# Insights into Phytogenics

## 1. A strong growth market

by Christine Hunger
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The global phytogenic feed additive (PFA) market has grown rapidly in recent years, having already topped $US500 million in annual sales globally. Though just 3% of the 1.2 billion tons of feed used worldwide today include these plant-based products, the market is expected to surpass US$1 billion in global sales by 2026. Global market demand is expected to increase by 10% per year on average.

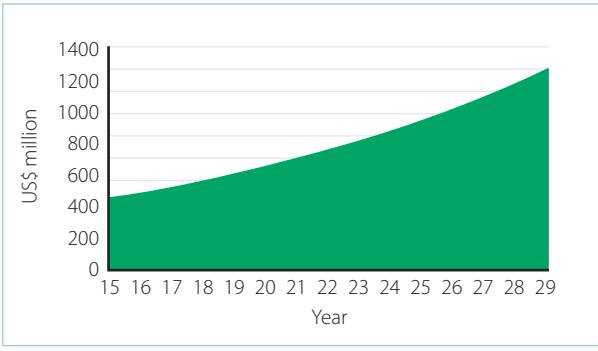


Fig. 1. Global PFA market projection; yearly sales (Source: Biomin).

The demand for PFAs is supported by several factors, including the move away from antibiotic growth promoters or coccidiostats and the need to reduce feed costs, improve efficiency and reduce emissions.

The PFA market spans a wide array of products that range from single essential oils or aroma chemicals to complex mixtures with dozens of ingredients. The diversity in product offering is reflected in differences in effects and scientifically-backed claims.

Generally, the most performing PFAs exert antimicrobial, anti-oxidative and anti-inflammatory effects, as well as increasing digestive secretions. This leads to improved feed conversion and better use of nutrients for animal performance.

PFAs hold the potential to contribute positively to gut performance and to increase productivity through higher nutrient utilisation, which in turn has a positive overall effect on profitability in broiler production.

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Table 1. Categories of phytogenic feed additives.

| | Composition | Physical form |
|---|---|---|
| Essential oils | Essential oils on mineral or silica carrier | Dry or liquid |
| Nature-identical compounds | Based on aroma chemicals e.g. carvacrol, cinnamaldehyde | Powdered or wax coated |
| Herbals | Ground herbs, spices | Powdered |
| Complex products | Essential oils, herbs, spices, other phytogenic ingredients | Fine powder |



First published in International Poultry Production volume 24.5

# Insights into Phytogenics

## 2. Antibiotic-free feeding

by Dr Richard Markus
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With the phasing out of antibiotic growth promoters, poultry producers often encounter challenges related to gut health and feed efficiency. Among novel growth promoters (NGPs), phytogenic feed additives (PFAs) stand out for their ability to support both, given that they exert a range of distinct biological activities e.g. anti-microbial, anti-inflammatory and anti-oxidative properties.

**Better gut performance**

Control of Gram-positive bacteria such as Clostridium perfringens is critical for poultry production. Overgrowth of Clostridium strains cause dysbiosis (imbalance of microbiota) in the gastrointestinal tract; the leading cause of necrotic enteritis. Certain essential oils have been proven to effectively control Clostridium strains both in vitro and in vivo.

On average, the estimated economic cost per bird to producers due to necrotic enteritis ranges from USD$0.050 to $0.063 – up to three times higher than the investment in an advanced phytogenic feed additive of $0.019 per bird (Fig. 1).

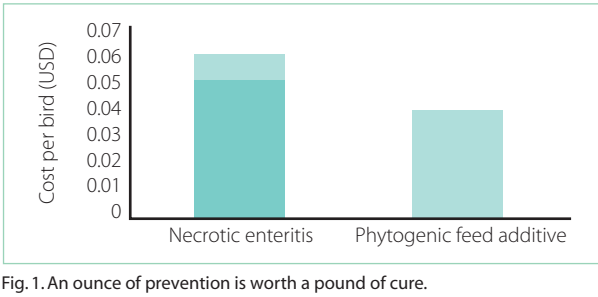


Fig. 1. An ounce of prevention is worth a pound of cure.

**Better feed efficiency**

With the help of emerging '-Omics' technologies e.g. genomics, transcriptomics, etc. it has been shown that certain phytogenics play a major role in anti-inflammatory processes. This matters because prolonged subclinical inflammation in birds leads to reduced performance due to lower feed intake and the redirection of energy towards cellular defence mechanisms that would otherwise go towards production, i.e. muscle building or egg laying. Selected PFAs shown to down regulate Nf-Kb target genes (IL-6, ICAM-1, MCP-1) reduce inflammation and thus improve feed conversion. They also promote Nr-f2 transactivation which stimulates the cell protection, anti-oxidative response.

Even modest feed conversion ratio (FCR) point improvements – stemming from dysbiosis control and reduced inflammation – translate into important feed cost savings for producers, as shown in Table 1.

| FCR | 1.76 | 1.74 | 1.72 | 1.70 | 1.68 |
|---|---|---|---|---|---|
| Feed cost savings (USD/ton)* | - | 3.73 | 7.55 | 11.46 | 15.46 |

*feed price (0.32USD/kg, final bird weight 2.5kg)

Table 1. Feed cost savings grow with feed efficiency gains.

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First published in International Poultry Production volume 24.6

# Insights into Phytogenics

## 3. Growth promotion

by Christine Hunger, Product Manager, Phytogenics, BIOMIN

Phytogenic feed additives (PFAs), categorised as sensory and flavouring compounds, consisting mainly of volatile and non-volatile plant extracts and their active compounds, have traditionally been used in human nutrition, in medicine or even for food preservation. Their increasing popularity in modern poultry production stems from the fact that their effects in birds can result in better growth promotion that is comparable or better than antibiotic growth promoters (AGPs).

### Effects in birds

Many different plant derived substances are known to have antimicrobial, antiviral and/or antioxidant properties. These beneficial properties of PFA are mainly due to their bioactive molecules. Phenolic compounds such as thymol, carvacrol and eugenol and their methyl ethers have strong antiseptic effects. Strong antioxidative properties are for example appointed to species of the families Apiaceae and Lamiaceae, such as caraway and peppermint, respectively. Additionally, specific plant compounds can improve digestibility by supporting digestive secretion such as bile, mucus and saliva as well as enhancing enzyme activity.

### Commercial trial results

In a meta-analysis looking across 14 broiler trials performed in various countries worldwide comparing performance results of birds receiving either an AGP or a PFA, each PFA group performed similar on average in terms of feed conversion ratio (FCR) and average daily gain (ADG) compared to the AGP group.

The FCR showed an average improvement of five points in the phytogenic supplemented group versus the AGP (control). In terms of ADG, the phytogenic-supplemented group recorded a slight improvement (1.5%) compared with the AGP group.


Fig. 1. FCR and ADG of meta-analysis comparing AGPs and PFAs.

Overall, these results show that specific PFAs can enhance nutrient digestibility and beneficially modulate the intestinal microbiota. PFA are capable of promoting intestinal health and gut performance, which is crucial for optimal profitability.

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First published in International Poultry Production volume 24.7

# Insights into Phytogenics

## 4. Digestibility enhancement

by Dr István Csutorás, Product Manager, Phytogenics, BIOMIN

The highest type of efficiency can utilise existing material to the best advantage. When it comes to feedstuffs and poultry production that is precisely what phytogenic feed additives (PFAs) can do.

### A profitability driver

In today's world, when efficiency drives every single moment of our life, one cannot pay enough attention to the effectiveness of the digestive system. Nutrition being the most important and expensive factor in animal husbandry is key to farm profitability. The efficacy of digestion plays a crucial role because better digestion means a better use of feed and thus translates into direct economic benefits.

### How PFAs improve digestibility

Phytogenic feed additives, among many other effects, are able to improve digestibility by enhancing the endogenous secretion and increasing the activity of digestive enzymes.

### The benefits of better efficiency

Better digestibility of the feed means an efficient way to produce more animal products from the same amount of feed: in other words, a lower feed conversion ratio (FCR). Greater efficiency is also a tool to reduce the opportunities for pathogens in the gastrointestinal tract. If animals adsorb and utilise more nutrients from the feed, they can produce more meat or eggs. When there are less nutrients available for the pathogen bacteria, these grow and multiply less. Additionally, by using the feed in a more efficient way, the birds' faeces and litter will have a lower nitrogen concentration, which ends up decreasing the ammonia level in the barn's air. As the animals use the feed more efficiently, the overall amount of wastage will also be reduced.

### Comparison to AGPs

When it comes to improving digestibility, and thus capturing the benefits mentioned above, supplementation of a selected PFA has shown significantly better performance in broilers than a commonly used antibiotic growth promoter (AGP) – see Fig. 1. Due to bacteria developing resistance towards AGPs, several countries have banned their use in livestock production.

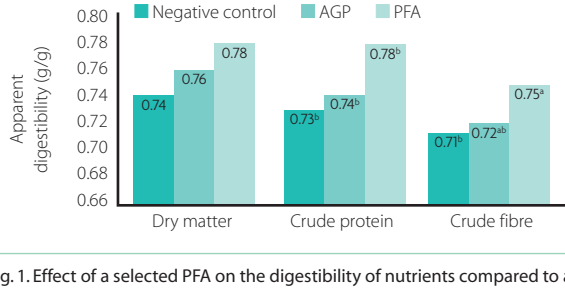


Fig. 1. Effect of a selected PFA on the digestibility of nutrients compared to an AGP. [a,b]Means with different superscripts differ significantly; $p<0.05$ (West Bengal University of Animal & Fishery Sciences, Kolkata, India, 2011).

### Conclusion

With the use of PFAs, through improved feed digestibility resulting in better feed conversion, poultry production can be even more economical. This supports profitability and sustainability, minimising pressure on the environment as a result of lower ammonia emissions.

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First published in International Poultry Production volume 24.8

# Insights into Phytogenics

## 5. Countering Inflammation

by Christine Hunger, Product Manager Phytogenics, BIOMIN

A bird's natural inflammatory response supports the immune system in fighting diseases. Yet, it can be wasteful in the sense that any energy spent on inflammation cannot be used for growth, laying performance, etc. Long-term inflammation causes progressive damage and results in impaired energy utilisation, weight loss, reduced feed intake, lower feed efficiency and greater incidence of diarrhoea.

**Link to gut health**

Inflammation and a bird's antioxidant status are decisive criteria for gut health. Inflammation leads to decreased gut protection in the intestinal tract resulting from infections or feed-dependent changes.

Intestinal disorders often cause damage in the bird's intestinal mucosa. Changes in the intestinal mucosa or gut morphology influence the development and differentiation of villi cells at the epithelial surface. The subsequent reduction in villi length results in decreased nutrient absorption capacity. Furthermore, low digestibility exacerbates inflammatory processes and reduces the antioxidant potential in the intestinal tract.

**Phytogenics exert anti-inflammatory and antioxidative effects**

The anti-inflammatory activity of selected phytogenic additives (PFAs) can be attributed to their antioxidant activities and their interactions with signalling cascades involving cytokines and regulatory transcription factors, favouring the expression of pro-inflammatory genes.

Transcription factor NF-κB (nuclear factor κB) is a major mediator of inflammatory processes. The activated form of NF-κB results in an increase in pro-inflammatory gene-expression. Nrf2 (nuclear factor erythroid 2 – related factor 2) is an antioxidant transcription factor involved in cell protection that increases the expression of several antioxidant enzymes.

To further investigate the influence on inflammatory response pathways an in vitro cell test with CaCo-2 intestinal epithelial cells was conducted at the Justus-Liebig-University Giessen, Germany, to measure the effect of a select phytogenic feed additive on an inflammatory stimulus.

The phytogenic feed additive reduced the mRNA expression of NF-κB target genes significantly compared to the positive control, indicating a significant positive influence by down-regulating the pro-inflammatory NF-κB pathway.

The cytoprotective effect of the PFA on intestinal epithelial cells was also assessed by measuring the Nrf2 target genes CYP1A1 (Cytochrome P450 1A1), HO-1 (Heme oxygenase 1) and UGT1A1 (UDP-glucuronosyltransferase 1A1). The mRNA-expression of those anti-oxidant and cytoprotective target genes of the Nrf2 pathway showed a significant increase compared to the control.

**Conclusion**

This study shows that a PFA inhibits the NF-κB pathway and down regulation of pro-inflammatory cytokines and stimulates the Nrf2 pathway. This results in lower inflammation and an improved anti-oxidative and cytoprotective status. Therefore, regular PFA supplementation can act against inflammatory reactions in the gastrointestinal tract, allowing birds higher feed intake, dietary energy and nutrients to put towards performance.

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First published in International Poultry Production volume 25.1

# Insights into Phytogenics

## 6. NutriEconomics

by Dr István Csutorás
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Global demand for animal protein is expected to double by the year 2050 – propelled by population growth, rising incomes and urbanisation in developing countries. This rising need, along with the limitations of the natural environment and the pursuit of sustainability, puts increasing pressure on agriculture production – particularly the livestock sector.

**Advanced approach**

Innovative companies must think ahead and increase efficiency through the use of science and cutting-edge technologies. The NutriEconomics program – a holistic approach combining nutrition, economics and sustainability – offers an advanced feed additive solution that considers nutritional expertise and applied life sciences, micro-economic conditions and macro-ecological factors.

NutriEconomics®
NUTRITION ECONOMICS ENVIRONMENT

**Nutrition**

A bird's nutritional needs must be supplied through proper feed – which entails use of quality raw materials rich in nutrients, a correct formulation, good palatability and digestibility. Today, the nutritionists can make use of many plant-derived compounds, or phytogenic substances, that do not contribute directly to the nutritional value of the feed, but can increase its safety and palatability and/or improve the biological availability and utilisation of dietary nutrients. Thinking outside the box and reformulating diets to include non-traditional feed ingredients and making use of functional feed additives in modern poultry production is a must.

**Environment**

Another important issue is pollution. Ammonia ($NH_3$) excreted as waste is a concern for poultry operations. Controlling ammonia's impact on the environment by reducing waste discharges is one of the industry's biggest responsibilities.

**Economics**

A select phytogenic feed additive with a documented mode of action has been shown to improve feed efficiency in poultry. Feed conversion ratio improvements mean that more animal product (meat, eggs) can be produced from the same amount of feed, or, alternatively, the same output can be achieved with less feed. Both scenarios result in a better bottom line, either from higher revenues or lower feed costs.

**A cornerstone of R&D**

At Biomin, all product development takes into account the concept of NutriEconomics, where product performance is evaluated based on key nutritional (growth, survival, feed conversion), economic (return on investment, profitability, breakeven), and environmental parameters (waste output, $NH_3$ discharge and $CO_2$ emissions). The result is an environmentally friendly, scientifically proven, economically viable and socially responsible concept.

**Conclusion**

Operating under the NutriEconomics concept, poultry farms can successfully maximise profitability and optimise animal performance, all while achieving the end goal of sustainable, ecologically sound animal production.

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First published in International Poultry Production volume 25.2

# Insights into Phytogenics

## 7. Consistent results

by Carina Schieder
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A 2017 survey of 1,140 respondents in 100 countries has shown that enhanced feed efficiency and a better feed conversion ratio (FCR) are the most important potential benefits of phytogenic feed additives (PFAs) for poultry producers. At the same time, 18.8% of respondents said that they do not use phytogenics because of concerns about reliability and consistency of results.

**Quality control for consistent results**

PFAs consist of various compounds of plant origin selected for their ability to positively affect animal performance. Due to ecological factors and climatic conditions, the natural raw materials used in phytogenics, e.g. essential oils or non-volatile extracts, typically contain varying levels of active compounds. This natural variation increases the likelihood of inconsistent results. The solution is for the PFA manufacturer to implement a robust and reliable quality control system.

**The 4 keys of quality control**

More sophisticated and advanced companies have a strict quality check system in place. The quality control system involves (1) working with certified suppliers, (2) applying detailed specifications for raw material procurement, (3) strict quality control plan execution and (4) analytical and sensory evaluation of raw materials and finished products.

**Smart buying**

The first two points pertain to intelligent procurement – which is necessary in order to source the raw materials with the correct amount of active substances. Given that the amount of active substances vary, as in the case of menthol in Fig. 1, it is important to be selective in choosing only the highest quality ingredients. That means rejecting raw materials that do not meet stringent specifications. Regarding the third point, faithful implementation of a QC plan is key to securing certifications, such as GMP+ and others.

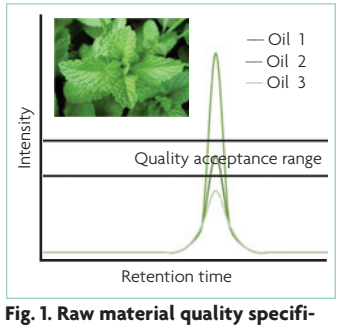


**Fig. 1. Raw material quality specifications, with the example of varying menthol content in different mint oils and a strict quality acceptance range.**

**Thorough evaluation**

Lastly, for poultry producers to get the best results from PFAs, it is important for manufacturers to conduct sensory evaluation of raw materials by a scientifically trained panel and, more importantly, analytical evaluation of raw materials and finished products. State-of-the-art, in-house use of analytical tools such as gas chromatography-mass spectrometry (GC-MS) and gas chromatography flame ionization detector (GC-FID) are essential for proper quality control of volatile active compounds.

**Results for poultry**

Ensuring high quality inputs and monitoring the quality of phytogenic feed additives is essential for poultry producers to see consistent, reliable results in their flocks. The antioxidant, anti-inflammatory and digestibility enhancing effects of a select PFA has been shown to optimise feed conversion. These benefits, coupled with reliability, make the right PFAs a powerful tool for modern poultry production.

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First published in International Poultry Production volume 25.3

# Insights into Phytogenics

## 8. Three tactics for better profitability

By Michael Noonan
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One of the key drivers of profitability in livestock production is feed efficiency. Improving feed efficiency is an ongoing key concern for the global livestock industry. Feed costs represent anywhere from 50-80% of production costs, depending on the livestock species and country. Producers can increase profitability in a number of ways by using PFAs in their diets as follows:

**1. Increased digestibility**
A key driver of feed efficiency is digestibility of raw materials. Given that there are many fluctuations in quality of different raw materials due to geographical location, temperature, extremes of weather, etc, PFAs can play a significant role. For example, scientific trial results demonstrated that when a PFA was added to a diet, the ileal digestibility of many amino acids was significantly increased, meaning higher availability of nutrients to the birds.

**2. Nutrient sparing**
Another strategy to increase feed efficiency and profitability is in nutrient sparing when formulating diets. Reduction of dietary energy and amino acids can have significant negative effects on animal performance when nutrients are removed. PFAs can play an important role here in recovering the lost performance while lowering the overall cost of diets.

A nutrient sparing trial in broilers carried out at the University of Serbia showed significant benefits when a PFA was added to the diet. When the PFA was added on top to a standard diet, live weight gain and FCR were improved. As the diet was reformulated to contain lower amino acids and energy, performance was reduced in the birds (lower live weight gain). However when the PFA was added to the down specified diet, performance was recovered to the same level as the standard diet. This meant a lower cost diet while maintaining performance, thus improving profitability (Fig. 1).

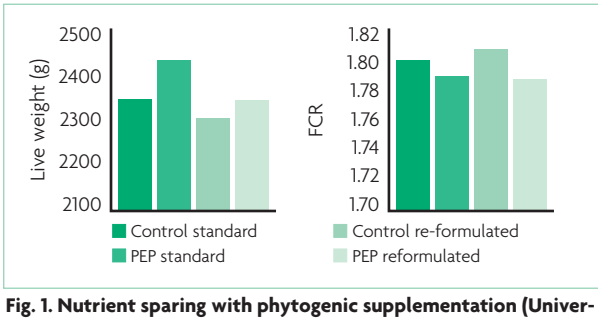


**Fig. 1. Nutrient sparing with phytogenic supplementation (University of Serbia trial).**

**3. Feed efficiency**
In birds that are heat stressed, feed intakes are often compromised – impacting performance. PFAs are able to alleviate the negative consequences of heat stress. A trial containing a PFA carried out with a flock of Lohmann Brown Classic birds in Germany showed a 2.3% increase in laying rate and a 19 point feed conversion improvement compared to the control group in a heat stressed environment, together with higher egg mass and average egg weights. The return on investment for the egg producer was 7:1.

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First published in International Poultry Production volume 25.4