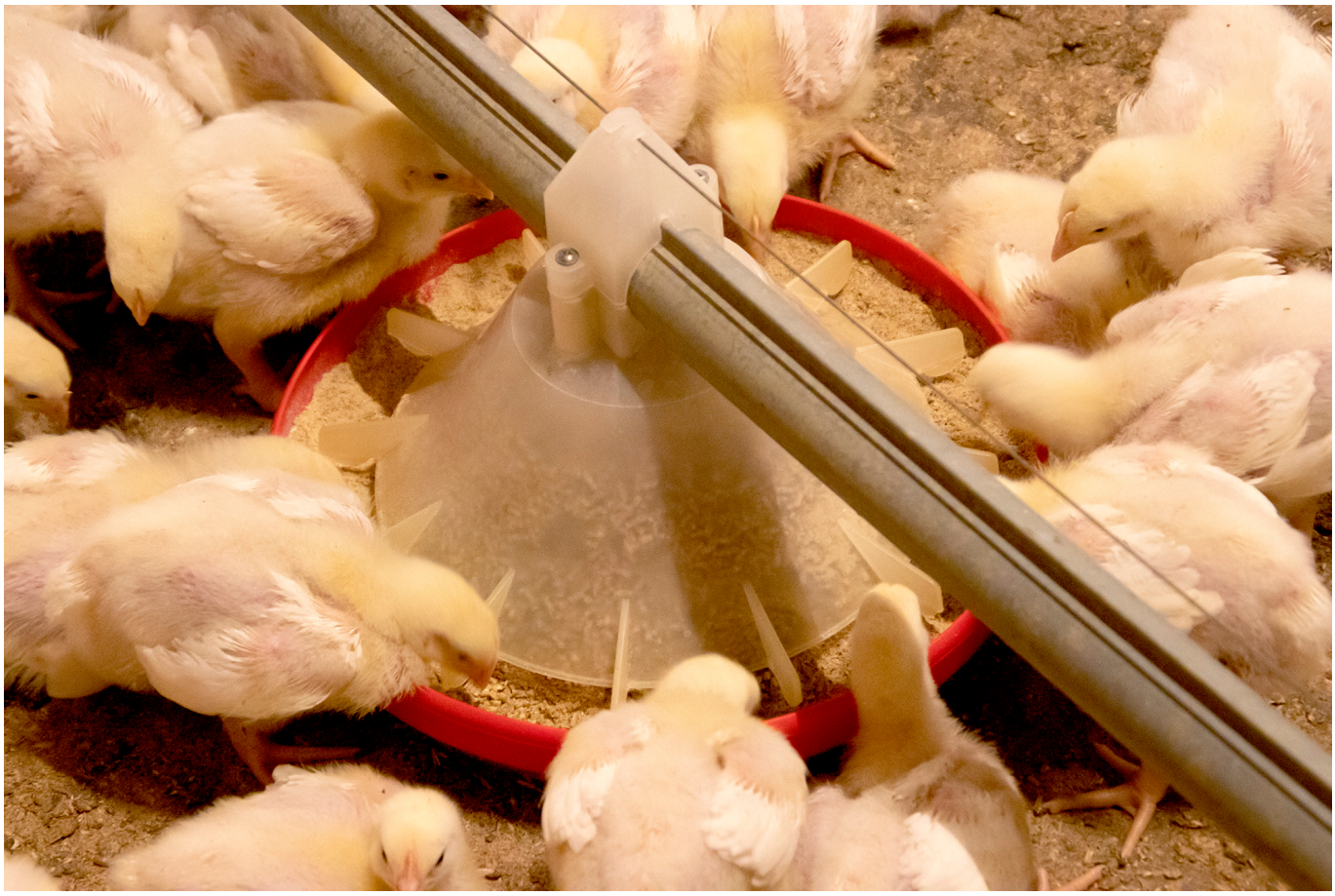
Effects on Performance and Gut Health of Ventar D Supplementation in Broiler Diets



*Summary of study by **Necmettin Ceylan, Sait Koca, Nejla Kahraman**, Ankara University, Faculty of Agriculture, Animal Science, 6110 Ankara/Türkiye*

The study conducted by Dr. Celyn et al. in 2023 focused on the impact of Ventar D supplementation in broiler diets on growth performance and gut health. The trial was carried out over six weeks on Ross 308 broiler chicks, comparing a control group with an experimental group supplemented with Ventar D. The trial feed was based on corn, soybean meal, wheat, sunflower meal, and poultry oil.

Key Findings

Growth Performance: The study demonstrated that Ventar D supplementation significantly improved body weight gain, feed consumption, feed conversion ratio (FCR) and EPEF during the starter, grower, and finisher periods. The overall performance of chickens fed with Ventar D was notably better, showing a 6.5% higher body weight and 1.67% better FCR compared to the control group.

Treatments	BWG, g	FCR	Corrected FCR2565	FI, g	Mortality,%	EPEF	
Control	2520.6^{a}±32,77	1.620^{a}±0.006	1.629^{a}±0.011	4082.2^{a}±46.77	3.25±0.28	367.2^{a}±5.18	

Ventar D	2684.3^{b}±23.65	1.593^{b}±0.010	1.568^{b}±0.015	4273.9^{b}±19.89	2.75±0.53	399.8^{b}±4.35	

Different letters indicate significance; P ≤ 0.05

Liver Enzymes: The addition of Ventar D led to a significant decrease in serum Alanine aminotransferase (ALT) levels

Treatments	ALP	ALT
Control	286.70±54.98	1.505^{a}±0.390
Ventar D	301.50±87.19	0.832^{b}±0.181

Different letters indicate significance; P ≤ 0.05

Gut Health: Ventar D supplementation resulted in higher concentrations of short-chain volatile fatty acids (SCVFA) in the cecum.

	Acetate	Propionate	Butyrate	Isobutyrate	Valerate	Isovalerate	BCFA	Total SCFA
Control	27.22^{a}±1.26	8.21±0.38	7.24^{a}±0.41	0.848±0.078	0.964±0.043	0.881±0.054	2.69^{a}±0.12	45.36^{a}±1.53
Ventar D	30.51^{b}±0.80	9.36±0.56	8.86^{b}±0.44	0.878±0.070	1.121±0.077	0.993±0.031	2.99^{b}±0.08	51.73^{b}±1.32

Different letters indicate significance; P ≤ 0.05

Conclusion

Considering the results summarized in the tables above according to the feeding phases and the overall study (0-41 days): Ventar D supplementation of broiler feeds at the level of 100 g/ton significantly improved growth performance parameters during the starter, grower and finisher periods (P ≤ 0.05), and in the final results was stable at 6.5% higher BW and 1.67% better FCR compared to the control group. European Production Efficiency Factor (EPEF) was also significantly better than the control group (P ≤ 0.05).

In the study, liver enzyme and the concentration of short-chain volatile fatty acids also improved significantly with the addition of Ventar D, which may be attributed to the gut health related mode of action for Ventar D.

Low Crude Protein Diets in Poultry: Understanding the Consequences

Conference report

The concept of feeding poultry, specifically broilers and layers, with reduced crude protein (CP) diets is gaining traction among nutritionists. The economic implications of balancing amino acids currently dictate dietary CP levels. At the recent EW Nutrition Poultry Academy in Jakarta, Indonesia, Dr. Steve Leeson, Professor Emeritus at the University of Guelph, Canada, raised a crucial question: “What does ‘low CP’ really mean?” He states that it typically means a reduction of maximum 2-3% relative to current CP levels.

Low CP diets generally involve a decrease in soybean meal, compensated by higher grain content. This change increases dietary starch and decreases dietary lipid levels. To meet nutritional needs, these diets also include higher amounts of crystalline (synthetic) amino acids.

Dr. Leeson outlined the advantages and disadvantages of low CP diets. **Positives** include improved gut health due to reduced proteolytic bacteria, less environmental pollution, lower water intake (improving litter quality), improved sustainability indices, increased dietary net energy, and better performance during heat stress. **Negatives** encompass issues like lower pellet quality, altered dietary electrolyte balance, higher diet costs, reduced growth rate and feed efficiency, and increased abdominal fat deposition. There are also questions about the presumed complete utilization of crystalline amino acids, which can be as high as 25kg/MT in these diets.

Challenges with Low CP Diets

- **Protein vs. Amino Acids**: Diets are typically formulated based on digestible amino acid content, though minimum CP levels remain common, to avoid reduced performance: Dr. Leeson noted that broiler diets with less than 19% CP in starter and 15% in finisher phases, and layer diets below 13% CP, often fail to deliver adequate performance, regardless of digestibly amino acid supply.
- **Utilization of Free Amino Acids**: The crystalline amino acids are immediately absorbable in

the small intestine, contrasting with protein-bound amino acids that are absorbed as di- and tri-peptides. Amino acids absorption dynamics and endogenous loss of amino acids are affected by (high) levels of crystalline amino acids.

- **Non-Essential Amino Acids**: The impact of reduced CP on animal performance might be related to the lower levels of presumed non-essential amino acids, e.g. glycine and serine. This is an area for further exploration.
- **Energy Level Considerations**: Dr. Leeson suggests maintaining specific ratios of digestible lysine to apparent metabolizable energy in broilers at different growth stages. The heat increment of CP is an essential factor, as it reduces net energy efficiency, possibly requiring an adjustment in amino acid to metabolizable energy ratios as poultry diets are not based on net energy values.
- **Gut Health**: Lower CP levels can reduce the flow of undigested protein into the hindgut, reducing the risk of necrotic enteritis, and the production of harmful metabolites, like biogenic amines.
- **Role of Proteases**: Protease use can lead to a further 2-4% reduction in dietary CP, with the response depending on the inherent protein digestibility of the diets.
- **Impacts on Pellet Quality**: Due to the binding properties of protein, each 1% reduction in CP typically results in a 2% decrease in pellet durability (index).
- **Electrolyte Balance**: Reduced CP can significantly lower dietary electrolyte balance, which has to be considered in feed formulation. Amongst the nutrients contributing to DEB value, Sodium and Potassium appear to be the most influential minerals to consider.

Conclusion

Dr. Leeson anticipates that low CP diets will become increasingly relevant. They have the potential to reduce environmental pollution and dependence on soybean meal, despite current challenges in reducing feed costs.

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EW Nutrition's Poultry Academy, featuring Dr. Leeson, took place in Jakarta and Manila in early September 2023. With nearly 50 years of industry experience, Dr. Leeson has made significant contributions to poultry nutrition and management, evidenced by his numerous awards and over 400 published papers.

Respiratory disease – one of the biggest problems in horses

By Judith Schmidt, Product Manager On-Farm Solutions

The respiratory tract in horses is prone to various problems, ranging from allergic reactions and inflammation to severe infections. Respiratory diseases are a constant topic of suffering and irritation in horse breeding and keeping. According to a study published in 2005, respiratory diseases account for about 40 % of all equine internal diseases recorded worldwide (Thein 2005). Through early diagnosis, appropriate treatment, and preventive measures, horse owners can help maintain the respiratory health of their horses and promote their well-being and performance.

The horse’s lung – a high-performance organ

The respiratory tract of our horses is a high-performance system with a large surface, allowing the exchange between the inside of the body and the environment. The lungs enable the gas exchange, i.e., the transfer of oxygen from the air into the horse’s bloodstream and the discharge of CO_2. A functioning gas exchange is crucial for the horse to supply its muscles with sufficient oxygen and perform.

Even when resting, a 600-kg horse breathes about 50 to 80 liters of air per minute into its lungs. With increasing load, this value can rise to 2.000 liters per minute at maximum load. If a horse is healthy, it breathes calmly and slowly and takes eight to sixteen deep breaths per minute.

A special mucous membrane covering the entire respiratory tract protects the lungs from harmful influences. When irritated by pathogens or foreign bodies, this mucous membrane generates higher amounts of mucous and transports it toward the mouth cavity with the help of the finest cilia. In this way, most harmful particles are usually trapped quickly, reliably, and, above all, effectively and, if necessary, coughed up before they can even reach the alveoli and cause damage there.

The most common respiratory diseases in horses

Chronic obstructive bronchitis

Chronic obstructive bronchitis is better known as COB or equine asthma. COB is more common in horses regularly kept in dusty or poorly ventilated environments, such as cramped stables or pastures with high mold levels. Inhalation of dust particles and allergens can cause respiratory tract inflammation, leading to coughing, increased mucus expectoration, and breathing difficulties. The clinical picture of COB can vary greatly. From occasional poor performance in show horses to chronic coughing with purulent nasal discharge or significant weight loss.

Tracheitis

Another common respiratory disease in horses is tracheitis, often caused by bacterial or viral infections. Young and older horses and those with a weakened immune system are particularly susceptible to tracheitis. Besides infections, factors such as dust, smoke, or chemicals can also irritate the mucous membrane of the trachea and trigger inflammation.

Hay fever

Hay fever, also known as allergic respiratory disease or rhinitis, is a common condition affecting horses. Known to humans, it is an allergic reaction to certain pollen, molds, or other environmental allergens that are present in the air. Common signs include sneezing, a runny nose, and itchy eyes. However, some horses may also suffer from coughing or respiratory symptoms. Hay fever in horses can occur seasonally, depending on the pollen emerging, and the symptoms may be more severe during spring, summer, or autumn.

Asthma

Asthma in horses, also known as equine asthma or heaves, is a chronic respiratory disease similar to asthma in humans in many ways. The main cause of this disease is hypersensitivity of the respiratory tract to dust, allergens, or mold spores in the horses' environment.

How to differentiate between respiratory distress and harmless rattling?

Horse owners know it – the four-legged friends have an impressive range of breathing sounds. But which are harmless, such as the exited trumpeting through the nostrils during a fright, and which could be respiratory disease symptoms?

Diagnosing respiratory problems in horses can be challenging because symptoms are often non-specific signs and similar to several diseases.

Snorting: When horses snort, it is a sign of relaxation. There is usually no cause for concern—quite the opposite.
Snorting at a gallop: Many horses snort rhythmically at a gallop, which is also considered harmless. Snorting is particularly common in thoroughbreds.
Coughing during, e.g., trotting: Occurs so frequently that it is often perceived as usual. But it is not. Coughing is always an alarm signal and can indicate an allergy, asthma, or a viral or bacterial infection.
Whistling when inhaling: In this case, to be on the safe side, a veterinarian should be consulted.

What are the consequences of respiratory disease?

Respiratory disease in horses can have significant economic consequences. If a horse suffers from chronic obstructive bronchitis or another respiratory illness, this can lead to various problems:

- Veterinary costs increase: Diagnosing and treating respiratory diseases often require veterinary visits, medication, and possibly further examinations such as x-rays or endoscopy.
- Performance decreases: A horse with respiratory problems may have severely limited performance. It may have difficulty breathing, negatively affecting its athletic performance, equestrian work, or other activities.
- Downtime: During the treatment or recovery, horses may have to take a break or be taken out of training, resulting in loss of income, especially if the horse was intended for competition or show.
- Decrease in value: A horse with chronic respiratory problems may lose its value as a sport or breeding horse. The demand for that horse and, therefore, the selling price might decrease.

Early diagnosis and treatment are crucial for containing the economic impact. However, the best strategy is to minimize the risk of respiratory disease by appropriate preventive measures.

Prevention

Preventing cough in horses is considerably important to reduce the incidence and severity of respiratory disease. Several measures can be taken to achieve this goal:

1. A clean horse stable is crucial: Dust is a common trigger of respiratory symptoms in horses. Removing dust, dirt, and mold spores regularly from the stable and horse boxes can help improve air quality and reduce respiratory stress.
2. Allow horses to breathe fresh air with efficient pasture management: When possible, horses should have access to fresh pastures. The natural outdoor environment helps horses breathe cleaner air and inhale fewer harmful particles.
3. Hay feeding should not increase exposure to allergens: The exposure to allergens can be reduced by choosing high-quality, low-dust hay. Moist soaking of the hay before feeding can also help reduce dust levels.
4. Ventilation ensures air exchange: Appropriate ventilation in the stable is essential to avoid stagnant air and dust accumulation. The use of fans or natural ventilation systems can improve air circulation.
5. Feed management: High-quality feed free of molds and allergens can reduce the risk of respiratory problems. It is vital to adjust feed rations to the individual needs of each horse.
6. Supplements support hygiene measures: Supplements can play a positive role in preventing respiratory problems in horses if used selectively and with expert advice.
    - Immune system support: Supplements such as vitamins, minerals, and antioxidants can strengthen the immune system. A healthy immune system helps the horse to better defend itself against infections and inflammation of the respiratory tract.
    - Certain supplements contain ingredients with anti-inflammatory properties, such as omega-3 fatty acids or herbal extracts. They can help alleviate inflammation in the respiratory tract and thus reduce the risk of respiratory problems.
    - Supporting respiratory health: Some supplements on the market have been specially designed to support respiratory function. They help regulate mucus production, improve respiratory protection, and facilitate the expectoration of mucus.
    - Strengthening lung capacity: Certain ingredients in supplements can support the horse’s lung capacity and promote better oxygen uptake, which is essential for performance and respiratory health.

Conclusion

Respiratory health is essential for horses. So, you should consult the vet in case of noticeable breathing sounds, coughing, fever, or a drop in performance. Respiratory diseases tend to become chronic and long-term problems if they are not treated appropriately. Fresh air and species-appropriate husbandry, feeding dust- and mold-free feed are the first steps to support the normal function of your horse’s respiratory tract. A holistic approach to equine health, including proper stable and feed hygiene, sufficient exercise, and good air quality in the stable is crucial. Appropriate feed supplements can be an excellent tool to round this approach off.

References:

Handbuch Pferd: Dr. med. vet. Peter Thein, 2005

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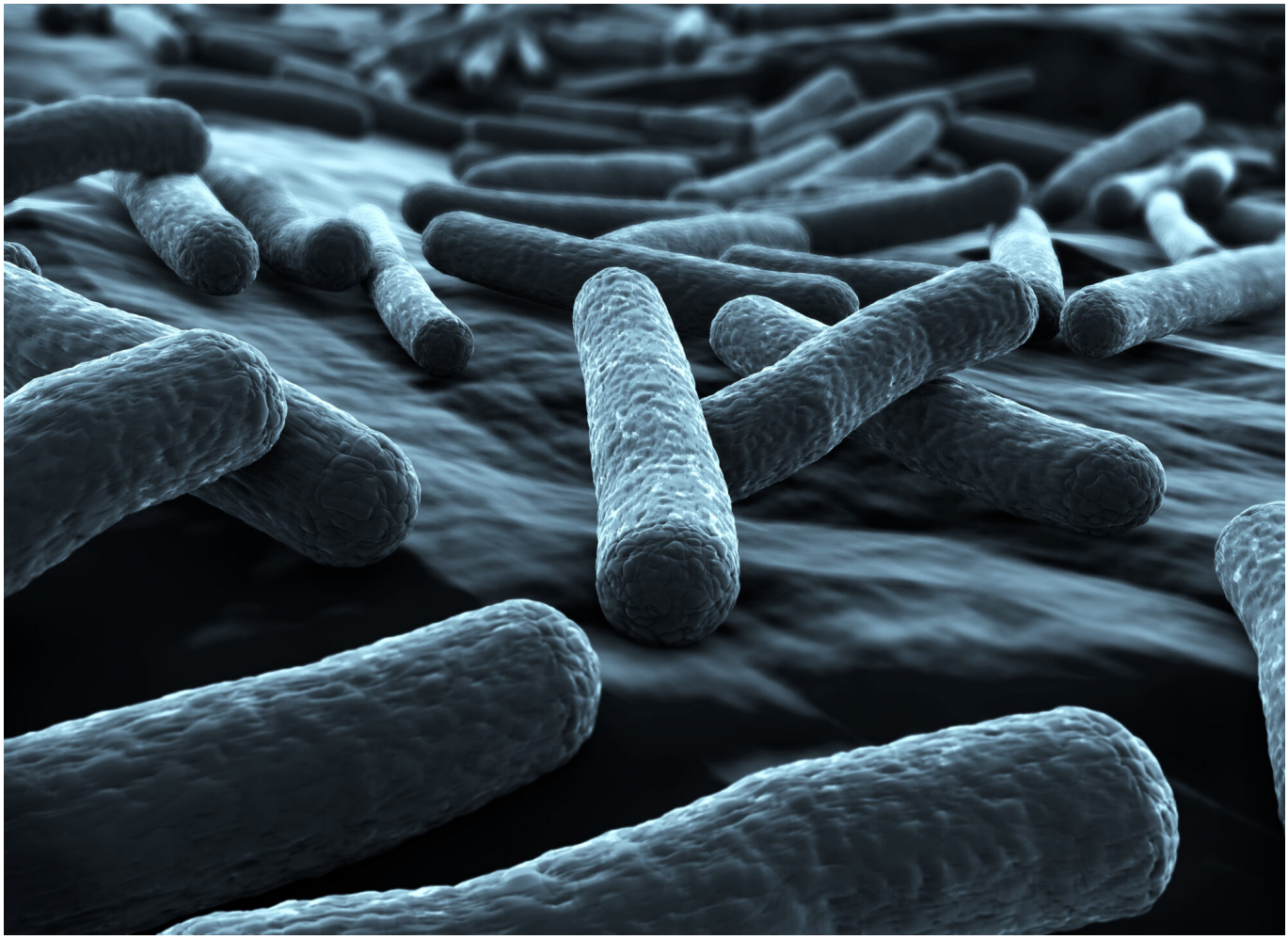
Endotoxins in 250 words



Dr Inge Heinzl, EW Nutrition

Endotoxins are… toxic, of course. The part “endo” in their name means that they are part of the bacterial cell, or, to specify it, they are part of the outer membrane of Gram-negative bacteria such as *E. coli*, *Salmonella*, *Shigella*, *Klebsiella*, and *Pseudomonas*.

When do they occur?

Always. Endotoxins are released with the lysis of bacteria, e.g., at the end of their life cycle, due to the effective immune defense of the host or treatments. The other possibility is bacterial growth as the membrane gets restructured and the endotoxins (or lipopolysaccharides -LPS-) are liberated.

What is the problem?

The “normal” occurrence (animals and humans always have Gram-negative bacteria in their gut) does not matter, because gut cells do not have receptors to recognize them as a danger in their apical side. However, when the barrier function is compromised, they pass into the bloodstream.

The liver still detoxifies small amounts. The problem comes with higher amounts of endotoxins in the bloodstream. Then, they provoke a strong immune reaction, feed intake drops, and nutritional resources are shifted from growth and production to immunity. These performance drops affect the profitability of the farmer.

What can be done?

Use broad-spectrum toxin binders that

- contain clay minerals showing high affinity and selectivity against endotoxins
- contain yeast cell walls, which, in addition to their binding capacity, support the immune response through macrophage activation and are involved in modulating microflora and bacterial load from the intestine
- provide adequate liver protection.

Housing and management strategies to mitigate heat stress in layers

Dr Daniel Valbuena, Global Manager of Technical Services, Hy-Line International – Conference Report

Heat stress is one of the major environmental stressors in the poultry industry, especially in regions with high temperatures and high humidity. In EW Nutrition's Poultry Academy in September, the topic was approached in a comprehensive and practical presentation.

A layer's normal body temperature is about 40° C. Hens are comfortable with an ambient temperature 18° C to 24° C. When that temperature gets above 32° C, the more serious consequences of heat stress occur.

To mitigate the negative effects of heat stress on bird welfare, production, and profitability, essential best practices include those listed below.

Ventilation

Airflow at the birds' level is key to removing bird heat. Naturally-ventilated barns are particularly at risk of heat stress. Increase the movement of air in open houses with stir fans. Ensure a minimum velocity of 1.8–2 meters/second in the bird areas.

Clean and ensure function of fan louvers. Fan belts should be tightened or changed to avoid slipping or breaking during periods of high temperature. Poorly maintained fans will operate at 50% reduced efficiency.

Air inlets must be adequate to supply the airflow needed to ventilate the house during warm weather. Inadequate inlet space will throttle down the fans and decrease airflow. Inlets should be kept clean and free of anything that might restrict the flow of incoming air. Use baffle boards to direct incoming air onto the birds. Thermostats should be checked for accuracy. An auxiliary power system must be in place in case of a power outage during hot weather.

In addition to running fans throughout the day when it's hot, fans should run overnight and early morning to bring in cooler air. Air inlets should be adjusted to achieve uniform airflow throughout the building.

In houses equipped with evaporative cooling systems, the pads should be cleaned or replaced when they become clogged. Water flow over the pads should be uniform with no dry areas. Air will flow preferentially through dry areas since there is less resistance. Clean spider webs and dust from window screens frequently to improve ventilation inside the house.

Fans increase air velocity within the house and create a cooling effect.

Foggers

Fogging or misting is effective at low humidity (<60% relative humidity). Excess moisture in the air from using foggers or misters at high humidity can worsen heat stress conditions.

Foggers or misters need to be checked routinely and should run about 2 minutes out of every 10 if the humidity is low, however, run times can be adjusted based on house temperature and humidity. Fogging the inlet air in negative pressure ventilation systems has a good cooling effect.

Fogging systems should have water filters (to keep nozzles from clogging) and have a positive shutoff to prevent dripping causing wet litter.

Foggers should mist, not irrigate, and not operate if the humidity exceeds 60%.

Roof design and cooling

Insulated roofs (R28 is recommended) reduce the radiation and conduction of solar heat through the roof to the interior of the house. Reflective roofing materials or light-coloured materials are recommended.

Ensure to provide ridge vents at roof level to allow hot air to exit so that fresh air may enter the house through side openings. The roof should have an overhang (minimum 60 cm) to reduce direct and indirect sunlight getting into the house.

Thatching can provide cost-effective insulation, but may need to be replaced every few years, and is difficult to clean, and may harbor vermin.

Use of shade netting (left) or thatching material such as palm fronds, paddy straw, corn stalks, sugarcane tops (right) to reduce solar heating of the roof.

Using roof sprinklers during times of extremely high temperature can remove heat from the roof and cool the inside of the house.

Curtains

Adjustable, porous side-wall curtains can be used control the flow of air into the house, and protect birds from direct, hot winds. Water dripping onto side curtains can reduce the house temperature.

Porous window shades block direct sunlight from entering the house but allow air to pass through.

Bird handling

Management practices that require bird handling, such as beak trimming, transfer, and vaccinations, should be done in the early morning hours, or in the evening, when it’s not so hot. Heat-stressed birds have decreased immune function and may not respond as well to vaccination. Alternatively, if birds are panting, they may breathe in too much of a spray vaccine or ingest too much of a water-administered vaccine. In both situations, birds may exhibit signs of the disease that the vaccines are intended to prevent.

Stocking density

It’s critical not to overstock cages. If stocking density is high, the radiant heat between the birds accumulates and the temperature increases. Birds need to be able to spread their wings to increase airflow around their bodies. Caged birds are more susceptible to heat stress because they are unable to seek a cooler place and there is less opportunity for conductive heat loss in cages. The temperature within a cage can be much higher than the measured air temperature in the walkway. Increased air velocity within the cages increases the convective heat loss and removes trapped air between birds.

Manure management

Manure allowed to accumulate reduces ventilation in cages. Remove manure from the house before the hot season, if practical. Heat produced during the decomposition of manure contributes to the heat load in the house. The presence of large amounts of manure in shallow pit houses or under cage batteries restricts the movement of air.

Be prepared and anticipate

- The key to minimizing the effects of heat stress is to be prepared and anticipate periods of high environmental temperatures, and implementing appropriate management measures *prior* to the rise in temperatures. Implement cooling systems, such as evaporative cooling pads, misting systems, or fans. Provide natural or artificial shading within the layer house to reduce direct sunlight exposure. Shade structures, curtains, or baffles can help protect the hens from excessive heat.
- Farm personnel should be trained to recognize and respond to heat stress promptly. You should also have an emergency plan in place for extreme heat events.

Feed and water management strategies to mitigate heat stress in layers

Dr Daniel Valbuena, Global Manager of Technical Services, Hy-Line International – Conference Report

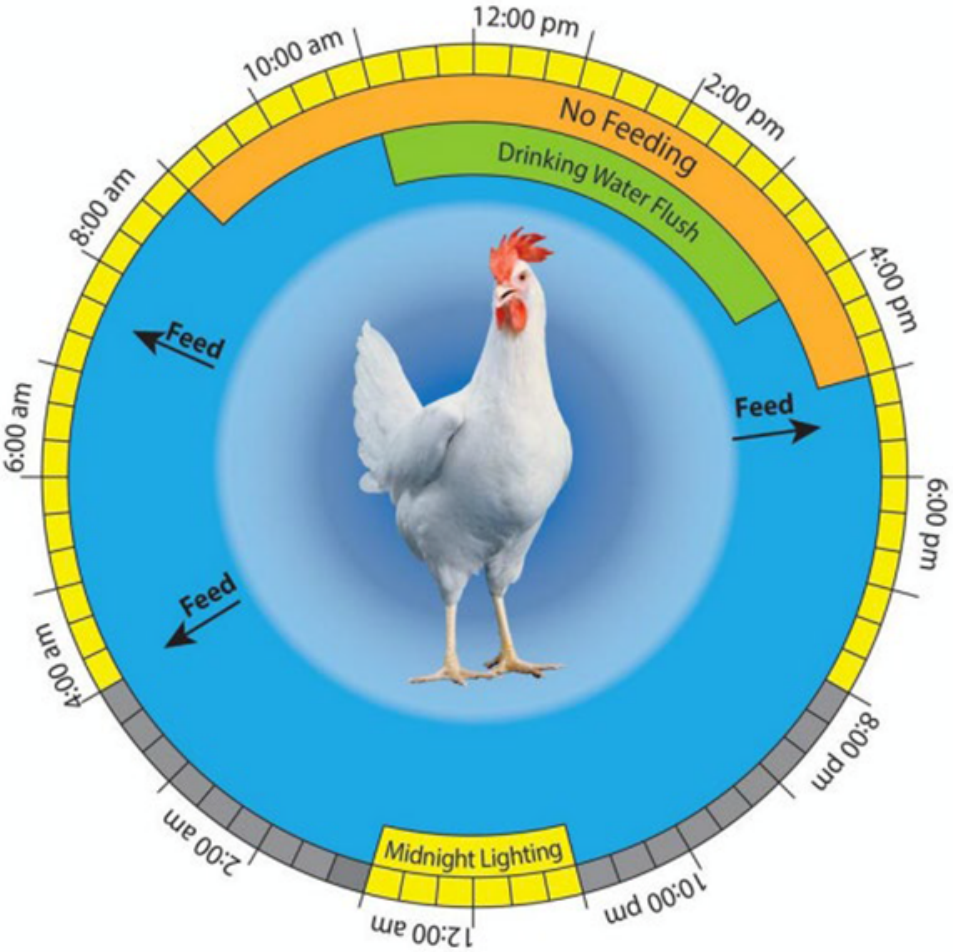
Feed and water management strategies are essential to help mitigate the negative effects of heat stress on bird welfare, production, and profitability. In EW Nutrition's Poultry Academy in September, the topic was approached in a comprehensive and practical presentation.

Feed management

Feed consumption of the flock should be closely monitored during hot weather. It is important to rebalance the diet for critical nutrients, particularly amino acids, calcium, sodium and phosphorous according to the birds' productivity demand (i.e., stage of production) and the observed feed intake. Insufficient amino acid intake is the primary reason for productivity loss during hot weather. Several strategies may be employed to help to manage elevated temperatures and maintain higher levels of feed intake:

- Withdrawing feed from birds 6 hours before peak hot temperatures in the afternoon can lower the risk of heat stress. Encourage as much consumption as possible in the early morning or evening. Using lighting for midnight feeding encourages feed intake.
- One third of the daily feed ration should be given in the morning and two thirds in the late afternoon. An additional advantage is the availability of calcium in the digestive system during shell formation at night and in the early hours of the morning. This will improve shell quality and reduce the birds from depleting bone calcium.
- Normally a maximum 1 hour for feeder clean-out time is recommended, but this can be extended to 3 hours when the temperature exceeds 36°C.
- Consider adding a 1-2-hour midnight feeding.
- Alter feed particle size, either by increasing it or by feeding a crumble diet. With crumble diets in laying flocks, a supplementary source or presentation of large particle limestone is recommended.
- Formulate diets using highly digestible materials, particularly protein sources. Metabolism of excess protein is particularly heat-loading on the bird. Formulate to digestible amino acid targets and do not apply a high crude protein minimum in the formula. Synthetic amino acids can reduce crude protein in the diet without limiting amino acid levels.
- Increasing the proportion of energy contribution from highly digestible lipid, rather than starches or proteins, will reduce the body heat production resulting from digestion. This is known as heat

increment and is lowest with the digestion of dietary fat.
- The bird's metabolizable energy requirement decreases as ambient temperature increases to above 21°C, resulting from a reduction of energy requirements for maintenance. The energy requirement will decrease with the rise of temperature up to 27°C, above which it will start to increase again since the bird needs additional energy for panting to reduce body heat.



Management schedule during times of heat stress

Water management

During periods of high environmental temperature, birds have a high demand for drinking water. The water-to-feed consumption ratio is normally 2:1 at 21°C but increases to 8:1 at 38°C. Adequate drinking water must be available to heat-stressed flocks. Ensure that drinkers have sufficient water flow (>70 mL/minute/nipple drinker). If water flow is less the lines need to be checked for flow restriction. If there's a build-up of iron and other minerals, it needs to be removed. Don't forget to routinely check water filters and replace them as needed.

It's easy to overlook a non-functioning drinker here and there; drinkers must be systematically checked to make sure they're all working. For floor-reared flocks, providing additional drinkers can help accommodate the increased water consumption.

During hot weather, you need to ensure your water system can accommodate the bird's increased water consumption, and the additional water demands for foggers, evaporative cooling systems and roof sprinklers. The availability of drinking water to a heat-stressed flock should never be compromised.

Cool water temperatures (<25°C) will encourage the birds to drink and reduces the birds' core temperature. Flush water lines and waterers routinely to keep the water fresh and cool, increasing water consumption, and sustaining egg production. If available, ice can also be added to header tanks. When mechanical cooling systems fail, water flushing can serve as an emergency measure during heat stress.

Drinking water from overhead water tanks can become hot if exposed to direct sunlight. These water tanks should be a light color, insulated and covered to avoid direct sunlight. Water tanks are ideally placed inside the house or underground. Water pipes in the house should not be installed close to the roof to avoid heat from the roof warming up the water in the pipes.

Having the water tank inside the house (above) or light-colored and covered to avoid direct sunlight (below) keeps the water cooler

Use vitamin (A, D, E and B complex) and electrolyte supplements in the drinking water to replenish the loss of sodium, chloride, potassium, and bicarbonate in the urine. Electrolyte supplements are best used in anticipation of a heat stress period and can be added to drinking water for up to 3 days.

Coping with evolutions in the performance and nutritional requirements of layers

***Dr. Vitor Arantes**, Global Technical Services Manager and Global Nutritionist, Hy-Line International – Conference Report*

The layer industry has gone through significant changes during the past decades and has a remarkable capacity to cope with new challenges. Dr Vitor Arantes, Global Technical Services Manager and Global Nutritionist, Hy-Line International, noted that increased egg production, improved feed efficiency, and adaptation of egg quality and bird welfare to consumer preferences have contributed significantly to the success of the egg industry. However, continuous improvement in egg production per hen housed is the most important selection criteria in layer breeding.

Egg producers needs include:

- More saleable eggs,
- Eggshell quality,
- Easier behaviour
- Housing systems
- Egg size specifics
- Sanitary / environmental challenges
- Profits through productivity

Primary breeders can deliver these producer needs through:

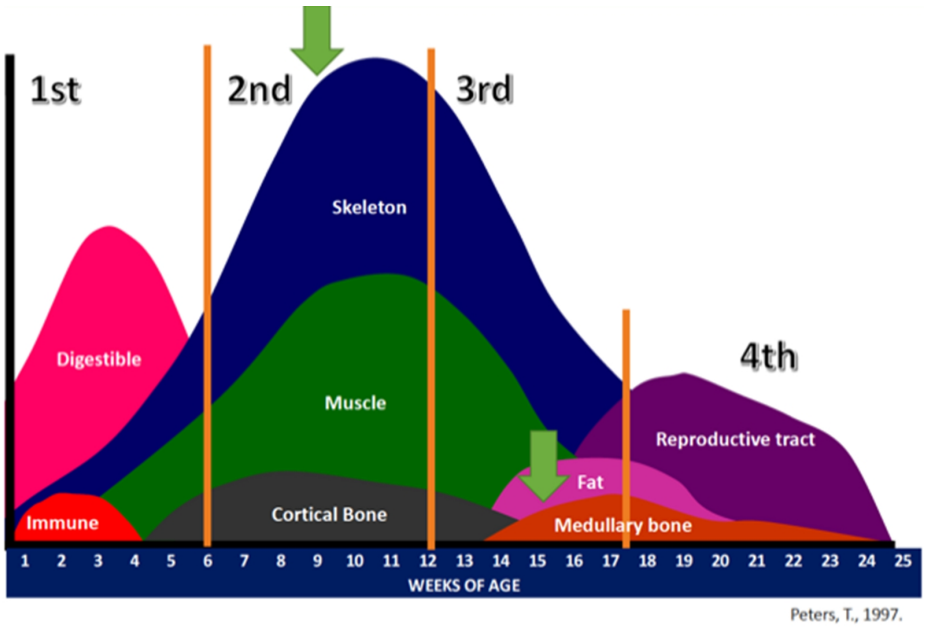
- Having the correct product for each country
- Constant follow up
- Local presence, trust relationship
- Accurate data collection
- Critical data analysis
- Understand the company's goals
- Customized technical services according to each customer needs

How has genetics changed?

Examples of genetic progress in layers from 1984 to 2022 cited by Dr Arantes include:

- Higher persistency (+30 weeks >90%)
- Higher egg mass (+5.5 kg/hen housed)
- Smaller hen (-21% mature body weight)

Dr Arantes states the record clutch size, defined as the unstopped length of individual egg production on a daily basis, was an amazing 474 days for a White Plymouth Rock hen. This genetic progress necessitates adjustments in nutrition and management.



As shown below, growth and organ development occur at various ages. "There is no margin for mistakes – a lack of growth during a stage could have a detrimental impact on pullet quality and subsequent production," stressed Dr Arantes.

Multi-phasic growth and development during rearing and start of lay

System	Age (weeks)	Consequence
Gastrointestinal	0-6	Shorter intestinal tract/reduced nutrient absorption
Immune	0-6	Flocks more susceptible to disease challenges

Skeleton	6-12	Shorter frames/less calcium reserves
Muscle	6-12	Impact in persistency of production
Fat	>12	Excess can lead to fatty liver, prone to prolapse and mortality

0-6 weeks of age

Most of the development of the organs of the digestive tract and the immune system occurs during the first 6 weeks of age. Problems that occur during this period can have negative effects on the function of these systems. Birds stressed during this period may have lifelong difficulties in digesting and absorbing feed nutrients. Immunosuppression may also result from problems during this period, leaving the bird more susceptible to diseases and less responsive to vaccinations.

6-12 weeks of age

Most of the adult structural components – muscles, bones and feathers are obtained during the period of rapid growth that occurs at 6-12 weeks of age. Growth deficiencies during this period will prevent the bird from obtaining sufficient bone and muscle reserves, which are necessary to sustain a high level of egg production and to maintain good eggshell quality. About 95% of the skeleton is developed at the end of the bird's 13 weeks of life. At this time, the plates of the long bones become calcified and further growth in bone size cannot occur.

12-18 weeks of age

During this period, the growth rate slows, and the reproductive tract matures and prepares for egg production. Muscle development continues and the proliferation of fat cells takes place. Excessive weight gain during this period can result in an excessive amount of abdominal fat. Low body weight and stressful events at this time can delay the start of egg production. From 7-10 days before oviposition of the first egg, the medullary bone that is located within the cavities of the long bones can be increased by feeding the bird a pre-laying ration with higher levels of calcium than the development stage.

Bodyweight is a key factor for flock management as this will influence future performance of birds. Consequently, bodyweight should be controlled during the whole life of the layer flocks. Management, in particular nutrition and lighting programs, can help to control bodyweight so birds can achieve their genetic potential.

Uniformity

Uniformity is the most important KPI in our business. However, with the trend towards larger flocks, maintaining uniformity is becoming more challenging. With larger flocks, it is difficult to source one unique flock which thus usually comprises multiple breeding flocks of different ages. Inevitably, uniformity will be poor, hence the need for tools to address unexpected issues. Lack of uniformity becomes a self-perpetuating cycle – dominant versus dominated.

Many egg producers use average body weights compared to the breeder recommendations as a guide to flock status. However, knowing if you have good body weight uniformity is another valuable management tool. In any flock some birds are lighter or heavier than the average body weight. Poor uniformity makes management decisions, such as lighting, feed amounts or diet phase more difficult.

Ideally, the body weight coefficient of variation (CV) should be +/-10% of the mean, increasing the likelihood that your management decision will be appropriate for most of the flock. Inappropriate diet changes, bird handling, vaccination and transfer can reduce uniformity. Flocks should be at 90% uniformity at the time of transfer to the laying facility. Body weight at point of lay significantly affected egg production and eggshell quality.

Grading into 2 or 3 sub-populations of different average bodyweights may be necessary so that each group

can be managed in a way that will achieve good whole flock uniformity at the point of lay. The best predictor of future laying performance is the pullet's body weight and body type at the point of lay.

Vision egg

Vision Egg is a custom diagnostic tool used to analyze data and emphasize flock performance to achieve the highest genetic potential from Hy-Line layers with recommendations connected to customer profitability. This growing, robust database includes data from over 1 billion hens strengthens our flock performance diagnostic tool for improved profitability for Hy-Line customers.

Hy-Line customers can take advantage of this opportunity by sending flock data to their regional business manager or technical service specialist. The information shared with Hy-Line is kept completely confidential.

Summary

The challenge is not egg numbers, stated Dr. Arantes, but saleable eggs. Correct body weight and high uniformity of the flock at point of lay will result in good performance over the laying period, with high peak production and good persistency of production and the production of good quality eggs. Management is the key factor to regulation of body weight during rearing and at point of lay.

How to mitigate formulation costs when ingredient prices are high

Conference Report

The price of corn and soybeans dictates the price of all other ingredients, including to some extent amino acids, stated Dr Steve Leeson Professor Emeritus, University of Guelph, Canada at the recent EW Nutrition Poultry Academy in Jakarta, Indonesia.

The big question is, when times get tough, can we reduce safety margins and still get good performance?, asked Dr Leeson. “When we formulate diets, we build in some insurance. But so do the breeding companies in their recommendations. For sure, reducing safety margins takes us out of our comfort zones, but we need to be nutritionists, not mathematicians,” he stressed.

Protein and energy are now expensive. As a result of this economic pressure, there is a focus on strategies to reduce feed costs and improving the production efficiency and profitability of poultry enterprises. Feed cost/kg body weight gain is not always at the lowest feed:gain.

To help achieve these targets, Dr Leeson discussed feeding and management strategies that take into account the cost mitigation requirement.

Optimize current digestibility/efficiency

With high feed prices, it is especially important to review the use of feed additives that optimize nutrient release and improve ‘digestibility’. The most obvious class of such additives are the various exogenous enzymes that improve the availability of phosphorus, energy, and amino acids. In most instances, these different classes of enzymes are additive in terms of nutrient release, since they have different target substrates or modes of action. All too often, the position is taken that “I take energy uplift from my amylase, so I can’t expect energy release from phytase or protease”.

The energy release from phytase is invariably net energy related to removal of the phytate molecule, which in effect is an ‘antigen’ and takes energy to counter its negative effects. The energy release from an amylase, however, is obviously related simply to the improved digestibility of carbohydrate complexes. Similarly, a protease enzyme will always provide energy, since all protein/amino acids are eventually used for energy during protein turnover, hence our use of the often forgotten ‘n’ in AMEn. We also have the choice of enzyme concentration, especially for phytase, which in the current economic solution is likely to be close to 2 – 2.5 doses, assuming a single dose is around 500-600 FTUs. The economics of super-dosing or mega-dosing is greatly impacted by the cost of the enzyme.

The response of phytase varies with individual amino acids, and with ingredients, with greater responses with ingredients of lower inherent digestibility. Generally, Dr Leeson suggests that a protease will capture 20% of indigestible amino acids. For example:

- 70% digestibility = +6% uplift
- 90% digestibility = +2% uplift

Relax ingredient constraint maximums

Probably the greatest current cost savings can be made from relaxing the maximum levels on ingredients. While corn and soybean meal levels are usually without restriction, we often impose limits on the upper levels of ‘alternative’ ingredients such as distillers grains, rice by-products and rapeseed/canola meals, etc. When the upper levels are reached in the formula, this suggests cost savings from using higher levels. Current restraints are based on past knowledge of perhaps variable nutrient composition and so the decision to use more of any ingredient must be based on past knowledge of on-going quality control assays. Although we can achieve considerable detail today in such QC assays, monitoring for (consistency of) crude fiber, crude protein, fat, and moisture alone, provide a sound basis for decisions on whether to use more of an individual ingredient.

Source alternate ingredients

Another option is to consider ‘new’ alternative ingredients. In reality, however, there are no new ingredients as such, since all monogastric nutritionists around the world have only around 19 ingredients available in sufficient quantities to sustain large-scale modern feed mills. There are certainly smaller quantities of specialised local by-products that can be used to advantage, yet these are becoming scarce. Therefore, an ingredient is only novel to you, since inevitably the same ingredient has been used for many years in other regions. As such, there is a wealth of information available on the nutritive value of these ‘new’ ingredients that can be simply transposed to our formulation matrices.

The bird is very adaptable to new ingredients, in fact it is more responsive to nutrients. Unless there are toxins, antinutritional factors, or other negative factors, it doesn’t matter to the bird. Knowing the ingredient composition is the critical feature regarding the success or failure with new ingredients.

Reduce nutrient density

Both layers and meat birds still eat quite precisely to their energy requirements. They are amazingly adaptable to a vast range of nutrient densities, assuming that they can eat enough feed as the lower levels of feed energy are approached. Success in using lower levels of nutrient density is invariably negatively impacted by factors such as high stocking density and a high environmental temperature. Conversely, reducing diet energy usually has the hidden advantage of improved pellet quality.

The key to successful use of lower energy diets lies in prediction of change in feed intake and corresponding adjustment to all other nutrients in the diet.

Flexible cost of Dietary electrolyte balance (DEB)

When first introduced in the 1970s, maintaining DEB around 250MEq was seen to optimize broiler performance, especially leg condition. There is now less emphasis on this, perhaps because of genetic selection for skeletal integrity. DEB, however, may be important during heat stress to stimulate water intake and control manure moisture. Formulating to fixed DEB levels always adds costs. Instead, Dr Leeson suggested to focus on sodium and chloride at a ratio of 1:1.3.

Optimize feed texture (pelleting)

The first consideration is to make a good quality pellet, then worry about pellet size, noted Dr Leeson. He also added he was “a big fan of sunflower meal – it’s great for pellet quality.”

When given a choice in particle sizes, birds invariably show a preference for the largest particles. This situation becomes obvious when ‘fines’ accumulate in the feeder pans over time. As shown below, as pellet size increases, so does the bird’s need to consume fewer pellets. As a result, they need to spend less time at the feeder. Naturally, this idealised pellet size must be balanced against the willingness of mill managers to accommodate the necessary changes in pellet die size. Matching pellet size to bird age becomes critical as stocking density increases.

Impact of pellet size on pellet number consumed by a 30-day-old broiler

Pellet size (diameter)	4 mm length	6 mm length
3 mm	580	390
4 mm	330	220

5 mm	210	140

In the end, cost mitigation should not require complex mathematics. Nutritionists should be able to play with several types of improvements without affecting health and performance.

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Dr. Leeson had his Ph.D. in Poultry Nutrition in 1974 from the University of Nottingham. Over a span of 38 years, he was a Professor in the Department of Animal &Poultry Science at the University of Guelph, Canada. Since 2014, he has been Professor Emeritus at the same University. As an eminent author, he has more than 400 papers in refereed journals and 6 books on various aspects of Poultry Nutrition & Management. He also won the American Feed Manufacturer's Association Nutrition Research Award (1981), the Canadian Society of Animal Science Fellowship Award (2001), and Novus Lifetime Achievement Award in Poultry Nutrition (2011).

Metabolic disorders and muscle defects

Conference Report

At the recent EW Nutrition Poultry Academy in Jakarta Indonesia, Dr Steve Leeson, Professor Emeritus, University of Guelph, Canada, defined metabolic disorders as: non-infectious, occurring with adequate diets in 'normal' conditions, and mostly species-specific. Their incidence is negatively correlated to productivity. Although they often have a major genetic component, genetic selection to manage the problem is often a last resort, as there is usually a negative correlation with productivity.

Ascites

First reported in the 1970s, ascites or 'water belly' is probably the number one metabolic issue today. It is the accumulation of fluid in the abdomen, which is caused by a cascade of events related to the need to supply high levels of oxygen to the tissues. The condition was initially most prevalent in fast-growing male broilers maintained at high altitude and where there is a degree of cold stress, but nowadays the problem can occur at any altitude. In extreme situations up to 8% mortality is seen, although 1-3% mortality is currently more common. The disorder is now re-emerging with faster growth rates, as growth rate is easily the main contributing factor.

Options to limit ascites include:

- Limit growth rate
- Feed texture (mash vs. pellets)
- Never let the temperature get below 15°C for any age of bird
- Brooding ventilation – economics of air flow vs. temperature
- Minimize environmental contaminants, such as dust
- Lighting programs (4-6 hours of darkness)

Sudden death syndrome (SDS)

SDS almost always affects males birds close to market weight. It frequently afflicts 1-5% of the flock and from 21-35 days it will usually be the major cause of death. Afflicted birds appear healthy, are well fleshed and invariably have feed in their digestive tract. Death occurs within 1-2 minutes, the birds most frequently being found dead on their backs. There are few changes in gross pathology. The heart may contain blood clots, that are likely post-mortem in origin, and the ventricles are usually empty. Diagnosis is usually by exclusion of other diseases. The lungs are often oedematous, although this usually occurs when birds spend time on their backs and fluid drains to the lung region by gravity. There are no specific changes in the tissue or blood profile that can be used for diagnosis. The condition is precipitated by fast growth rate, and so conversely it can be prevented by varying degrees of nutrient restriction.

Spiking mortality syndrome (SMS)

SMS is characterized by severe unexplained hypoglycemia, and always occurs from 18-21 days of age. There are few post-mortem observations, so it is often misdiagnosed. Mortality can be 2-3%. Males are more susceptible than females, probably because they are growing faster. Birds fed all-vegetable diets may be more prone to SMS. Supplementing an all-vegetable diet with milk-powder (which is high in serine), casein or serine is recommended and results in increased blood glucose.

Skeletal integrity

This disorder is not due to increased bodyweight of broilers, as the broiler is capable of supporting weight that far exceeds its own body weight. Instead, it’s due to shifting the bird’s center of gravity forward as breast muscle yields have increased, moving the legs further apart which puts torsional pressure on the head of the femur. Not only does it cause on-farm problems, but also complications with mechanical processing.

Imbalanced nutrient supply, such as excess of chloride, or infection with bacteria, viruses, and particularly mycoplasmas are involved.

Tibial dyschondroplasia (TD)

TD is due to abnormal cartilage development. Failure of normal vascularization limits mineralization. TD is characterized by enlargement of the hock, twisted metatarsi, and slipped tendons. A low electrolyte balance (<200MEq), high chloride (>0.3%), or low Ca:P or high P:Ca can precipitate TD. Adding manganese and choline to the diet will largely eliminate it.

Perosis

Now often termed Chondrodystrophy, it has manganese or choline deficiency as the classical cause, but it can also be seen with other B-vitamin deficiencies. As with TD, it can be aggravated by some grain fumigants.

Kinky back

Also known as Spondylolisthesis, it is not really a metabolic disorder, as *Enterococcus* infection is the most common cause. Chickens with kinky back syndrome are often seen sitting on their tail, extending their feet outward or letting them fall over to one side of their body. Once the condition stops birds from being able to walk, they are unable to reach food or water on their own and are at risk of dying from starvation. There is no treatment for kinky back.

Gizzard erosion and proventriculus

Although gizzard lesions are very common, Dr Leeson suspects their importance is overemphasized. Gizzard condition is seen in both layer and broiler chickens, but the incidence is more in broilers.

Access to grit and inclusion of at least 20% cereal particles larger than 1 mm in size in the diet will have a positive effect on the development and functioning of the gizzard and it will also reduce the frequency and severity of gizzard lesions in poultry. Ingestion of non-soluble fibers has been shown to exert strong effects on the structure and function of the gizzard. Inclusion of at least 3% coarse fibers in the feed increased the relative weight of the gizzard and reduced the pH of the gizzard contents suggesting a preventive effect of fiber.

Proventriculus appears as a very large organ and is often associated with gizzard erosion. When the proventriculus glands are affected, there is a lower secretion of hydrochloric acid and enzymes and therefore more undigested feed arrives to the intestine, where it can act as a substrate of pathogens and start digestive infections.

Breast muscle defects

Breast muscle defects are not problematic for the bird, efficiency/economics of growth, or a food safety issue. The main issue is seen at primary or secondary processing, and consumer acceptance. Due to the fast muscle growth and the enlarged muscle cells, the space between muscle fibers is reduced. This restricts the blood supply to the muscles, which can no longer reach the desired oxygen levels.

White-striping

White striping is a quality factor in chicken breast meat caused by deposits of fat in the muscle during the bird's growth and development. It is like marbling in red meat. Dr Leeson joked that it be promoted as marbled chicken – like Wagyu beef. Because hypoxia is associated with white striping, it was thought that arginine supplementation could help with vasodilation, thus supplying the muscles with better oxygen resources.

Wooden breast (WB)

WB is an emerging quality defect. Macroscopically, it is characterized by palpably hard, pale ridge-like bulges at the caudal end, along with clear viscous fluid, small hemorrhages, and white striping, that may occur separately or together. The main cause is the high growth rate and high breast meat yield. There is no nutritional or management solution.

Wooden breast is common in male broilers >2.5 kg bodyweight, and the incidence tends to increase with the size of the breast fillet. As the incidence of wooden breast increases, the incidence of white striping tends to decrease. Due to the visual defects and hard and chewy texture, consumers have a low acceptance of WB fillets, and they are usually downgraded to use for ground products.

Reducing oxidative stress and supplying more oxygen to the cells, enabling the muscle cells to grow very fast without meat loss will reduce the incidence of WB.

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Meat quality is a result of genetics, feeding, the microbiome, and the handling of animals and meat

*by **Dr. Inge Heinzl**, Editor EW Nutrition*

Nowadays, nutrition is no longer about pure nutrient intake; enjoyment is also a priority. Consumers attach great importance to the high quality of food and, therefore, also of meat. The genetic selection for faster growth and feeding high-energy diets made meat production more efficient and shortened the raising period. However, this selection may sometimes also result in challenges to meat quality, such as worse water holding capacity, less marbling, less flavor, and reduced storage & processing properties.

The following article will provide detailed information about what meat quality is, how the gut microbiota influences it, and how we can increase meat quality by feeding and modulating the intestinal microflora.

Which factors can contribute to meat quality?

Meat quality is a complex term. On the one hand, meat quality covers measurable parameters such as the content of nutrients, moisture, microbial contamination, etc. On the other hand, and to no small extent, the consumers' preferences are significant. Since meat today is often sold as cuts or in parts (e.g., broiler drumsticks, breast), processing also affects the quality of meat and meat products.

Physical characteristics are objective determinants of meat quality

Physical characteristics are parameters that can be measured. For meat, the following measurable parameters determine meat quality:

1. Fat content and fatty acid composition influence tenderness and taste

Some years ago, the majority of consumers asked for completely lean meat, which, fortunately, has now changed. Fat is a flavor carrier. Especially intramuscular fat (marbling) melts during the preparation, making the meat tender, juicy, and taste good. Fat also transports fat-soluble vitamins.

A further criterion is the composition of the fat, the fatty acids. Geese fat, e.g., is known for its high content of oleic, linoleic, linolenic, and arachidonic acid, all of them derivates of the enzymatic denaturation of stearic acid (Okruszek, 2012).

One exception is cholesterol. Although belonging to the lipids and improving the sensory quality of meat, consumers prefer meat with low cholesterol content.

2. Protein and amino acid content influence the meat value

The content and the composition of protein are important factors in meat quality. Protein is essential for constructing and maintaining organs and muscles and for the functionality of enzymes. The human body needs 20 different amino acids for these tasks, eleven of which it can manufacture by itself. Nine amino acids, however, must be provided by food and are called essential amino acids. Meat is a highly valuable protein source, rich in protein and essential amino acids. The protein quality, therefore, includes the chemical and amino acid score, the index for essential amino acids, and the biological value.

In addition to the pure nutritional value, amino acids contribute to flavor and taste. These flavor amino acids directly influence meat's freshness and flavor and include threonine, alanine, serine, lysine, proline, hydroxyproline, glutamic acid (glutamate is important for the umami taste), aspartic acid, and arginine.

3. Vitamins and trace elements are essential nutrients

Meat is a primary source of B vitamins (B1-B9) and, together with other animal products such as eggs and milk, the only provider of Vitamin B12. Vitamin A is available in the innards, vitamin D in the liver and fat fish, and vitamin K in the flesh.

The most important mineral compounds in meat are zinc, selenium, and iron. Humans can utilize the iron from animal sources particularly well.

4. pH and speed of pH decline decide if the meat is suited for cooking

Since broiler chicken meat nowadays is usually consumed as cut-up pieces or processed products, the appearance at the meat counter or in the plastic box is essential for being sold. The color, seen as an apparent measurement of the freshness and quality of the meat, is influenced by the pH. The muscle pH post-mortem plays an essential role in meat quality. Due to the glycolytic process, the pH post-mortem is a good indication for evaluating physiological meat quality. A rapid pH decline post-mortem to 5.8-6.0 in most cases leads to pale, soft, and exudative (PSE) meat with reduced water retention (Džinić et al., 2015), whereas a high ultimate pH results in dark, firm, and dry (DFD) meat with poor storage quality (Allen et al., 1997)

5. Nobody wants meat like leather

The shear force is a measure of the tenderness of the meat. To determine the shear force, the meat undergoes the process of cooking and chilling. Afterward, standardized meat blocks, with fibers running along the length of the sample, are put into the Warner-Bratzler system. The blade used simulates teeth, and the system measures the force necessary to tear the piece of meat.

6. Microbial contamination is a no-go

The microbial contamination of the meat often occurs during the slaughter process. Let's take a look at salmonella or campylobacter in poultry. The chickens take up salmonella with contaminated feed or water. Campylobacter is transmitted by infected wild birds, inadequately cleaned and disinfected cages, or contaminated water. The bacteria proliferate in the intestine. At slaughter, the intestine's microorganisms can spread onto the meat intended for human consumption.

7. High water holding capacity is necessary to have tender meat

The moisture content contributes to the meat's juiciness and tenderness and improves its quality. If the meat loses its moisture, it gets tough, and quality decreases. Additionally, drip loss reduces the nutritional value of meat and its flavor.

8. Fat oxidation makes meat rancid, and oxidative stress can cause myopathies in broiler breasts

Rancidity of meat occurs when the fat in the flesh gets oxidized. There are different signs of meat rancidity: bad odor, changed color, and a sticky, slimy texture. Poultry meat is considered more susceptible to the development of oxidative rancidity than red meat. This can be explained by its higher content of phospholipids, PUFAs, especially in the thighs. The breast meat, however, has a relatively low level of intramuscular fat (up to 2 %) and, additionally, myoglobin is a natural antioxidant.

But oxidative stress in broiler breasts – and this more and more happens due to a selection of always bigger breasts – can lead to muscle myopathies such as white stripes or wooden breasts, making the meat only usable for processed products.

Sensory meat quality addresses the human senses

Besides physical quality, the sensory and chemical characteristics are essential to meat's economic importance. All attributes of meat that stimulate the human senses (vision, smell, taste, and touch) belong to the sensory quality. It, therefore, is more subjective and hard to determine. The most important features for the consumer include color (attractive or unattractive), texture (tenderness, juiciness, marbling, drip loss), and taste/ flavor (Thorslund et al., 2016).

The appearance is the first impression

Nowadays, meat is often sold as cuts lying in polystyrene or clear plastic trays, over-wrapped with transparent plastic films, so the appearance is paramount. The meat must show an attractive color. Muscle myopathies, such as the ones occurring in chickens, would not meet consumers' needs.

How does the flavor of meat develop?

There is a reaction between reducing sugars and amino acids when meat is cooked (Mottram, 1998). This Maillard reaction, along with the degradation of vitamins, lipid oxidation, and their interaction, is

responsible for the production of the volatile flavor components forming the characteristic aroma and flavor of cooked meat (MacLeod, 1994). Werkhoff et al. (1990) consider cysteine and methionine the most significant contributors to meat flavor development. One factor deteriorating this quality characteristic is lipid peroxidation, which turns the taste to rancid.

Some sensory characteristics are related to physical ones

The parameters of sensory meat quality can be partly explained by measurable parameters. Water retention, e.g., influences the juiciness of the meat. The palatability increases with higher intramuscular fat or marbling (Stewart et al., 2021), the initial pH and the speed of decline decide if the flesh will be pale, soft, and exudative or normal, and lipid peroxidation is the leading cause of a decrease in meat quality (Pereira & Abreu, 2018).

Processing quality

For the processing quality, muscle structure, chemical ingredient interactions, and muscle post-mortem changes are decisive (Berri, 2000).

Does the microbiome influence the meat quality?

The gastrointestinal tract of monogastric animals disposes of a microbiome of primarily bacteria, mainly anaerobic Gram-positive ones (Richards et al., 2005). With its complex microbial community, the digestive tract is responsible for digesting feed and absorbing nutrients, but also for eliminating pathogens and developing immunity. Gut microbiotas play an essential role in digestion, are decisive concerning the synthesis of fatty acids, proteins, and vitamins, and, therefore, influence meat quality (Chen, 2022).

Intestinal microbiotas vary by species/breeds and age (Ma et al., 2022; Sun et al., 2018), and so does meat quality. For example, Duroc pigs with meat of high tenderness, good flavor, and excellent tastiness show different microbiota than other breeds (Xiao, 2017). Zhao et al.(2022) examined high- and low-fat Jinhua pigs, with the high-fat pigs showing more increased backfat thickness but also a higher fat content in the longissimus dorsi. They found low-fat pigs showed a higher abundance of Prevotella and Bacteroides, Ruminococcus sp. AF12-5, Faecalibacterium sp.OFO4-11AC und Oscillibacter sp. CAG:155, which are all involved in fiber fermentation and butyrate production. The high-fat animals showed a higher abundance of Firmicutes and Tenericutes, indicating that they are responsible for higher fat production of the organism in general but also a better fat disposition in the flesh. Lei et al. (2022) showed that abdominal fat was positively correlated with the occurrence of Lachnochlostridium and Christensenelleceae.

The intestinal microbiota-muscle axis enables us to improve meat quality by controlling intestinal microbiota (Lei, 2022). However, to develop strategies to enhance the quality of meat, understanding the composition of the microbiota, the functions of the key bacteria, and the interaction between the host and microbiota is of utmost importance (Chen et al., 2022).

Different factors influence the microbiome

Apart from that microbiotas are different in different breeds, they are additionally influenced by diseases, feeding (diets, medical treatments with, e.g., antibiotics), and the environment (climate, geographical position). This could be shown by different trials. The genetic influence on microbiota was impressively documented by Goodrich et al. (2014), who detected that the microbiomes of monozygotic twins differ less than the ones of dizygotic twins. Lei et al. (2022) compared the microbiota of two broiler breeds (Arbor Acres and Beijing-You, the last one with a higher abdominal fat rate) and found remarkable differences in

their microbiota composition. When raising them in the same environment and with the same feed, the microbiotas became similar. Zhou et al. (2016) contrasted the cecal microbiota of five Tibetan chickens from five different geographic regions with Lohmann egg-laying hens and Daheng broiler chickens. Besides seeing a difference between the breeds, slightly distinct microbiota between the regions could also be noticed.

The intestinal microbiome can actively be changed by

- promoting the wanted microbes by feeding the appropriate nutrients (e.g., prebiotics)
- reducing the harmful ones by fighting them, for example, with organic acids or phytomolecules
- directly applying probiotics and adding, therefore, desired microbes to the microbiome.

An increase in the abundance of Lactobacillus and Succiniclasticum could be achieved in pigs by feeding them a fermented diet, and Mitsuokella and Erysipelotrichaceae proliferated by adding a probiotic containing B. subtilis and E. faecalis to the diet (Wang et al., 2022).

How to change the intestinal microbiome to improve meat quality?

Before changing the microbiome, we must know which microbes are “responsible” for which characteristics. However, the microbiotas do not act individually but as consortia. The following table shows a selection of bacteria that, besides supporting the gut and its functions, influence meat quality in some way.

Metabolites	Producing bacteria	Biological functions and effects on pigs
Short-chain fatty acids (acetate, butyrate, and propionate)	Ruminococcaceae Ruminococcus Lachnospiraceae Blautia Roseburia Lactobacillaceae Clostridium Eubacterium Faecalibacterium Bifidobacterium Bacteroides	Regulate lipid metabolism Improve meat quality
Lactate	Lactic acid bacteria Bifidobacterium	Important metabolite for cross-feeding of SCFA-producing microbiota
Bile acids (primary and secondary bile acids)	Clostridium species Eubacterium Parabacteroides Lachnospiraceae	Regulate lipid metabolism
Ammonia	Amino acid fermenting commensals Helicobacter	By-product of amino acid fermentation Inhibits short-chain fatty acid oxidation
B Vitamins and vitamin K	Bacteroides Lactobacillus	Serve as coenzymes in neurological processes (B vitamins) • Essential vitamin for proper blood clotting (vitamin K)

Table 1: Bacteria influencing meat quality (according to Vasquez et al., 2022)

Fat for meat quality is intramuscular fat

If we talk about increasing fat to improve meat quality, we talk about increasing intramuscular fat or marbling, not depot fat. The fat in meat-producing animals is mostly a combination of triglycerides from the diet and fatty acids synthesized. Fat deposition and composition in non-ruminants reflect the fatty acid composition of the diet but are also closely related to the design of the microbiome; short-chain fatty acids in monogastric, e.g., are exclusively produced by the gut microbiome (Dinh et al., 2021; Vasquez et al., 2022). Intramuscular fat is mainly made of triglycerides but also disposes of phospholipids associated with proteins, such as lipoproteins or proteolipids, influencing meat flavor. The fermentation of indigestible polysaccharides or amino acids results in short-chain or branched-chain fatty acids, respectively. Lactate, produced by lactic acid bacteria, is utilized by SCFA-producing microbiota. An imbalance in the microbiome fosters lipid deposition, as shown by Kallus and Brandt (2012), who found a higher proportion of Firmicutes to Bacteroidetes (50% higher) in obese mice than in lean ones. In a trial described by Zhou et al. (2016), tiny Tibetian chickens with a low percentage of abdominal fat were compared to two breeds (Lohmann layers and Daheng broilers) being large and with a high percentage of abdominal fat. The Tibetan chickens showed a two to four-fold higher abundance of Christensenellacea in the cecal microbiome. Christensenellas belong to the bacterial strain of firmicutes. They are linked to slimness in human nutrition, which was already proven by Goodrich et al. (2014) and is the contrary stated by Lei et al. (2022).

Another example was provided by Wen et al. (2023). They compared two broiler enterotypes distinguished by Clostridia vadinB60 and Rikenellaceae_RC9_gut and saw that the type with an abundance of Clostridia_vadinBB60 showed higher intramuscular fat content but also more subcutaneous fat tissue. The scientists also found another bacterium especially responsible for intramuscular fat: A lower plethora of Clostridia vadimBE97 resulted in a higher intramuscular fat content in breast and thigh muscles but not adipose tissues. Similar results were achieved in a trial with pigs and mice: Jinhua pigs showed a significantly higher level of intramuscular fat than Landrace pigs. When transplanting the fecal microbiota of the two breeds in mice, the mice showed similar characteristics in fat metabolism as their donors of feces (Wu et al., 2021).

According to several studies (e.g., Chen et al., 2008; Liu et al., 2019), intramuscular fat in chicken has a low heritability but may be controlled by feeding up to a certain extent. In pigs, Lo et al. (1992) and Ding et al. (2019) found a moderate to low (0.16 – 0.23) heritability for intramuscular fat, but Cabling et al. (2015) calculated a heritability of 0.79 for the marbling score.

At least, especially the composition of fatty acids can easily be changed in monogastric (Aaslyng and Meinert, 2017). Zou et al. (2017) examined the effect of Lactobacillus brevis and tea polyphenol, each alone or combining both. Lactobacillus is probably involved in turning complex carbohydrates into metabolites lactose and ethanol, but also acetic acid and SCFA. SCFAs are mainly produced by Saccharolytic and anaerobic microbiota, aiding in the degradation of carbohydrates the host cannot digest (e.g., cellulose or resistant polysaccharides into monomeric and dimeric sugars and fermenting them subsequently into short-chain fatty acids). Including fibers and various oligosaccharides was shown to increase the gut microbiome's fermentation capacity for producing short-chain fatty acids.

In a trial conducted by Jiao et al. (2020), they showed that SCFAs applied in the ileum modulate lipid metabolism and lead to higher meat quality in growing pigs. A plant polyphenol was used by Yu et al. (2021). The added resveratrol, a plant polyphenol in grapes and grape products, to the diet of Peking ducks and could significantly increase intramuscular fat.

Oxidation of lipids and proteins must be prevented

The composition of the fatty acids and occurring oxidative stress in adipose and muscle tissue influences or impacts meat quality in farm animals (Chen et al., 2022). During the last few years, the demand for healthier animal products containing higher levels of polyunsaturated fatty acids has increased. Consequently, the risk of lipoperoxidation has risen (Serra et al., 2021). Solutions are needed to counteract this deterioration of meat quality. As can be seen in table 1, ammonia produced by amino acid-fermenting commensals and Helicobacter inhibits the oxidation of SCFAs. Ma et al. (2022) changed the microbiome of sows by feeding a probiotic from mating till day 21 of lactation and achieved a decreased level of MDA, a

sign of reduced oxidative stress. Similar results were achieved by He et al. (2022). In their trial, the supplementation of 200 mg yeast ß-glucan/kg of feed significantly decreased the abundance of the phylum WPS-2 as well as markedly increased catalase, superoxide dismutase (both $p<0.05$) and the total antioxidant activity ($p<0.01$) in skeletal muscle. Another approach was done by Wu et al. (2020) in broilers. They applied glucose oxidases (GOD) produced by Aspergillus niger and Penicillium amagasakiense. Both enzymes did not disturb but improved beneficial bacteria and microbiota. The GOD produced by A. niger reduced the content of malondialdehyde in the plasma.

Another alternative is antioxidant extracts from plants (Džinić, 2015). As consumers nowadays bet more on natural products, they would be good candidates. They are considered safe and, therefore, well-accepted by consumers and have beneficial effects on animal health, welfare, and production performance.

Hazrati et al. (2020) showed in a trial that the essential oils of ajwain and dill decreased the concentration of malondialdehyde (MDA) in quails' breast meat and, therefore, lipid peroxidation and reduced cooking loss. The antioxidant effects of thymol and carvacrol were shown by Luna et al. (2010). The group receiving the essential oils showed lower TBARS in the thigh samples than the control group but similar TBARS to the butylated hydroxytoluene-provided group.

Protein quality is a question of essential amino acids

Protein with a high content of essential amino acids is one of the most critical components of meat. Alfaig et al. (2014) tested probiotics and thyme essential oil in broilers. They found out that the content of EAAs in breast and thigh muscles numerically increased gradually from the control over the probiotic and a combination of a probiotic up to the thyme essential oil group. A significant ($p<0.05$) increase in all tested amino acids (arginine, cysteine, phenylalanine, histidine, isoleucine, leucine, lysine, methionine, threonine, and valine) could be observed in the samples of the breast and the thigh muscles when comparing the thyme essential oil group with the control. Zou et al. (2017) provided similar results, showing a significant increase in leucine and glutamic acid as well as a numerical increase in lysin, valine, methionine, isoleucine, phenylalanine, threonine, asparagine, alanine, glycin, serin, and proline through the addition of a combination of Lactobacillus brevis and tea polyphenols. They also determined an increase in the beneficial bacteria Lactobacillus and Bacteroides. The experimental results led them to the assumption that both additives may also improve the taste of meat by increasing some of the essential and delicate flavors produced by amino acids.

Tenderness is closely related to drip loss

The already mentioned trial conducted by Lei et al. (2022) with two different broiler breeds (Arbor Acres and Beijing-You) having different microbiota showed a negative correlation between drip loss and the abundance of Lachnochlostridium. They remodeled the Arbor Acres' microbiome by applying a bacterial suspension derived from the Beijing-You breed and decreased drip loss in their meat. He et al. (2022) changed the microbiome by adding yeast ß-glucan to the diet of finisher pigs. They achieved a reduced cooking loss (linear, $p<0.05$) and a lower drip loss ($p<0.05$), together indicating a better water-holding capacity, as well as a decreased lactate content. The addition of a multi-species probiotic to the diet of finishing pigs tended to result in lower cooking and drip loss($p<0.1$) besides modulating the intestinal flora (higher lactobacilli and lower E. coli counts in the feces) (Balasubramanian et al., 2017) and the inclusion of Lactobacillus brevis and tea polyphenol individually or in a synergistic combination improved water holding capacity and decreased drip loss Zou et al. (2017).

Puvača et al. (2019) observed the lowest drip-loss values in breast meat and thigh with drumstick through feeding chickens 0.5 g or 1.0 g of hot red pepper per 100 g of feed, respectively, in the grower and finisher phase. The feeding of resveratrol reduced drip loss of Peking ducks' leg muscles. SCFA infused into the ileum enlarged the longissimus dorsi area and alleviated drip loss (Jiao et al, 2021).

The decrease and increase of the pH after slaughtering determines meat quality

The pH in the muscles of a living animal is about 7.2. With slaughtering and bleeding, the energy supply of the muscles is interrupted. The stored glycogen gets degraded to lactic acid, lowering the pH. Usually, the lowest pH value of 5.4-5.7 in meat is reached after 18 to 24 hours. Afterward, it starts to rise again.

In stressed animals, the stress hormones adrenalin and noradrenalin provoke a rushly occurring and, due to a lack of oxygen, anaerobic metabolism and the quick production of lactic acid. This too rapid decrease in pH leads to the denaturation of proteins in the muscle cells and reduced water-holding capacity. The result is PSE (pale, soft, and exudative) meat.

On the contrary, DFD meat (dark, firm, and dry) occurs if the glycogen reserves, due to challenges, are already used up, and the lactic acid production is insufficient. Especially PSE meat is closely related to breeds – some are more susceptible to stress, others less. However, some trials show that influencing pH in meat is possible to a certain extent.

He et al., 2022 added yeast ß-glucan to the diets of finishing pigs and a higher $pH_{45\ min}$ (linear and quadratic, $p<0.01$) and a higher redness (a*; linear, $p<0.05$) of the meat. Wu et al. (2020) achieved a significantly increased pH_{24h} through the addition of Glucose oxidase produced by Aspergillus niger.

Sensory characteristics are very subjective

In general, the sensory characteristics of meat are seen very individually. Some prefer lean, others fatty meat, some like meat with a characteristic taste, and others with a neutral. However, the typical meat taste of umami is partly determined by the nucleotide inosine monophosphate (IMP), which is regarded as an essential index for evaluating meat flavor and the acceptability of meat products. IMP provides about 40-fold higher umami taste than sodium glutamate (Huang et al. 2022).IMP is the organophosphate of inosin. Inosine, however, according to Kroemer and Zitvogel (2020), is produced by Bifidobacterium pseudolongum, which possibly can be controlled by feeding. Sun et al. (2018) compared Caoke and Partridge Shank chickens and divided them into free-range and cage groups. They found out that, except for acids, the amounts of flavor components were higher in the free-range than in the cage groups. The two housing systems also modified the microbiota, and Sun et al. took it as an indication that meat flavor, as well as the composition and diversity of gut microbiota, are closely associated with the housing systems. Fu et al. (2023) examined the addition of a mixture containing Pulsatilla, Gentian, and Rhizoma coptidis and a mixture with Codonopsis pilosula, Atractylodes, Poria cocos, and Licorice to the feed of Hungarian white geese. They saw that in both groups, the total amino acid levels, especially Glu, Lys, and Asp, increased, with, according to Liu et al. (2018), Glu and Asp directly affecting meat's freshness and flavor. Yu et al. (2021) achieved similar results by adding resveratrol to the diet of Peking ducks. The addition of the herbs additionally led to a higher Firmicutes/Bacteroidetes ratio and an increased level of lactobacilli (Fu et al., 2023).

How can EW Nutrition's feed additives help to improve meat quality?

Meat quality is influenced by the microbiome. So, feed additives that stabilize the microbiome or promote certain beneficial bacterial strains are an opportunity.

Ventar D modulates the microbiome

Ventar D balances the microbiome by promoting beneficial bacteria such as lactobacilli and fighting harmful ones such as Clostridia, E. coli, and Salmonella. (Heinzl, 2022). In another trial with broilers, the addition of Ventar D to all feeds (100 g/t) showed an increase in short-chain fatty acids in the intestine:

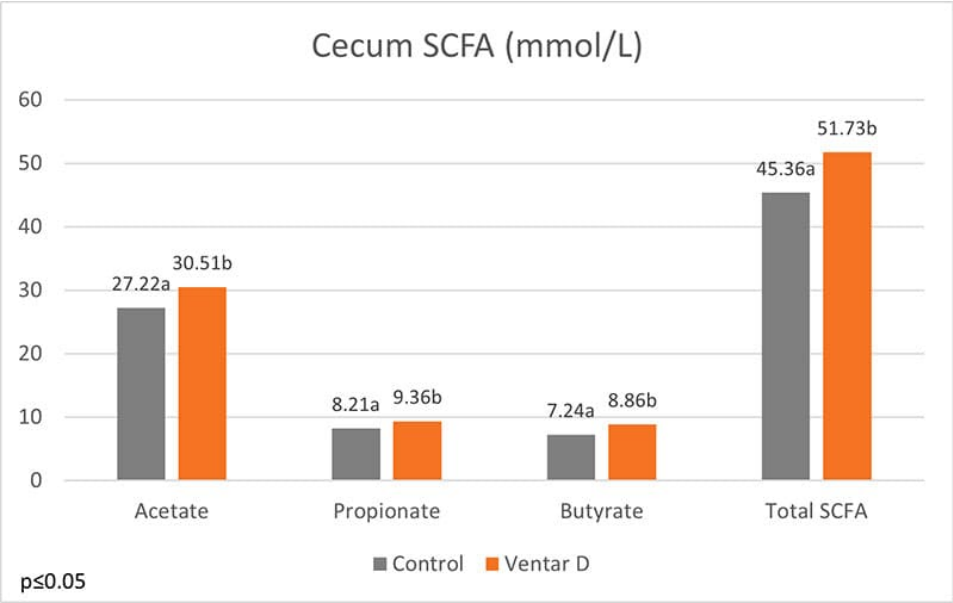

Figure 1: Short-chain fatty acids in the cecum of broilers

Santoquin countersteers oxidation

Another helpful product category is antioxidants. They can prevent the oxidation of lipids and proteins. For this purpose, EW Nutrition offers Santoquin M6*, a product tested by Kuttapan et al. (2021). Santoquin M6 was tested concerning its ability to minimize the oxidative damage caused by feeding oxidized fat. A control group receiving oxidized fat in feed was compared to one receiving oxidized fat plus 188 ppm Santoquin M6 (≙125 ppm ethoxyquin). The main parameters for this study were TBARS in the breast muscle, the incidence of wooden breast, and the live weight on day 48.

Results indicated that the inclusion of Santoquin M6 reduced the production of TBARS in the breast muscles, demonstrating a lower level of oxidative stress in the breast muscles.

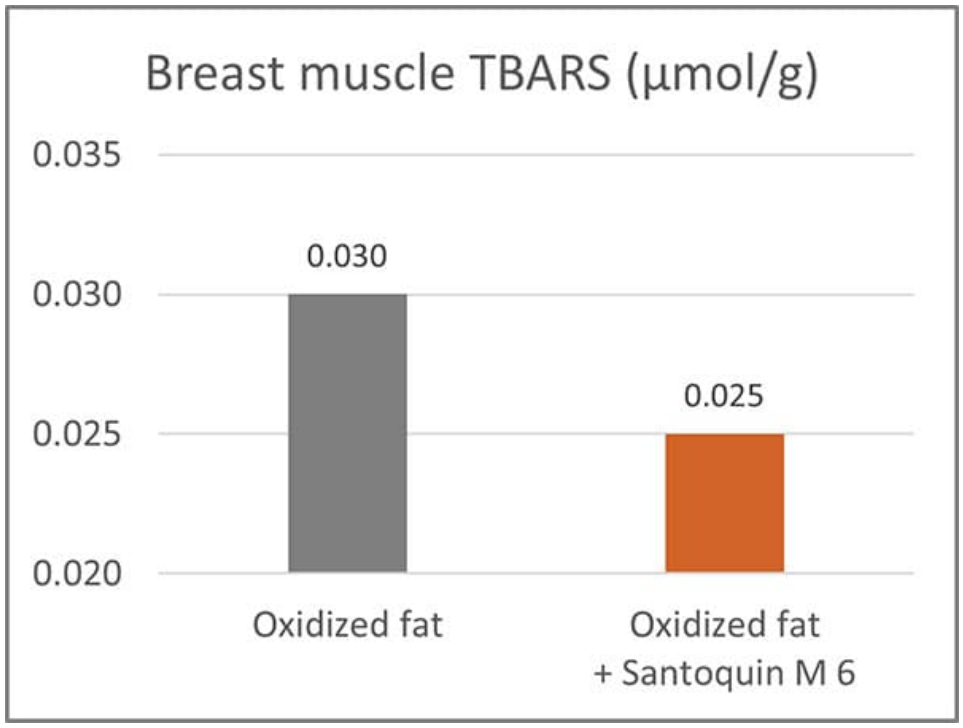

Figure 2: Thiobarbituric acid reactive substances (TBARS) in broiler breast muscles. TBARS are formed as a by-product of lipid peroxidation.

Additionally, it reduced the incidence of severe woody breasts (Score 3) by almost half and helped

mitigate the impact of breast muscle degradation due to increased oxidative stress.

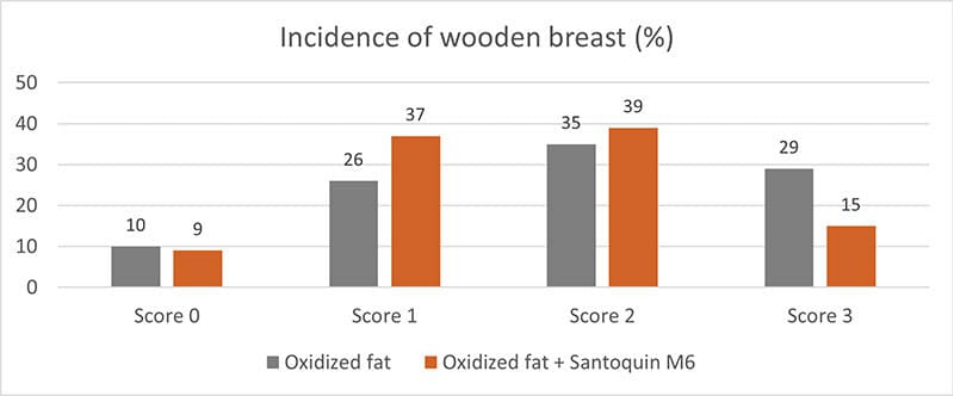

Figure 3: Incidence of wooden breast in broilers

*Usage of ethoxyquin is dependent on country regulations.

Feed hygiene with Acidomix products minimizes harmful pathogens

The Acidomix product line offers liquid, powdery, and micro-granulated products to be added to feed and water. The organic acids in Acidomix directly act against pathogens in the feed and the water and help keep the intestinal flora in balance.

A trial evaluating the effect of different Acidomix products against diverse pathogens showed lower MICs for most Acidomix products than for single organic acids. The trial was conducted with decreasing concentrations of the Acidomix products (2 – 0.015625 %) and 10^5 CFU of the respective microorganisms (microtiter plates; 50 µl bacterial solution and 50 µl diluted product).

Feeding is the one side, slaughtering the other one

With feeding, the microbiota and some meat characteristics can be changed; however, the last step, handling the animals before and the meat after slaughtering also significantly contributes to a good quality of meat. Stress due to the transport and the slaughterhouse atmosphere, combined with stress-sensible breeds, can lead to PSE meat. Incorrect handling at the slaughterhouse can lead to meat contaminated with pathogens.

Combining feeding measures with professional and calm handling of the animals is the best strategy to achieve high-quality meat.

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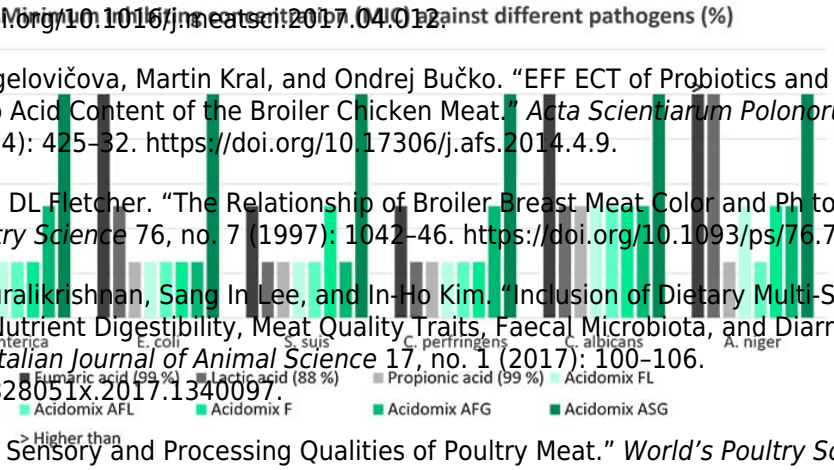

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