

## INFLUENCE OF FUNCTIONAL FEED ADDITIVES ON GUT MICROBIOME, HEALTH AND PRODUCTIVITY OF LAYING HENS: A REVIEW

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### Abstract:

*Functional feed additives significantly influence the composition and dynamics of the gut microbiome, with reciprocal effects on host health and productivity. The gut microbiome, therefore, plays a pivotal role in the health and productivity of laying hens. This review consolidates existing knowledge on the interplay between functional feed additives, gut microbiome, health and productivity of laying hens. It examines the influence of functional feed additives such as prebiotics and probiotics, organic acids, enzymes, vitamins, minerals, omega 3 fatty acids, and amino acids as interventions on gut microbiome composition, immune responses, and productivity. It equally highlights the potential of these tailored nutritional strategies to enhance egg production, promote sustainable practices, and advance the poultry industry.*

**Keywords:** Gut microbiome, Functional feed additive, Laying hens, Productivity

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### INTRODUCTION

Poultry products, particularly eggs, are essential sources of high-quality protein food globally (Dai *et al.*, 2022; Korver, 2023; Bernard *et al.*, 2024). The increasing demand for eggs has intensified production (Desbruslais *et al.*, 2021), introducing challenges such as infectious diseases and reduced productivity if adequate managements are taken. Functional feed additives are a critical factor influencing the health, productivity, and welfare of laying hens (Desbruslais *et al.*, 2021). The gut microbiome is composed of diverse microorganisms, and plays vital roles in immune modulation, nutrient digestion, absorption and intestinal function (Khan *et al.*, 2020). Bernard *et al.* (2024) elucidated the differences in microbial diversity between layers and broilers, which arise from their unique gut immune responses to specific pathogens, such as *Campylobacter*. This review presents the influence of functional feed additives on gut microbiome, health and productivity of laying hens.

### METHODOLOGY

In conducting this review, a systematic search of academic databases, including PubMed, Science Direct, scopus and Google Scholar, was performed using relevant keywords such as "Functional feed additives," "gut microbiome, Laying hens," "health," and "productivity." Only peer-reviewed articles published in English between 2015 and 2024 were included. 20 articles were selected based on their relevance to the topic and quality of research.

### RESULT AND DISCUSSION

**Gut microbiome composition and dynamics:** The gut microbiome of laying hens is characterized by a delicate balance among commensal, beneficial, and potentially harmful microbes (Bernard *et al.*, 2024). Predominant bacterial phyla include Proteobacteria, Firmicutes, and Bacteroidetes (Keres *et al.*, 2018; Bernard *et al.*, 2024). Age, dietary changes, and production systems significantly influenced gut microbiome composition (Bernard *et al.*, 2024). Essentially, the early colonization of the gut is vital for establishing a stable microbiome that promotes good health and productivity throughout the laying period (Ballou *et al.*, 2016; Lee *et al.*, 2019)

**Influence of functional feed additives on gut microbiome:** Functional feed additives perform a critical role in modulating the gut microbiome of laying hens with resultant improvements in gut health and immune function, increased resistance to disease, enhanced nutrient utilization and absorption, reduced stress and inflammation and improved productivity of laying hens. They are, therefore, critical in promoting a balanced and healthy gut microbiome (Table 1). For example, probiotics (live beneficial micro-organisms) such as *Lactobacillus*, *Bacillus*, *Faecilbacterium*, *Bifidobacterium*, and *Saccharomyces*, function to promote a healthy gut microbiome (Khan *et al.*, 2020). In the same vein, prebiotics, a non-digestible fibre (complex carbohydrates) such as fructo-oligosaccharide, mannose, glycan, oligosaccharide etc., that feed (through the production of short chain fatty acids) beneficial gut bacteria, help in maintaining healthy gut microbiome (Mahmood and Guo, 2020; Petranyi *et al.*, 2024).

**Influence of Functional feed additives on health:** Exogenous enzymes such as yeast and beta-glucans help support immune function and good gut health (Lei *et al.*, 2018). Short chain fatty acids (SCFAs) like acetate, propionate, butyrate, and lactate are linked to host-microbiome crosstalk (Morrison and Preston, 2016), which is a metabolite of saccharolytic fermentation of carbohydrates (Dai *et al.*, 2022). This help to increase intestinal

nutrient uptake by stimulating intestinal epithelial cell growth and development, resulting in increasing intestinal villus height and absorption capacity (Table 1).

**Table 1: Influence of Functional Feed Additives on Gut Microbiome, Health, and Productivity of Laying Hens**

Functional Feed Additives	Areas/ Specific Influence		
	Gut microbiome	Health	Productivity
<b>Probiotics and Prebiotics</b>	Modulates gut microbiome. Increases beneficial bacteria. Reduces pathogenic bacteria	Promotes healthy gut structure Increases villus height and crypt depth	Improves egg production Improves feed efficiency
<b>Organic acids</b>	Modulates of gut microbiome Increases beneficial bacteria Reduces pathogenic bacteria	Enhances immune function Reduces mortality antioxidant properties.	Improves egg production Improves feed efficiency:
<b>Enzymes</b>	Modulates gut microbiome Increases beneficial bacteria Reduces pathogenic bacteria	Improves gut health and reduces inflammation. Enhances immune function	Improves egg production Improves feed efficiency
<b>Vitamins</b>	Alters composition and activity of the gut microbiome. Inhibits pathogenic bacteria	Improves gut health and reduces inflammation. Enhances immune function	Increases hatchability Improves fertility rates Enhances egg production and quality.
<b>Minerals</b>	Modulates gut microbiome Increases beneficial bacteria Reduces pathogenic bacteria	Enhances nutrient absorption Improves gut health Enhances immune function	Improves fertility Enhances immune function
<b>Omega 3 fatty acids</b>	Promote the growth of beneficial bacteria *EPA and **DHA can alter the composition and activity of the gut microbiome.	Improves gut health Enhances nutrient absorption, Reduces the risk of nutrient deficiencies.	Improves egg production Improves feed efficiency Improves meat quality
<b>Amino acids</b>	Helps in modulating gut microbiome and support to muscle growth	Improves reproductive health Maintains gut barrier function and supports immune function.	Improves fertility Improves productivity Reduces mortality
<b>Sources</b>	Khan <i>et al.</i> (2020); Petranyi <i>et al.</i> (2024); Mahmood & Guo (2020); Jha & Mishra (2021); Bernard <i>et al.</i> (2024).	Khattak and Helmbrecht (2019); Alagawany <i>et al.</i> (2020); Feng <i>et al.</i> (2021); Petranyi <i>et al.</i> (2024).	Ashayerizadeh, <i>et al.</i> (2024); Lv <i>et al.</i> (2019); Alagawany <i>et al.</i> (2020); Lei <i>et al.</i> (2018).

\* Eicosapentaenoic Acid    \*\* Docosahexaenoic Acid

**Influence of Functional feed additive on Productivity:** Dietary interventions, including prebiotics, probiotics, organic acids, exogenous enzymes, and phytochemical compounds, can modulate the gut microbiome, enhancing productivity and egg quality (Table 1) (Zhan *et al.*, 2019; Khan *et al.*, 2020; Feng *et al.*, 2021). Dai *et al.* (2022) and Aruwa & Sabiu (2024) noted that tailored nutritional strategies can promote beneficial microbial populations, improve immune responses, and increase egg production. Several studies show that functional feed additives such as amino acids, vitamins and minerals, natural plant bioactive compounds, probiotics and prebiotics as well as enzymes are pivotal in modulating production performance and egg quality of laying hens (Khattak and Helmbrecht, 2019; Alagawany *et al.*, 2020; Feng *et al.*, 2021; Khan *et al.*, 2020; Lei *et al.*, 2018). Specifically, Lv *et al.* (2019) reported that Genistein, a type of soy isoflavone used as a supplement in laying hen diet, improved egg production and eggshell strength.

## CONCLUSION

There is an intricate relationship between functional feed additives, gut microbiome, health and productivity of laying hens. By optimizing dietary strategies involving functional feed additives, poultry producers can foster a balanced gut microbiome, enhance egg production, and promote sustainable practices. It will be beneficial to focus

future studies on elucidating the mechanisms underlying the interplay between individual functional feed additives and gut microbiome, with a view to exploring innovative nutritional interventions that will advance the poultry industry.

### RECOMMENDATIONS

Poultry producers should adopt tailored nutritional strategies to promote beneficial microbial populations and enhance productivity using known functional feed additives. Future studies are needed to elucidate the mechanisms underlying the interplay between functional feed additives and gut microbiome. Innovative nutritional interventions, such as precision feeding and nutritional genomics, should be explored to advance the beneficial influences of functional feed additives in the poultry industry.

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