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USE OF ORANGE PEEL AND ITS BY-PRODUCTS IN BROILER NUTRITION: AN ADVANCED REVIEW

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INTRODUCTION

The increasing cost of conventional feed ingredients and restrictions on antibiotic growth promoters have intensified the search for sustainable and natural feed additives in broiler production. Agro-industrial by-products have gained attention due to their economic and environmental advantages. Orange (*Citrus sinensis*) peel, a major by-product of the citrus processing industry, is produced in large quantities and often discarded as waste.

Orange peel is rich in bioactive compounds such as flavonoids, essential oils, phenolics, pectin and vitamin C, which possess antioxidant, antimicrobial and immunomodulatory properties. Recent studies have demonstrated its potential to improve growth performance, feed efficiency, gut health, immune response and carcass quality in broiler chickens. However, its utilization depends on appropriate processing and inclusion levels due to high fiber content. This review summarizes current knowledge on the use of orange peel and its by-products in broiler nutrition, highlighting their benefits, limitations and future prospects.

Nutritional Significance and Bioactive Molecules

Orange peel contains a concentrated profile of nutraceutical compounds, notably limonene, hesperidin, naringin, carotenoids, ascorbic acid, phenolic acids and natural essential oils. These bioactive constituents exhibit strong antioxidant, antimicrobial, hypocholesterolemic and immunomodulating activities. Pectin and soluble fibres support gastrointestinal health, whereas flavonoids contribute to improved metabolic efficiency. Although its crude fibre

content may restrict inclusion levels, processing methods—such as fine grinding, fermentation and enzymatic supplementation—enhance digestibility, allowing optimal dietary inclusion of 1–5% in broiler rations.

Effects on Growth Performance

A large body of evidence supports the growth-promoting potential of orange peel-based additives.

- *Abd El-Latif et al.*¹ demonstrated that orange peel meal supplemented with multi-enzymes significantly improved body weight gain, feed conversion ratio and nutrient utilization during the grower phase.
- *Abu Al-Makarem et al.*² reported that low-level inclusion (1–2%) of dried orange peel powder enhanced growth rate, feed efficiency and economic returns.
- *Vlaicu et al.*³ highlighted improved weight gain, nutrient digestibility and overall performance with dried orange and grapefruit peel mixtures.

Processing techniques such as fermentation or water-soaking improve fibre degradability and reduce anti-nutritional bitterness. *Oluremi et al.*⁴ revealed that fermented peel can effectively replace part of maize without compromising performance, while *Sunmola et al.*⁵ confirmed that water-soaked peel supported acceptable growth. However, inclusion above 10–12% generally depresses performance due to excessive fibre load and reduced palatability.

Carcass Traits and Meat Quality

Dietary inclusion of orange peel-derived products exerts measurable improvements in carcass characteristics.

- *Vlaicu et al.*³ documented enhanced dressing percentage and significantly reduced abdominal fat deposition, attributed to the hypolipidemic action of citrus flavonoids on lipid metabolism.
- *Erhan et al.*⁶ reported that citrus peel essential oils improved intestinal morphology—specifically villus height and crypt architecture—resulting in better nutrient absorption and growth.

Citrus peel also enhances meat oxidative stability due to its rich antioxidant matrix. Several studies including *Ajila et al.*⁷ noted reductions in serum cholesterol and triglycerides as well as improved lipid profiles in treated broilers.

Antioxidant and Physiological Benefits

One of the most consistent outcomes of orange peel supplementation is the marked improvement in antioxidant capacity.

- *Abd El-Latif et al.*¹ recorded elevated activities of key antioxidant enzymes such as SOD and GPx.
- *Ogunlade et al.*⁸ found enhanced total antioxidant capacity along with reduced malondialdehyde (MDA) levels.

Citrus essential oils demonstrate potent antimicrobial and gut-health-promoting functions. *Erhan et al.*⁶ observed a reduction in pathogenic load and improved microbial balance in the intestine.

Modulation of Immune Response

Orange peel and its derivatives exhibit notable immunostimulatory activity.

- *Pourhosseini et al.*⁹ reported significantly higher antibody titres in broilers fed dried sweet orange peel.
- *Ogunlade et al.*⁸ described increased levels of immunoglobulins (IgG, IgM).

Economic and Environmental Sustainability

The incorporation of orange peel contributes to cost-effective and environmentally friendly poultry production systems. As a low-cost agro-industrial residue, its utilization reduces feed expenses while promoting circular economy principles. *Abu Al-Makarem et al.*² reported favourable economic efficiency indices.

Limitations and Future Outlook

High fiber content and bitterness can limit use at higher inclusion levels. Advanced processing—fermentation, enzymatic hydrolysis, pelleting, micronization and extraction—can enhance nutrient availability. Future research should focus on standardized processing protocols, synergy with gut-health promoters, and nano-delivery of citrus bioactives.

CONCLUSION

Orange peel and its by-products represent promising natural feed additives in broiler nutrition due to their rich content of bioactive compounds with antioxidant, antimicrobial and immunomodulatory properties. When included at optimal levels (1–5%) and appropriately processed, orange peel supplementation improves growth performance, feed efficiency, gut health, immune response and carcass quality without adverse effects. In addition to enhancing

broiler productivity, its utilization contributes to sustainable poultry production by reducing feed costs and valorizing citrus processing waste. With increasing emphasis on antibiotic-free feeding strategies, orange peel offers an economical and eco-friendly alternative; however, further studies are warranted to optimize processing methods and elucidate long-term physiological effects.

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