*) pasture.

Materials and methods

The study was conducted at Outeniqua Research farm in George, South Africa, during spring 2023. The study comprised of a production and a rumen study.

Cows used in the study were selected from a group of 54 lactating cows, based on various parameters including milk production, milk composition (milk fat,

Figure 1: The mode of action of *Aspergillus oryzae* fermentation product (Orpin, 1977; Bercovitz *et al*., 1990; Martin and Nisbet, 1990; Kellems *et al*., 1990; Borneman *et al*., 1992; Varel *et al*., 1993; Doyle *et al*., 2005; Sallam *et al*., 2020).



protein, lactose, and SCC), lactation number, and days in milk. Data on these parameters were collected during a two-week pre-study period. Using this data and the data on previous lactations, 34 early- to mid-lactation cows were selected (17 cows/treatment), blocked according to milk production, days in milk (DIM), and lactation number. Cows were then randomly allocated to one of two treatments for the production study.

Treatments were as follows:

- **Control:** Cows received 6kg per cow per day (as fed) of a pelleted dairy concentrate (159,6g/kg DM CP and 12,3MJ ME/kg DM).
- **AOFP treatment:** Cows received 6kg per cow per day (as fed) of the same dairy concentrate with AOFP mixed in at 0,5g/kg (3g/cow/day; as fed).

Cows underwent a three-week adaptation period, followed by a six-week measuring period. Cows strip-grazed ryegrass pasture and were milked twice daily, with fresh pasture allocated after each milking. Concentrates were fed in the milking parlour during milking (3kg per session).

Production study

Daily milk production was recorded using an Afimilk system. Weekly milk samples were collected to determine the fat, protein, and lactose content of the milk. Dry matter intake (DMI) was estimated using the TiO_2 method, with TiO_2 as an external marker and indigestible neutral detergent fibre (NDF) as an internal marker. Total faeces excreted and DMI was determined using the calculations in De Souza *et al*. (2015).

Rumen study

Six rumen-cannulated cows were used in a crossover design with two treatments and two periods. A 21-day adaptation period separated each seven-day measuring period. The data collected for the rumen study included rumen pH, extent, and rate of DM and NDF disappearance, and rumen volatile fatty acid (VFA) and rumen ammonia nitrogen (NH_3-N) concentrations.

Rumen pH was measured using a TruTrack pH data logger fitted in a radiator hose, attached to a cannula plug. An *in sacco* study was performed according to the methods described in Cruywagen (2006), to estimate the rate and extent of DM and NDF disappearance of ryegrass pasture after six, 18, and 30 hours of incubation. Rumen fluid samples were collected using a modified pump to analyse rumen VFA- and NH_3-N concentrations.

Table 1: Production (n = 17) and rumen (n = 6) study data of Jersey cows grazing ryegrass pasture during spring with or without supplementation of AOFP.

Parameter[1]	Treatment[2]		SEM[3]	P-value[4]
	Control	AOFP		
Production study				
Milk yield (kg/cow/day)	20,9	20,4	0,403	0,41
Milk fat (g/kg)	50,6	52,9	0,097	0,10
Milk protein (g/kg)	40,3	40,4	0,042	0,85
Milk lactose (g/kg)	47,8	48,0	0,036	0,74
MUN (mg/dℓ)	6,93	6,75	0,265	0,64
SCC (x 1 000/mℓ)	116	105	32,65	0,81
Daily pasture DMI (kg/cow)	7,42	8,78	0,642	0,17
Daily total DMI (kg/cow)	12,9	14,2	0,642	0,17
Rumen study				
Average logger pH (24 hours)	6,18	6,10	0,222	0,05
Total VFA (mmol/ℓ)	111,21	111,32	3,721	0,98
Acetate: propionate	4,45	4,24	0,077	0,12
NH_3-N (mg/dℓ)	11,4	9,94	0,631	0,18
DMd (g/kg DM)				
6h	479	481	10,6	0,91
18h	665	668	16,3	0,90
30h	815	814	5,10	0,85
NDFd (g/kg NDF)				
6h	231	242	17,1	0,62
18h	482	493	23,0	0,77
30h	708	705	9,10	0,82
NDF kd[2] (%/h)	4,36	4,39	0,148	0,88

[1]MUN – milk urea nitrogen; SCC – somatic cell count; DMI – dry matter intake; VFA – volatile fatty acids; NH^3-N – ammonia nitrogen; DMd – dry matter disappearance; NDFd – neutral detergent fibre disappearance. [2]Control – 6kg/day (as fed) standard dairy concentrate; AOFP – 6kg/day (as fed) standard dairy concentrate + 0,5g/kg (as fed) AOFP. [3]SEM – standard error of the mean. [4]P-value – P ≤ 0,05 = significant difference; P > 0,05 = not significant difference; 0,05 < P ≤ 0,10 would indicate a trend towards significance.

Results and discussion

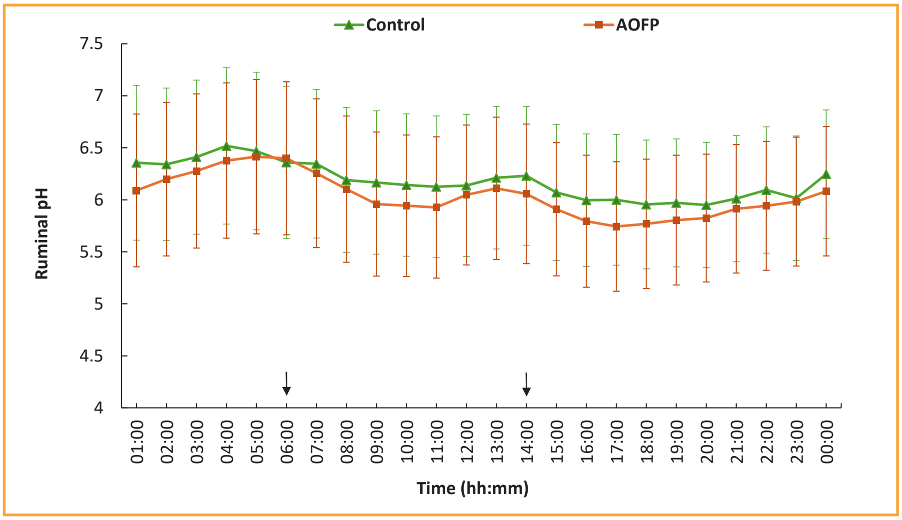
Supplementing cows with AOFP did not significantly (P > 0,05) affect milk production and composition (*Table 1*). Milk fat content tended (P = 0,10) to be higher for cows on the AOFP treatment with a 2,3g/kg difference. Similar to our findings, some studies reported higher milk fat content when AOFP was supplemented (Bach, 2003; Baumgard, 2004), while others reported no effect (Higginbotham *et al*., 2004; Sun *et al*., 2013; Zhang *et al*., 2022).

Cows supplemented with AOFP did not exhibit a higher pasture or total DMI. The *in sacco* DMd and NDFd of ryegrass after 30h rumen incubation were also unaffected by AOFP supplementation.

Diurnal rumen pH patterns are depicted in *Figure 2*. The black arrows on the figure indicate the times that cows were in the milking parlour, consuming concentrate. The figure shows a distinct decline in rumen pH following concentrate consumption. Rumen pH reaches its lowest point in the afternoon post-milking, and recovered after 20:00, consistent across both treatment groups.

While the average rumen pH was slightly lower (P = 0,05) for cows supplemented with AOFP, it remained within the optimal range for rumen function (Bargo *et al*., 2003)

Figure 2: Diurnal fluctuations in ruminal pH of cows (n = 6) grazing ryegrass pasture in spring, with or without AOFP supplementation. Error bars represent the SEM. (Control – 6kg/day [as fed] standard dairy concentrate; AOFP – 6kg/day [as fed] standard dairy concentrate + 0,5g/kg [as fed] AOFP).

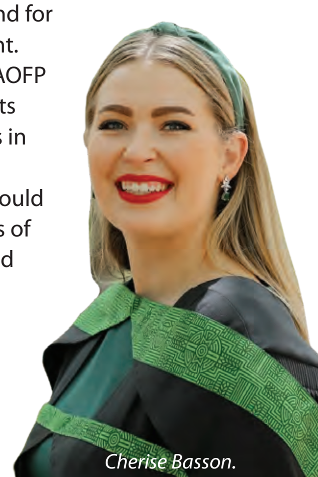


and fibre degradability was not compromised (*Table 1*). Rumen NH_3-N- and VFA concentrations, and acetate to propionate ratio of cows did not differ between treatments (P > 0,50), indicating similar microbial activity and fermentation in the rumen of cows fed the control and AOFP treatments.

Conclusion

Previous studies have demonstrated AOFP's potential to increase fibre degradation *in vitro* and in TMR systems. It may be that AOFP has a more pronounced impact on production and rumen parameters when the animal is under physiological stress. Cows in this study were not under significant physiological stress, which may have reduced the additive's impact. Milk production was unaffected with a trend for higher milk fat content. Supplementation of AOFP also had limited effects on rumen parameters in this study.

Future research should investigate the effects of AOFP in pasture-based dairy systems with different pasture types and qualities, and different levels of concentrate supplementation.



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Legislation governing agricultural remedies: Why are certain products disappearing from the agriculturalist's toolbox?

By Roleen la Grange, regulatory manager, CropLife

Agricultural remedies are regulated under the *Fertilisers, Farm Feeds, Agricultural Remedies and Stock Remedies Act, 1947 (Act 36 of 1947)*, which falls under the mandate of the National Department of Agriculture (formerly known as the Department of Land Reform and Rural Development or DALRRD). These products include not only conventional chemical pesticides, but any product claiming the "destruction, control, repelling, attraction or prevention" of a pest organism.

Therefore, even biological products such as predatory insects, parasitic wasps, plant extracts, entomopathogenic nematodes, bacteria, viruses, or even pheromone-based products that make these claims, must also be registered under the *Act*.

Why regulate agricultural remedies?

When an agricultural remedy is registered under *Act 36 of 1947*, the applicant has to provide a wealth of data to the Registrar of the *Act* in order to prove, among others, that the product is effective for the intended purpose, that it is safe to use on the intended crop, that the residues remaining on the crop at the time of harvest is safe for human or animal consumption, that the product does not cause undue harm to the environment, is within the declared specifications, and remain viable during the shelf life claimed.

Consequently, when an agricultural remedy is registered in South Africa and sold to a farmer, that farmer can rest assured that the remedy was rigorously tested in respect of all these parameters.

Apart from providing the requirements for registration of an agricultural remedy in South Africa, the *Act* and it's supporting regulations also govern other types of products (fertilisers, farm feeds, stock remedies) and services (acquisition, importation, sale and disposal of these products, as well as the registration of pest control operators and sterilising plants).

The most recent regulations published in support of the *Act* were promulgated on 25 August 2023 and is called the "regulations relating to agricultural remedies". As the name suggests, these regulations are specific to the products defined in the *Act* as "agricultural remedies".

As many observant producers would have noticed, these regulations (as well as regulatory changes promulgated by other state departments) have resulted in several recent changes affecting the layout of labels, the requirements for dealing with empty pesticide containers and obsolete stock, and likely the most important change, the availability of products.

The phasing out of HHPs

Highly hazardous pesticides (HHPs) are those that present particularly high levels of acute or chronic hazards to health or the environment. Many countries, including South Africa, are signatories to binding international conventions or agreements that aim to phase out HHPs and replace them with safer, less hazardous alternatives, with South Africa aiming to have all HHPs removed from the local market by 2035.

As part of this process, the regulations relating to agricultural remedies define two new types of products, namely substances of concern and restricted agricultural remedies. These two definitions encompass all products considered to be HHPs.

Substances of concern

These are products that pose chronic hazards to human health, and is predominantly detrimental over long-term exposure, for example substances that have the potential to cause cancer, genetic mutations, or detrimentally affect reproduction or the unborn child. Agricultural remedies meeting such criteria are currently being phased out of the South African market and will no longer be available after June 2025.

Only in exceptional circumstances, where there are no viable alternatives, may the registrar grant an approval of a remedy classified as a substance of concern for a specified period and for restricted uses. This is only possible when certain requirements are met (as stipulated in the regulations), and the registration holder conducts a risk assessment and make the report available for public comment.

The registrar of the *Act* will then review the data and evaluate whether a derogation is justified. Although some of these remedies may remain on the market for now, it is highly likely that these products will be completely removed over the next few years, and finding viable alternatives to replace them must be prioritised.

Some of the remedies affected by this new requirement, and for which registration holders have indicated that they intend to apply for a derogation, include glufosinate ammonium and dimethomorph. Products that will be discontinued include flurochloridone, linuron and thiacloprid.

Restricted agricultural remedies

Restricted agricultural remedies, on the other hand, encompass products that are acutely toxic and may be fatal even after short-term exposure. The regulations relating to agricultural remedies, along with the pest control operator regulations, require that persons buying and using these remedies be sufficiently trained and qualified to do so safely, and thus be registered as PCOs.

To register as a PCO, a person must apply to DALRRD with proof of certain qualifications and practical experience.

Some of the remedies affected by this new requirement include alachlor, cadusafos, carbofuran, chlorothalonil, fenamiphos, methamidophos, methomyl, oxamyl, terbufos and paraquat. In most cases, the classification of a product as a restricted agricultural remedy will depend on the hazard classification of the entire formulation and not just the active ingredient, consequently farmers will have to consult the agricultural remedy label to confirm restrictions.

Change is the only constant

Although change is uncomfortable, these new regulations are necessary to safeguard the health, safety, and environment of all South African citizens, in line with our *Constitution*. The current restrictions on use are measures put in place to extend the availability of these remedies to South African farmers while investigating options for safer, viable alternatives.

On the positive side, the regulations also make provision for the Registrar to prioritise the registration of viable alternatives to replace affected remedies, and to expedite the registration of remedies that are considered low risk. It will be up to all stakeholders in the agricultural sector to adapt and proactively seek alternatives to address these gaps, ensuring a thriving agricultural economy and food security.

For more information, email the author at roleen@croplife.co.za.

Sectoral Determination 13 in a nutshell

By Christiaan Swart, senior legal advisor, LWO Employers Organisation

South Africa's labour legislation is highly regulated, creating a challenging environment for employers. This article provides a summary of the basic rights of employees earning below the earnings threshold, as provided for by the *Basic Conditions of Employment Act, 1997 (Act 75 of 1997)*, or *BCEA*, as amended.

The following are key points to remember:

Normal working hours

No employee may work more than 45 normal hours per week. Furthermore, an employee may not be required to work more than nine normal hours per day for a five-day week, or more than eight normal hours for a six-day or more week.

Overtime

Overtime is limited to ten hours per week, and no more than three hours per day. Payment for overtime is one and a half times the employee's normal hourly rate.

Meal intervals

Employees must be granted a 60-minute meal interval after five consecutive working hours, which can be reduced to 30 minutes by agreement.

Work on a Sunday

If a Sunday is a normal working day, the employee must be paid at one and a half times the normal hourly rate. There must be a written agreement to this effect, usually in the employee's contract. If a Sunday is not a normal working day, and the employee is required to work on a Sunday, the employee must be paid double the normal hourly rate.

Public holidays

If a public holiday falls on a day on which the employee would normally work, an employer must pay:

- Employees who do not work on the public holiday at least their ordinary daily wage.
- Employees who do work on the public holiday, at least double the daily wage or their normal daily wage, plus an hourly rate for the actual hours worked, whichever is the greatest.

If an employee works on a public holiday and he/she normally would not work on this day, the employer must pay him/her an amount equal to his/her daily wage plus hourly wage for each hour worked on the public holiday.

Leave

- An employee is entitled to 21 consecutive days of paid annual leave per cycle, or the parties can agree that annual leave will be calculated at one day's paid leave for every 17 days worked.
- An employee is entitled to six weeks of paid sick leave during each three-year cycle. In the first six months an employee is entitled to one day's paid sick leave for every 26 days worked.
- An employee employed for more than four months, and working at least four days per week is entitled to three days of paid family responsibility leave per year when the employee's child is sick or the employee's spouse, life partner, parents, adoptive parents, grandparents, child, adoptive child, grandchild, or sibling passed away.
- A pregnant employee is entitled to four consecutive months' unpaid maternity leave and can submit a claim to the Unemployment Insurance Fund (UIF).
- *Parental leave*: The employee is entitled to ten consecutive days of unpaid parental leave at the birth of a child and can submit a claim to the UIF. (Note that an employee who is taking maternity leave cannot also take parental leave).
- *Adoption leave*: An employee who adopts a child aged two years or younger is entitled to ten consecutive weeks of unpaid adoption leave and can claim UIF.
- *Commissioning parental leave*: An employee whose child is born through surrogacy is entitled to ten consecutive weeks of unpaid commissioned parental leave and can claim UIF.

Retirement age

Retirement age is not prescribed by law. Employers are encouraged to determine the applicable retirement age and include it in the employment contract or a policy.

The LWO Employers Organisation assists employers to comply with labour law, and to use it to their advantage to protect their business. As a registered employers' organisation with the Department of Employment and Labour, the LWO has the right to represent members at the Commission for Conciliation, Mediation and Arbitration (CCMA). Take note that this article is not legal advice – consult one of our legal advisors about any specific legal problem or matter. For more information, email Christiaan Swart at christiaan@lwo.co.za, info@lwo.co.za, or visit *www.lwo.co.za*.

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