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Feed Efficiency and Targeted Genetic Selection as the Key for Sustainable Performance and Profitability in Laying Hens

Written by:

Dr Sylwia Sobolewska NSch

October 2024

A NUFFIELD FARMING SCHOLARSHIPS REPORT

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NUFFIELD Farming Scholarships

Date of report: October 2024

Title	Feed Efficiency and Targeted Genetic Selection as the Key for Sustainable Performance and Profitability in Laying Hens
Scholar	Dr Sylwia Sobolewska
Sponsor	The British Egg Marketing Board Research and Education Trust (BEMB)
Objectives of Study Tour	1. What are the tools to assess layer profitability. 2. To evaluate market opinion on feed additives for layers. 3. To understand if genetics and artificial intelligence can help with improving feed efficiency. 4. What is best practice to achieve the most profitable feed efficiency
Countries Visited	UK, USA, Canada, Poland, Spain, Zambia, Kenya, Hungary, Czech Republic, Israel, Netherlands
Messages	1. There is no index for layers to easily assess their profitability. 2. Feed efficiency can be improved significantly when more feed additives are used in laying hens' diets. 3. White layers are more sustainable and more profitable compared to brown birds. 4. Low cost and high functionality are still a challenge with the technology supporting feed efficiency.

EXECUTIVE SUMMARY

The global population is forecast to reach 9.7 billion in 2050. Eggs are one of the best sources of high-quality protein. To assure the number of eggs to satisfy the rising food demand without compromising economic losses, the feed efficiency of laying hens needs to be improved. More efficient feed systems will not only give economic benefits to farmers but will also have a positive impact on the environment.

This study aims to identify the best way to achieve the most profitable feed efficiency. During the study tour the available tools for layer profitability were assessed. Moreover, market opinion on feed additives for layers was evaluated to see how genetics and artificial intelligence can help with feed efficiency improvement.

Feed additives are substances and chemical compounds which are added to feed but are not essential and do not constitute basic nutrients. The feed additives which were discussed during the study are probiotics, prebiotics, postbiotics, enzymes, organic acids, medium-chain fatty acids and phytobiotics. Feed additives should be used more often in laying hens' diets as they can improve the feed conversion ratio (FCR), egg production, health and consequently profitability of the birds.

Poultry farming is the fastest growing livestock husbandry sector. The average improvement of FCR for layers is around 0.005 kg feed/dozen eggs/year. White laying hens are more profitable and sustainable compared to brown layers. The production traits like FCR, egg production and liveability are better for white layers. Moreover, white laying hens can be kept for more than 100 weeks and the carbon footprint is lower compared to brown layers.

The new technologies which can significantly improve gut health and target feed formulation for laying hens are still in the process of development. The biggest challenge for technological improvement is balancing low costs with high functionality. It would be helpful to organise meetings of farmers from the same area to compare anonymously their production data. In this way it would be easier to get the solutions for best practice.

Even though sustainability is currently a big topic, there is no space for any products which only improve sustainability in laying hens. Egg producers prioritise production output and feed intake over feed efficiency metrics. This is why it's more difficult to get egg producers to change diets solely for improving feed efficiency. However, there are numerous feed additives which improve the quality of feed and, at the same time, improve nutrient utilisation efficiency, egg production and the health status of birds which in turn leads to less ammonia emissions and reduces the carbon footprint.

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DISCLAIMER

The opinions expressed in this report are my own and not necessarily those of the Nuffield Farming Scholarships Trust, or of my sponsor, or of any other sponsoring body.

All photos are the author's own unless otherwise stated.

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CHAPTER 1: INTRODUCTION

I grew up in a city in Poland and have always been passionate about animals. I love expanding my knowledge and pursuing my passions. The natural way to expand my knowledge was to study Animal Production and Science (BSc), Animal Nutrition (MSc) followed by a PhD. I was always passionate about nutrition. This is why my masters and bachelor theses were on phytase in poultry and my PhD topic was: The Effect of Antioxidants in Feed Enriched with Omega-3 Fatty Acids on Fatty Acid Profile and Antioxidant Stability of Eggs and Feed.

Figure 1: The author, Dr Sylwia Sobolewska.

During my time at university, I volunteered and had internships at vet clinics, dog schools, beef farms, the Wrocław zoo in Poland, dog shelters in Germany and game reserves in Namibia.

Following my PhD studies, I started work as a research assistant at Wroclaw University of Environmental and Life Sciences in Poland teaching Animal Nutrition and Feed Science, Ecotrophology and Statistics for Animal Science. I also conducted trials on poultry and worked closely with Wroclaw Medical University in which I hatched eggs and examined the influence of dioxins on birds and rats.

I came to the UK in 2017 as a research assistant at Harper Adams University. I decided to stay in the UK and change my carrier path from a scientific to a commercial role. Currently I work as a senior technical and account manager for Anpario plc which is an independent British manufacturer and international distributor of natural feed additives for animal health, nutrition and biosecurity. I'm in the team covering Europe where I cover 10 countries. Thanks to my scientific background I can organise training for customers and co-workers and I conduct commercial trials in poultry. I really like connecting the two worlds as I think it's very important to undertake research to provide a full statistical analysis. However, profitability and efficiency is a must-have for every farm.

Outside work, I like to spend time with my family and friends. I also like to travel, sightsee and try new, local foods. I like to cook and bake and to replicate what I've eaten during my travels. I enjoy reading and spending time in my garden. I can't imagine my life without dogs and exploring woods and the local environment with them.

CHAPTER 2: BACKGROUND TO MY STUDY SUBJECT

The global population is forecast to reach 9.7 billion in 2050 and around 10.4 billion during 2080 (United Nations, 2022). The UK population is growing as well and it's predicted to reach 76.6 million by mid-2046 (Figure 1.; ONS, 2024). To feed this number of people, food production needs to be increased by an estimated 56% (van Dijk et al., 2021). Eggs are one of the best sources of high-quality protein (Puglisi and Fernandez, 2022). Therefore, the UK poultry sector could make a significant impact on providing food for the growing population. However, to protect natural resources, all available techniques need to be used to sustainably increase the number of eggs without compromising the environment.

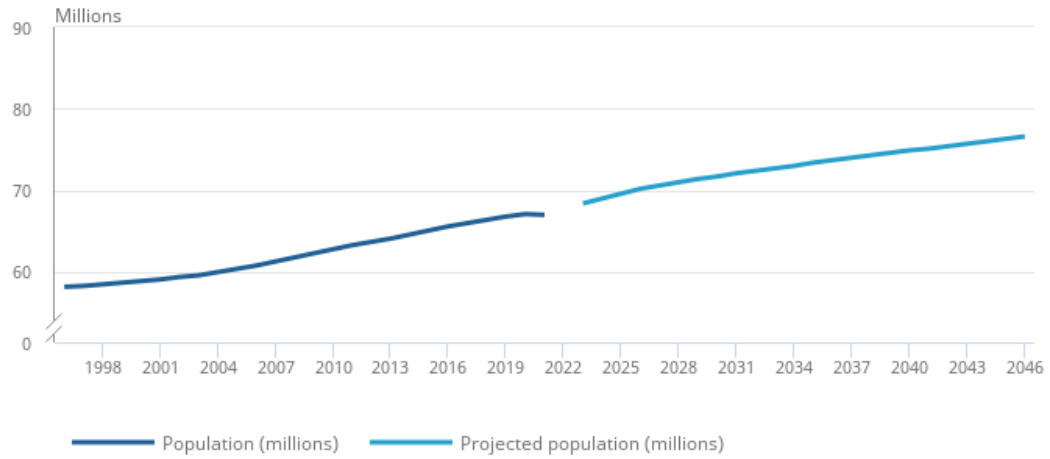

Figure 2: Population estimates in the UK (ONS, 2024)

The cost of feed contributes to 60-70% of the total production cost (Clark et al., 2019). To guarantee the number of eggs to satisfy the rising demand for food without risking financial losses, the feed efficiency of laying hens needs to be improved. More efficient feed systems will not only give economic benefits to farmers but will also have a positive impact on their carbon footprint and the environment.

Maintaining the feed intake of layer hens whilst keeping the egg mass and egg production level, improves the profitability of the production systems. The conversion of feed into eggs depends on many factors such as feed composition, genetic selection, environment (temperature, light, humidity) and the technology used in the sheds (robots, modern equipment).

The data shows that average egg production in the UK can be still significantly increased without compromising the health of the birds. Improved profitability of birds can be achieved by using speciality feed additives, targeted genetic breeds and adjusted technologies

CHAPTER 3: MY STUDY TOUR

Date	Country
January and February 2023	USA
February, May to June and October 2023	Poland
March 2023	Canada
April 2023	Spain
April and May 2023	Kenya
April 2023	Zambia
May 2023	Hungary
July 2023	Israel
October 2023	Czech Republic
January 2024	Netherlands
December 2023 to May 2024	UK

CHAPTER 4: THE EGG INDUSTRY – MAIN CHALLENGES

The significance of different challenges varies depending on country, production system and chosen strain of birds. However, the parameters below and the issues are shared amongst most people I interviewed:

- Production parameters to be improved:
  - Egg production
  - More bigger eggs at the beginning of lay and then getting large eggs (the Netherlands) or above large eggs (USA and Canada).
  - Better shell quality (especially after 55 weeks old)
  - Persistence of lay
  - Liveability
- Health issues:
  - Reduced stress for example during transport
  - Gut health
  - E. coli
  - Salmonella
  - Better liver health – especially protection from fatty liver
  - Manure moisture
  - Pecking
  - Newcastle Disease
  - Avian Influenza
- Economic issues:
  - Feed price

From the countries I visited, only the Netherlands and the UK set sustainability and improving the carbon footprint as goals in the poultry industry. Life Cycle Analysis (LCA) is a tool which is used to assess the impact of egg production on the environment. The key drivers are feed, pullets and manure management.

The Feed Conversion Ratio (FCR) is the first parameter which broiler and turkey producers want to improve. However, feed efficiency is generally not the main focus within the layer industry. From all the countries visited, only in the US, Poland and Israel is it considered as one of the parameters which should be improved.

CHAPTER 5: FEED EFFICIENCY

To maintain high quality production and to assure profitability, it is essential to calculate the feed efficiency of laying hens. The most common parameters which allow us to assess the feed efficiency in layers are:

- Feed Conversion Ratio (FCR):
  - Per kg of eggs mass

$$FCR\ (per\ kg\ egg) = \frac{Feed\ consumend\ (kg)}{Egg\ produced\ (kg)}$$

  - Per production of 1 egg

$$FCR\ (per\ 1\ egg) = \frac{Feed\ consumend\ (kg)}{Eggs\ produced}$$

  - Per production of dozen eggs

$$FCR\ (per\ dozen\ eggs) = \frac{Feed\ consumend\ (kg)}{Egg\ produced\ (kg)} \times 12$$

- Egg income minus feed cost

However, as Hristo Lukanov from Trakia University in Bulgaria pointed out, there is an absence of a commonly used economic indicator which would assess the profitability of layers' production. Feed efficiency equations for laying hens don't take into account liveability, which has a direct impact on profitability and is an indicator of the birds' health and welfare.

In contrast, in the poultry meat industry there are two main economic indexes: European Broiler Index (EBI) and European Production Efficiency Factor (EPEF) which has been used for more than 40 years.

$$EPEF = \frac{Viability\ (\%) \times Body\ Weight\ (kg)}{Age\ (d) \times FCR(kg)} \times 100$$

$$Viability\ (\%) = 100 - Mortality\ (\%)$$

$$FCR = \frac{Feed\ consumend\ (kg)}{Weight\ gain\ (kg)}$$

This is why Dr Lukanov and his team created the Egg Production Efficiency Index (EPEI) for laying hens. EPEI is based on the main productive traits which affect egg-producing profitability. Dr Lukanov adapted the existing economic indexes from the broiler industry to the egg industry. The EPEI takes into account liveability and

egg mass produced as it combines the two most important productive traits: egg-laying capacity and egg weight. The feed conversion ratio is also a unifying feature that represents the transformation of feed into output.

$$Daily\ egg\ mass\ produced = \frac{Hen - Day\ egg\ production\ (number) \times Average\ egg\ weight)}{period\ (days)}$$

$$EPEI = \frac{(Liveability \times Daily\ egg\ mass\ produced)}{FCR\ (per\ kg\ egg)} \times 100$$

Teun van de Braak (Manager Global Technical Service & Customer Support) and Estella Leentfaar (Product Manager) from Hendrix Genetics in the Netherlands have said that the lowest FCR for their layers is in the US and it is 1.9. The explanation for it is the use of more concentrated diets based on corn and soya and keeping birds in cages.

CHAPTER 6: FEED ADDITIVES

Feed additives are substances and chemical compounds which are added to feed but are not essential and do not constitute basic nutrients. They can improve palatability of feed, digestibility and absorption of nutrients, increase egg production, growth of birds and have a positive effect on the health of birds (Zawadzki, 2008). The feed additives which are going to be discussed are probiotics, prebiotics, postbiotics, enzymes, organic acids, medium-chain fatty acids and phytobiotics.

The beneficial influence of feed additives is not normally seen on the first day, this is why they are not always added to feed for laying hens. The decision to add feed additives often depends on egg price and margins. This is why feed additives are much more commonly used in organic and cage-free production.

Vitor Arantes, who is the Global Technical Services Manager at Hy-Line International, said: "Farmers who choose prevention instead of fixing problems seems to have better financial results." Feed additives work best when they are applied in small quantities every day for animals instead of only when there is already an existing problem like peritonitis.

In the US the goal is to not spend any extra money on feed for laying hens. Even some vaccinations are not used if they are not crucial. However, if it can be proved that using feed additives will add an extra three eggs per hen then it can be enough to justify the additional cost. In Canada feed additives are more often used which is probably related to higher egg prices due to their quota system. Synbiotics and phytobiotics are mostly used as an insurance policy instead of only for challenges. However, all the interviewed nutritionists agreed that to improve feed efficiency in laying hens, it's advisable to add feed enzymes and feed additives which improve gut health.

Broiler and turkey farmers take a different approach and use more feed additives compared to layer farmers. Craig Maynard, Director of Poultry Nutrition at Bell & Evans in the USA, said thought should be given to how to feed the microbiome, not the chicken.

6.1 Probiotics, prebiotics, synbiotics and postbiotics

Probiotics are products which contain life microorganisms like lactic acid, bacteria, and yeast. They are used to regulate the composition of microflora in certain parts of the host (Wang et al, 2021). Prebiotics are used to support beneficial bacteria in the gut but they are non-digestible by the host (Gibson and Roberfroid, 1995). Feed additives which contain probiotics and prebiotics are called synbiotics (Zawadzki, 2008). Postbiotics are inanimate microorganisms and/or their metabolites (Vinderola et al. 2022). The mode of action is similar to probiotics but instead of life microorganisms, only the beneficial active compounds are added to the birds' diet.

Probiotics are well established products which are widely used and liked by producers, nutritionists and vets. In the US they are mostly used during stressful periods even though the best results are when they are used daily. The favoured option in the US are synbiotics containing mannan oligosaccharides (MOS) from yeast cell-walls. Different species of bacteria are popular in different countries. In the US probiotics with *Lactobacillus spp.* are often used, in Poland with *Bacillus spp.* or *Enterococcus spp.* and in the Netherlands with *Bacillus subtilis*.

In the US probiotics are used to help with cocci issues in turkeys. As for layers, probiotics are used more during challenges or to 'boost' birds' health. For example, if they are used once a week the birds can be seen to be less lethargic immediately. In Poland probiotics are used in the first days of production for poultry and during and after antibiotic use.

Louis Hurdidge, Key Account Manager for Lallemand Animal Nutrition in the UK, said that it's important to use probiotics, generally non-host origin organisms as it's not recommended to use microorganisms which can dominate in chickens' guts but instead support the natural microbial balance. Louis Hurdidge emphasised that in choosing the right probiotic it is crucial to check the influence of heat treatment on the living organisms within the probiotics and their recovery after the heat treatment. For example, heat treatment promotes spore germination in *Bacillus spp.* which may mean that the probiotic is less effective. Microencapsulate probiotic can be used as an alternative for heat treated or pelleted feed.

Postbiotics are a new and very interesting product within the poultry feed market although they are not well known within the poultry industry. Trials by Hagen Schulze from Livalta, and AB Agri company in the UK, are showing that beyond positively influencing healthy development and welfare of the bird, postbiotics can improve the digestion of feed, FCR, body weight gain and egg size in antibiotic-free production systems.

6.2 Phytobiotics

Phytobiotics are also called phytogenics or phytochemicals. They are non-nutritive bioactive compounds of plant origin. There are more than 5,000 phytobiotics which have been found i.e. in essential oils, herbs, fruits, vegetables and nuts (Kikusato, 2021).

A few nutritionists I interviewed said that they don't use phytobiotics as they don't know enough about them to feel safe in recommending them to their customers. Probiotics and prebiotics are more established and this is why they are recommended more often.

There are numerous trials on phytobiotics but even choosing a phytobiotic made from one plant, there are still countless possibilities of what is in the product. Firstly, genetic, seasonal and environmental factors have an influence on the composition of phytobiotics (Figure 2.). This is why when phytobiotics are used it's important to check the consistency of the chosen products. In Hungary, at a company which specialises in rectification of essential oils which are used in products such as Orego-Stim. Balázs Bartyik (Innovation Director in an Anpario strategic partner) explained how important it is to check the profile of essential oils in plants before harvesting and in which way the oil is going to be extracted. Moreover, the essential oil profile needs to be checked after production to assure consistency.

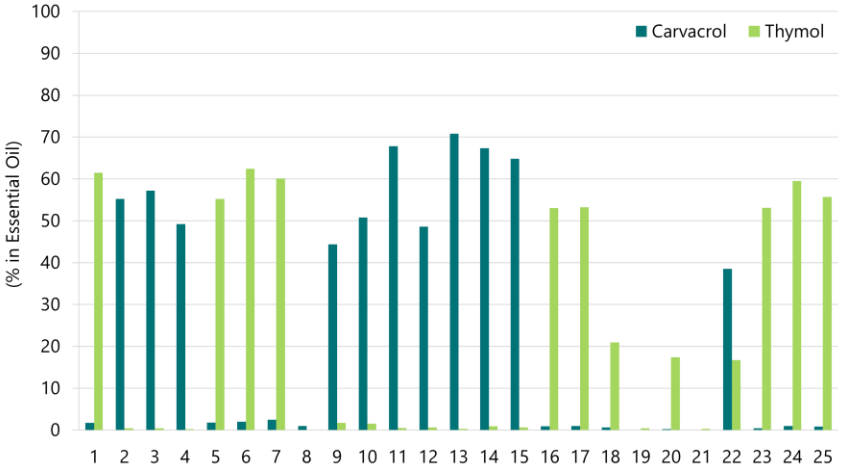

Figure 3: Carvacrol and thymol levels in oregano essential oil from Southern Italy (Mastro et al, 2017)

Products containing oregano oil are quite often used for poultry. In the Netherlands they are used for gut health, in the US for bacterial challenges and respiratory problems, in Poland to support the immune system and for bigger egg production. Garlic extracts are another example of popular phytobiotics used in poultry nutrition. They are used for general health in the Netherlands and Poland where they are used mostly during the winter months and early spring. Phytobiotics, like turmeric (*Curcuma longa*), are also used to improve yolk colour. There are also a lot of blends of essential oils on the market which are used for gut health and to prevent diarrhoea. Phytobiotics work very well with probiotics and organic acids. Using all three can deliver the best results.

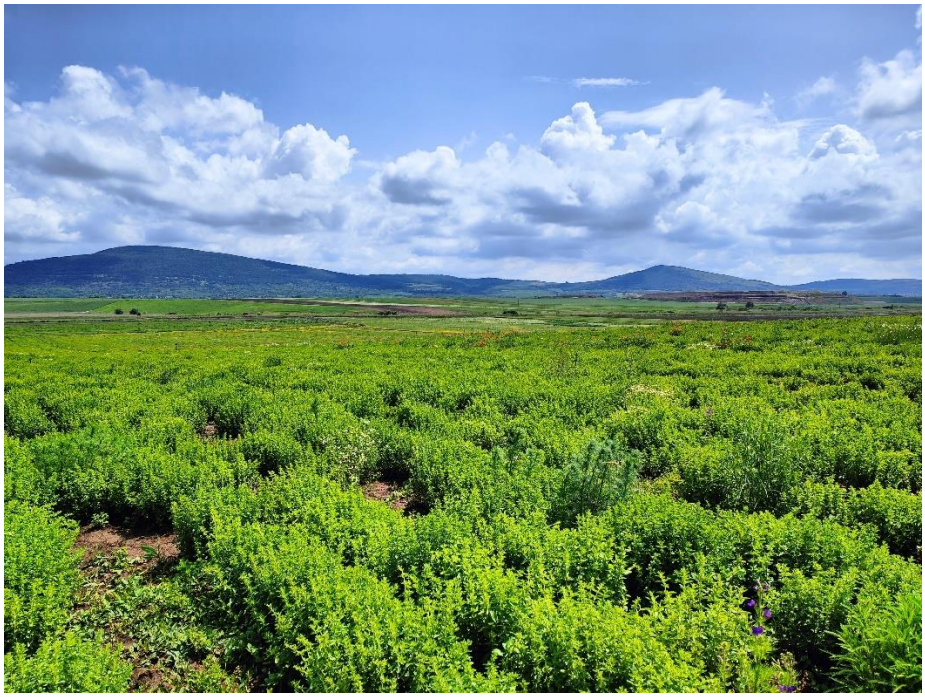

Figure 4: Oregano field in Hungary

6.3 Medium-chain fatty acids

Medium-chain fatty acids (MCFA) are saturated fatty acids with 6 to 12 carbon atoms. MCFA used as feed additives are naturally present in milk, coconut oil and palm kernel oil (Liu et al. 2020). They are not very popular but they are used in the poultry industry. For example, in Israel lauric acid is used for gut health. In the Netherlands MCFA are used for gut health and health support but the results are inconsistent.

6.4 Organic acid-based products

Organic acid-based products contain short chain organic acids and their salts. The most popular organic acids are: formic, propionic, citric, lactic and sorbic acid (Zawadzki, 2008). Depending on the carrier, they can be used for pathogen control in feed and/or for gut health of birds.

Organic acid-based products are commonly used for pathogen control in raw materials or feed in countries where formaldehyde is banned. Mostly they contain two or more organic acids, of which the most popular are: formic, propionic, lactic and acetic acid. Organic acid-based products are also used for gut health. In this case, it's important what type of carrier is used to ensure it goes through the stomach barrier.

Organic acids can be also used as water additives to acidify water for birds. The most popular acids are: formic, propionic, lactic, acetic, citric and their mixtures. For optimum results, it's important to achieve pH4 which will ensure the best kill rate.

Organic acids in waterlines are used mostly for gut health and to prevent diarrhoea. In Poland butyric acid esters are used to prevent diarrhoea followed with hydrogen peroxide to prevent biofilm build up.

Tributyric acid is used for gut health and egg shell quality when birds are older. However, Michael Leslie (Poultry Nutritionist from Ritchies Smith Feeds in Canada) uses butyric acid only for broilers as he didn't see any effect in layers. In Poland Calcium butyrate is used for better absorption of nutrients as it supposed to enhance growth of villi in the gastrointestinal tract. In Brazil butyric acid is used during the first five weeks for pullets to develop more beneficial microbiome and for better growth of villi.

6.5 Feed enzymes

Feed enzymes break down indigestible ingredients in poultry feed, which improve digestibility (Zawadzki, 2008). The most commonly used enzyme is phytase which makes phosphorus from plants available for birds. Phytase has influence not only on better mineral digestibility but also on lower phosphorus extraction. Moreover, using phytase reduces the cost of feed as less mineral phosphorus is required. There is a trend to super-dose phytase (2-3 times the amount of the standard inclusion rate) to benefit production and possibly egg shell quality. Michael Elliot (poultry nutritionist from USA) uses super-dose phytase from 55 weeks to the end of lay (around 90-95 weeks).

Non-starch polysaccharides (NSP) are a big part of poultry diets as they are present in cereals. Soluble NSP have a high-water retention capacity which has an influence on increased viscosity, excreta moisture and poorer digestion. NSP enzymes can hydrolyse NSP. The main one is xylanase which is the second most used enzyme in poultry diets. Michael Leslie (poultry nutritionist from Canada) uses xylanase to improve feed intake and to get less 'sticky' manure which is important for poultry management. The other NSP enzymes are β-glucanase and cellulose or hemicellulose. As Gina Harris (poultry nutritionist from the USA) said: "NSP enzymes are important to limit gut viscosity and help improve digestion and passage rate."

Another enzyme which is used in poultry diets is protease. However, the level of protein is not as high in laying hens' diets. This is why the use of protease is not as necessary as for broilers or turkeys.

Lipase and emulsifiers are not as common. Emulsifiers help with digestion, but the added value is not always seen as Europe has good quality plant oils. If palm oil is used, then it's necessary to use emulsifiers.

6.6 How to choose the right feed additive?

Feed additives are a tricky part of layers' diets. They can help a lot and improve feed efficiency, health and consequently profitability. However, not all the products on the market deliver what they promise. Outlined below are a few situations that occur across all of the visited countries, which can reduce improvement in layer production:

1) It's believed that good management of birds reduces the need for feed additives.
2) There is little belief in the scientific value of feed additives.
3) Maintaining the status quo, as unnecessary change may result in problems.

The genetic potential of current birds is brilliant and it's improving every year. To keep up with it, the feed should be improved as well to help the birds to reach their full genetic potential. Unfortunately, there are so many feed additives in the market that it's really hard to choose the right one. Michael Leslie (Poultry Nutritionist from Ritchies Smith Feeds in Canada) said that only 10-15% of their internal trials showed positive results after using feed additives.

To determine whether a certain company and a product is a good fit for a farm, it's good to check:

1) Is the product registered and safe for use in laying hens?
2) How many scientific and commercial trials were done in layers? What are the results and were there significant differences between experimental groups?
3) How is the consistency of the product assured?
4) Are there available trials on the heat stability of the product and what is the recovery after any heat treatment?
5) What is the return on investment (ROI) of the product?
6) Is it possible to run a trial with the product to check how it works at this particular farm?

CHAPTER 7: GENETIC SELECTION

Poultry farming is the fastest growing livestock husbandry sector (Mottet and Tempio, 2017). World egg production was 93 million tonnes in 2022 which is 69% more compared to 2000 (FAO, 2023). This is why genetic selection must always be of a very high standard.

Dr Danny Lubritz Director of Research and Development from Hy-Line said that feed efficiency is one of the top selection targets for broiler breeders. Feed efficiency is important for layers as well as egg production, egg weight, shell strength, robustness and liveability. Feed efficiency was always on the target list for layers they just selected on indirect measures of feed efficiency like lower feed intake, reduced body weight and increased egg production. Today there are more direct measures of feed efficiency being considered such as feed residuals. It's four years from the moment when pedigree birds are selected to when commercial birds come to market. The average improvement of FCR for layers is around 0.005 kg feed/dozen eggs per year. For comparison it's 0.02 kg feed/kg gain for broilers.

Target selection parameters are hard to classify as it's always a combination between them, moreover their prioritisation is linked to the market in the country. John Wynn-Higgins from Novogen in the UK said that laying persistency and liveability are the most important selection parameters, however egg size profile and egg quality are always taken into consideration. Feed efficiency is an important economic trait which is related to other parameters like persistency, liveability and egg size. "Egg producers make money if they produce a lot of eggs per hen housed with good FCR."

Teun van de Braak (Manager Global Technical Service & Customer Support) and Estella Leentfaar (Product Manager) from Hendrix Genetics in the Netherlands said that the longtime goal is to achieve 1,000 eggs in 180 weeks. This will be possible in around 50 years' time. Currently the best result belongs to the DeKalb White layer breed which can produce up to 592 eggs per hen housed. Hendrix Genetics is focusing on consistency of production instead of feed intake which will result in lower FCR. Teun and Estella believe that one of the overlooked factors influencing high production of layers are pullets' development: "If you want to have a 500 eggs flock, you need to invest in your pullets."

7.1 What is the direction: white, brown or dual-purpose birds?

The colour of birds can be dictated by consumers, religion and availability of specific genetics in the country. In a lot of countries in Europe and Africa, consumers prefer brown eggs as they believe that they are healthier and more natural compared to white eggs. In Israel there are only white layers as white eggs contain less blood and meat spots. Moreover, it's easier to see any contamination

on egg shells. In some countries in Africa, like Zambia, there is no choice in birds' genetics as the only option available are brown birds.

Figure 5. On the left Hy Line Brown layer hens in Zambia and on the right DeKalb White layers in the Netherlands

In the 1970s in the UK, consumers switched to brown eggs as they were advertised as more natural and healthier compared to white eggs which were linked to hens in cages. Now the shift is back toward white eggs which are more sustainable. However, in the UK there are currently around 8% of white birds.

Peter Van Horne (poultry economist at Wageningen University in the Netherlands) said that white layers have a 5% lower carbon footprint, lower FCR and there is less pecking in flocks compared to brown layers. In the Netherlands, the production costs of white eggs are 8% lower compared to brown eggs as white layers produce more eggs and they can be kept for more than 100 weeks. Other people who were interviewed mentioned that white layers have less intestinal problems, better gut health and higher liveability compared with brown layers.

Dual purpose birds are mostly used in Africa and in some parts of Germany. The dual-purpose birds lay less eggs than layers and grow slower than broilers so they are not profitable and they have a worse impact on the environment compared to specialised birds.

CHAPTER 8: TECHNOLOGIES SUPPORTING BETTER FEED EFFICIENCY

The new technologies which can significantly improve gut health and target feed formulation for laying hens are still in the process of development. Currently feed efficiency can be improved by installing good ventilation and evaporative cooling pad systems which protect big fluctuations in temperature in buildings during summer. Moreover, the right lighting is very important. New solutions show the positive influence of different colours of lighting on birds. Nevertheless, it's still new and more investigation is necessary.

Figure 6. Broiler shed with cooling pads in Israel

Cameras in poultry sheds are only installed on demand and they are not a part of the essential equipment. It's best to install rotating cameras to have a better view. However, there will always be places in a shed where birds are not visible on screen. Installing cameras in sheds may significantly improve the welfare of birds as it's easier to spot if there are any problems in their movements. Moreover, it can protect smothering as it can be detected when birds are concentrated in one place. There are already algorithms for pullets and broilers which can detect potential smothering problems, but they are still not available for layers.

Technology companies are working on adding the ability to detect abnormal looking excreta and on this basis assess the gut health of the laying hens. Thanks to this feature it will be possible to act faster and improve birds' health and, therefore, feed efficiency. Nevertheless, it's still not available to farmers.

David Speller (the Founder CEO at OPTIfarm in the UK) said that measuring acoustic behaviour will help to determine when birds are stressed or have respiratory problems. Furthermore, it can predict mortality of birds. However, automated acoustic monitoring is still in the experimental phase as it takes a significant time to build a good database. As Kristof Mertens (entrepreneur from Belgium) said: “Collecting standardised reliable data is still a challenging task. It’s OK to do it for one farm, but globally it’s a big challenge.”

The programmes which are available for farmers only show the data from their own farms which are compared with genetic standards. In Belgium and the Netherlands, there are organised meetings of farmers from the local area in which they share their parameters to compare and together find better solutions. Worldwide people are cautious about sharing their data as there is always the possibility of it being leaked and being subject to a cyber-attack from an external organisation. However, the more information people share, the more they can improve their production.

CHAPTER 9: SUSTAINABILITY

Even though sustainability is a big current topic, there is no space for any products which only improve sustainability in laying hens. Vitor Arantes (the Global Technical Services Manager at Hy-Line International from the US) said that the drive is in the direction of profitability and cheaper production. Only if feed efficiency is better; the customers would add something and then in an indirect way the sustainability of birds will be improved.

The egg producers are driven by egg production output and feed intake but not by feed efficiency metrics which is why it's more difficult to get egg producers to consider changing layers' diet to improve feed efficiency. However, there are numerous feed additives which improve the quality of feed and, at the same time, they improve nutrient utilisation efficiency, egg production and the health status of the birds, which influences decreased levels of ammonia emission and reduces the carbon footprint.

At the moment, the actions towards sustainability are focused on planting more trees, installing wind turbines and adding beehives to improve biodiversity. Regarding feed, the most popular is replacing soya meal in birds' diets with other protein sources to reduce the carbon footprint. In the near future, more action is planned to help enable the UK to reach its commitment to net zero by 2050 (Burnett et al. 2023).

CHAPTER 10: DISCUSSION

To improve feed efficiency, first the level of nutrients needs to be correct. Then it's important to be sure that the feed is homogenous and the birds are getting everything that is in the feed. For example, in Israel some farms feed layers pellets instead of mash to ensure uniform structure of the feed.

The addition of feed additives depends on the stage of the country's development. In Nigeria and Zambia, only basic feed additives like amino acids and enzymes are added to the feed and even this is not universal. Another variable is the production system. For birds in cages, often a simple feed formulation with additional enzymes is used. More sophisticated feed additives are used in free range, barn and organic production as they can significantly improve the production parameters of birds which are more challenged compared to cage systems where everything is under close control. Another parameter which influences which feed additives are used is how influential companies are in geographical areas. For example, in Israel phytobiotics are more preferably used than probiotics. Most of the people interviewed had not heard about postbiotics.

One of the challenges which were listed by the people interviewed was the price of feed. Using white birds and feed additives will improve FCR. Getting better feed efficiency means that the extra feed cost will result in smaller quantities needed per egg mass or egg number. Only if the digestion and absorption of feed is good can the birds actually use all the nutrients which are included in the feed and show their best genetic potential. The more digestible the feed, the less waste goes into environment.

To assess profitability of layers it would be helpful to have one economic index. To build an equation the following needs to be taken into consideration: first quality eggs, feed intake, hen day production and egg mass.

The biggest challenge for technological improvement is keeping costs low and delivering high functionality. It's still too early to reach the solution which is needed. It would be helpful to organise meetings of farmers from the same area to compare their production data. In this way it would be easier to get the solutions for best practice.

CHAPTER 11: CONCLUSIONS

- There is no easy way to compare the profitability of laying hens as there is no economic index for layers.
- Egg producers most often use egg production and feed intake and they don't pay much attention to feed efficiency.
- Feed additives are underused for laying hens.
- White layers are much more sustainable and they are more profitable compared to brown layers.
- Artificial Intelligence is not available yet to help with feed efficiency. However, there are a few very interesting ideas in the pipeline which could help improve feed efficiency in the future.

CHAPTER 12: RECOMMENDATIONS

- Develop one economic index to compare profitability of laying hens.
- Phytase, xylanase and β-glucanase are essential for getting better digestion and they should always be added to feed for layers.
- Good quality phytobiotics and/or probiotics and/or postbiotics should be added to feed to improve gut health, egg production and feed efficiency.
- Continue customer and consumer education to change from brown to white layers – white eggs should be treated as premium eggs because they are more sustainable.
- Organise a database to enable farmers to compare their data anonymously with other farmers from the same area.

CHAPTER 13: AFTER MY STUDY TOUR

The Nuffield Farming Scholarship has made a big impact on my work and personal life. It made me more confident and grounded in the UK. As a foreigner, it's a really nice feeling part of the Nuffield family. Since last year I'm part of the Nuffield Poultry Group and it's amazing to share knowledge and good practice with poultry scholars. I'm proud to have been chosen as the secretary of the group for the next three years.

My knowledge of agriculture has improved, I feel more open minded and I have gained insights into new areas such as regenerative farming. During my Nuffield journey I have met a lot of people from the industry and I'm still in touch with them. Moreover, I feel more confident in my work decisions and more independent in my personal and work life.

Thanks to the Nuffield Scholarship I can fulfil my dream of helping charities in Africa. During my scholarship I went to Zambia to carry out egg farmer training with the First Zambia Global Egg School on behalf of the International Egg Foundation (IEF). I delivered workshops for Sub-Sahara Africa and KwaZulu-Natal Poultry Institute's (KZNPI). I plan to continue supporting IEF and deliver more classes in the future.

Figure 7. Egg farmer training in Zambia

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