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Review on Effect of various feed additives on Pig production performance

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***Abstract*— *This review provides an exhaustive examination of the efficacy and mechanisms of action of various feed additives in pig diets, including acidifiers, essential oils, prebiotics, probiotics, and feed enzymes. The additives' impact on growth performance, gut health, and antibiotic reduction is critically evaluated. The review elucidates the additives' mechanisms of action, encompassing antimicrobial activity, immune modulation, and nutrient digestion enhancement. A meta-analysis of the additives' effects on growth performance metrics, including average daily gain and gain-to-feed ratio, is presented. The review highlights the necessity for further research to optimize additive usage and elucidate their effects on pig production. Additionally, the importance of tailoring diets to meet the specific needs of young pigs and promoting gut health and development is emphasized. This comprehensive review synthesizes the current state of knowledge on feed additives in pig diets, providing valuable insights for researchers, producers, and industry stakeholders.*

Keywords*— *Pig farming, Feed additives, Probiotics, Essential oils, Enzymes, Antibiotic alternatives.

I. INTRODUCTION

Pig farming is a common practice in various parts of India, particularly in the South-Central and North Eastern Regions (NER). Each region has its own locally adapted pig breed, and most households raise one or two pigs annually (Mahak *et al.*, 2020). Pigs are highly valued for their ability to convert kitchen and agricultural waste into nutrient-rich fertilizer, and their meat is consumed occasionally, often as part of local celebrations (Bujarbaruah *et al.*, 2007; McAuliffe *et al.*, 2017). Although pork consumption has a long history in India, the smallholder model of raising pigs as part of diverse agro-ecosystems defines much of the country's pig and pork history (Das and Bujarbaruah, 2005; Kakati *et al.*, 2019).

According to the 20th Livestock Census of India, the country's pig population is approximately 9.06 million (Indian Livestock Census, 2019), which is a small fraction of the global pig population of around 900 million (FAOSTAT Databases, 2020). India's pig population has been declining over the past 15 years (Indian Livestock Census, 2019).

Various feed additives have been widely used in the swine feed industry to improve growth performance without negatively affecting average daily gain (ADG). These additives include acidifiers, essential oils (EO), direct-fed microbials (DFM), yeasts, copper (Cu), zinc (Zn), betaine, chromium (Cr), conjugated linoleic acid (CLA), and L-carnitine. These additives have antibacterial and immune-promoting properties, which help control pathogens and maintain a balanced gut microbiota (Nguyen *et al.*, 2020; Espinosa *et al.*, 2021; Zamojska *et al.*, 2021; Stevanovic *et al.*, 2018; Dumitrache *et al.*, 2019; Belkova *et al.*, 2018). Exogenous enzymes, such as carbohydrases, proteases, and phytases, are also added to improve nutrient digestibility and potentially positively impact gastrointestinal health and immune functions (Aranda-Aguirre *et al.*, 2021; Jerez-Bogota, 2020). This review aims to provide an overview of the available additives for pig diets, their mechanisms of action, and recent results from growth performance and digestibility experiments. However, it is not an exhaustive review of each additive.

II. FEED ADDITIVES

As ingredients or combinations of ingredients added to the basic feed mix or parts thereof to fulfill a specific need. Usually used in micro quantities and requires careful handling and mixing. Feed additives have emerged as a game-changing component in pig production. As the industry strives to meet the growing demand for pork, understanding the role and impact of these feed additives has become crucial for producers seeking to optimize their operations.

Many feed additives have been evaluated that are aimed at either

- Enhancing the pigs' immune response (e.g. immunoglobulin; ω-3 fatty acids, yeast derived ß glucans)
- Reducing pathogen load in the pig's gut (e.g. organic and inorganic acids, high levels of zinc oxide, essential oils, herbs and spices, some types of prebiotics, bacteriophages, anti-microbial peptides).
- Stimulate establishment of beneficial gut microbes (probiotics and some types of prebiotics).
- Stimulate digestive function (e.g. butyric acid, gluconic acid, lactic acid, glutamine, threonine, cysteine, and nucleotides).

2.1 Antimicrobials:

The positive effects of feeding acids to pigs on gut health and development, and indirectly on pig health and productivity, may be attributed to various factors, including:

Antimicrobial activity of non-dissociated organic acids

1. Lowering digesta pH, in the stomach, aiding protein digestion
2. Lowering stomach emptying rate
3. Stimulating (pancreatic) enzyme production and activity in the small intestine
4. Providing nutrients that are preferred by intestinal tissue thereby enhancing mucosal integrity and function.

The use of organic and inorganic acids in pig diets has beneficial effects, particularly for newly-weaned pigs (Blank *et al.*, 1999; Mroz *et al.*, 2006). The effectiveness of acid feeding varies depending on the types and combinations of acids, the animal's state, and feed characteristics, such as buffering capacity (Blank *et al.*, 1999; Mroz *et al.*, 2006). A relatively recent development is the encapsulation of acids for targeted delivery to different gut segments, which has shown promising results (Piva *et al.*, 2007). This technique allows for delayed absorption and more effective delivery of acids to the distal ileum, caecum, and colon. Additionally, feeding acids in specific salt forms, such as potassium-diformate, can raise acid levels in the distal ileum and improve growth performance (Canibe *et al.*, 2001; Overland *et al.*, 2000). Furthermore, medium-chain fatty acids have strong antimicrobial properties (Decuypere and Dierick, 2003)

2.2 Pre and probiotics:

A probiotic is defined as a live microorganism which when administered in adequate amounts confers a health benefit on the host (FAO/WHO 2002). For young piglets, a probiotic is expected to deliver at least one of the following functions to the GIT:

- Stimulating the development of a healthy microbiota—predominated by beneficial bacteria.
- Preventing enteric pathogens from colonization.
- Increasing digestive capacity and lowering the pH.

- Improving mucosal immunity.
- Enhancing gut tissue maturation and integrity.

Recent studies have shown that piglets exhibit a positive growth response to dietary supplements containing a combination of Bacillus lichiniformis and Bacillus subtilis (Kremer, 2006). Various Lactobacillus and Bifidobacterium species have also been found to improve the performance of newly-weaned piglets (Stein and Kil, 2006). For instance, Lactobacillus sobrius 001T has been shown to have a probiotic effect by reducing ileal ETEC abundance and promoting growth in piglets challenged with ETEC K88 (Konstantinov, 2005). However, some studies have reported no response or even adverse effects of probiotic supplementation in piglets (Jost and Bracher, 1999; Lallès *et al.,* 2007). These inconsistent findings highlight the complexity of probiotic development and application, emphasizing the need for further research to understand the underlying molecular mechanisms and modes of action. The gut microbiota plays a crucial role in pig health, and increasing the population of beneficial bacteria such as Bifidobacterium, Lactobacilli, and Eubacteria can improve animal health and reduce disease risk (Roberfroid *et al*., 2010; van der Aar *et al*., 2017). As these beneficial bacteria grow, they produce more lactic and acetic acid, which lowers the intestinal pH and increases fermentation. This leads to an increase in short-chain fatty acids (SCFA) and a decrease in pathogenic bacteria (Smiricky-Tjardes *et al*., 2003).

2.3 Feed enzymes:

The main goal for using exogenous feed enzymes in swine diets has been to improve the nutritive value of feedstuffs. This is achieved through several mechanisms including the breakdown of anti-nutritional factors present in feed ingredients, elimination of nutrient encapsulation effect thus increasing availability, breakdown of specific chemical bonds in raw materials that are otherwise not cleaved by endogenous enzymes, thus releasing more nutrients, and complementation of the enzymes produced by young animals (Simon, 1998; Bedford and Schulze, 1998).Majority of the vegetable feedstuffs used in swine diets contain a considerable amount of non-starch polysaccharides (NSP) whose anti-nutritional effects are well-established and has been a subject of intense research (de Lange *et al.*, 2000).

Similar observations were made regarding NSP hydrolysis products from wheat and flaxseed. These findings can be attributed to various mechanisms, including the possibility that hydrolysis products interfere with pathogen attachment to the intestinal mucosa, a crucial step in infection. Additionally, these products may act as prebiotics (Cummings and MacFarlane, 2002), promoting the growth of lactic acid-producing bacteria, as demonstrated by Högberg and Lindberg (2004) and Kiarie *et al*. (2007). Therefore, it has been hypothesized that supplementing swine diets with enzymes to digest soluble NSP will reduce intestinal microbial load, increasing nutrient availability to the host and minimizing the growth of pathogenic bacteria.

2.4 Essential oils:

Essential oils, volatile plant components, have been used in food preparation and other applications for centuries. These oils are generally recognized as safe (GRAS) by the US Food and Drug Administration (FDA) and have been used as flavorings, preservatives, perfumes, and in over-the-counter medicines. Many essential oils exhibit strong antimicrobial activity (Kalemba and Kunicka, 2003), particularly those with phenolic structures (Dorman and Deans, 2000). The antimicrobial activity of phenolic essential oils, such as carvacrol and thymol, is attributed to their delocalized electrons and hydroxyl group on the phenolic ring (Ultee *et al*., 2002). These oils damage the bacterial cell membrane, disrupting pH homeostasis and inorganic ion equilibrium, leading to the collapse of the proton motive force and ATP depletion (Ultee *et al.*, 2002). Essential oils also show selectivity, with some studies reporting greater inhibition towards Gram-negative bacteria like Salmonella and E. coli than Gram-positive Listeria monocytogenes (Lin *et al*., 2000).

For ADG (average daily gain), there were 20 comparisons between pigs fed a control diet or diets with added EO (Essential oils) with an average of a 5.8% improvement (range between −2.9 and 18.8%) in pigs fed EO. There were 17 comparisons for G:F (gain-to-feed ratio) between pigs fed a control diet or diets with added EO with an average of a 5.8% improvement (range between −2.6 and 19.9%) in pigs fed EO. Fourteen comparisons evaluated BF between pigs fed a control diet or diets with added EO with an average of a 2.7% decrease (range between −14.2 and 6.3%) in pigs fed EO. For percentage lean, there were 9 comparisons with an average of a 0.9% improvement (range between −2.5 and 2.8%) in pigs fed EO. For LMA/LD, (loin muscle area, loin depth) there was an average of a 1.9% improvement (range between −6.3 and 12.3%) in pigs fed EO. Overall, the results indicate that essential oils (EO) had a positive impact on average daily gain (ADG) and gain-to-feed ratio (G:F). Adding EO alone or in combination with acids shows promise in improving growth performance. However, it is important to note that the current body of research on EO's effect on growth performance is limited, and only three studies were conducted in the US. Therefore, the benefits of using EO in US-based conditions are uncertain. Further experiments are necessary to determine the effects of including EO in the diets of grow-finish pigs. (Rao *et al.*, 2023).

III. CONCLUSION

A conclusion section must be included and should indicate clearly the advantages, limitations, and possible applications of the paper. Although a conclusion may review the main points of the paper, do not replicate the abstract as the conclusion. A conclusion might elaborate on the importance of the work or suggest applications and extensions. Large amounts of research have been conducted evaluating the impact of a wide range of feed ingredients and feed additives on various aspects of gut health and development in pigs, to improve growth performance around the time of weaning while minimizing the use of antibiotics and rather expensive feed ingredients, such as milk products. A better understanding of the mechanisms whereby nutrients, feed ingredients and feed additives influence animal physiology will lead to the development of alternatives to in-feed antibiotics. Given the considerable advances made in the understanding of intestinal nutrient utilization and metabolism, a complimentary goal in nutrition might be to formulate young pig diets with the specific task of optimizing the growth, function and health of the gut.

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