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MICROBIAL BIOPREPARATIONS IN BROILER NUTRITION: PRODUCTION, SAFETY, QUALITY, AND REGULATION

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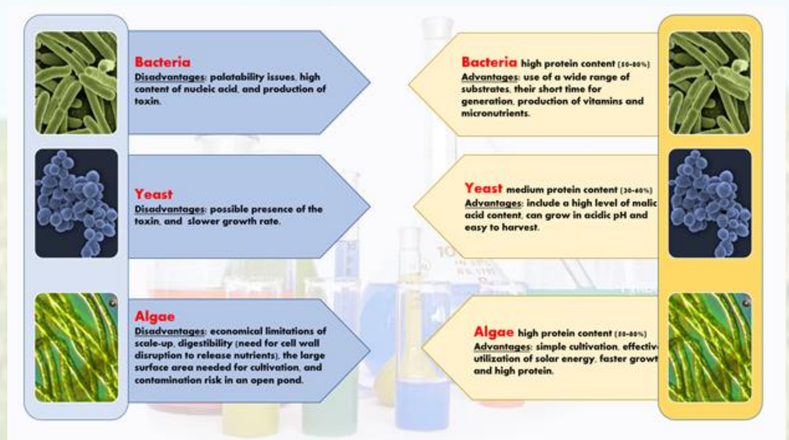
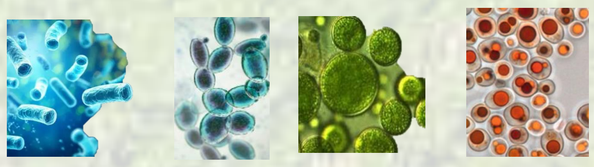
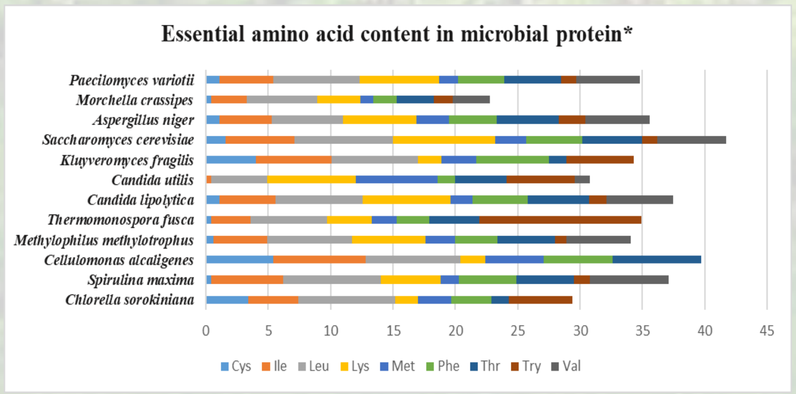
Abstract: *Special attention is given to microbial protein sources, including single-cell proteins derived from bacteria, fungi, algae, and yeasts. Among microbial biotechnology products, yeasts and mixed microbial cultures are discussed as versatile bioresources with high protein content and potential probiotic benefits. Integrating brewery by-products and brewers' spent yeast as substrates or feed ingredients is highlighted as a sustainable approach to waste valorization and circular economy principles. The review further explores the qualitative aspects of microbial biopreparations, such as protein digestibility, bioavailability, and amino acid composition, which are critical for optimizing broiler performance. Safety concerns, including microbial contamination, mycotoxins, and the presence of anti-nutritional factors, are discussed alongside quality assurance practices. The manuscript also outlines the current legal frameworks and international standards governing the use of microbial proteins in animal nutrition, identifying challenges and opportunities for market integration. Lastly, the impact of microbial protein inclusion on broiler health, growth performance, gut microbiota, and immune response is critically evaluated based on recent experimental studies. This review aims to consolidate current knowledge and identify knowledge gaps in microbial biopreparations, supporting their advancement as sustainable and functional alternatives in broiler nutrition.*

• Introduction

Over the past sixty years, the global human population has witnessed an unprecedented rise of approximately 250%. Projections by the United States Census Bureau suggest that if this upward trend persists, the world population could reach 9 billion by the year 2050. Relying solely on traditional sources such as agriculture, livestock, and fisheries may not be sufficient to support the expanding population. The broiler diets generally limit soybean meal inclusion to around 30%, which still accounts for 40–50% of the total expense in formulated feeds. Beyond economic aspects, soybean farming is associated with environmental degradation, especially due to deforestation activities in Brazil's Amazon basin, prompting broader socio-economic and ecological concerns. Moreover, animal nutritionists are encouraged to explore cost-effective and sustainable alternatives that do not compromise animal productivity. When selecting alternative feed options for poultry, several factors must be carefully evaluated, including nutritional profile, accessibility, taste acceptability, and formulation consistency. Promising substitutes, including microbial sources, all of which offer potential as economical and effective replacements for conventional animal-based feedstuffs.







• Microbial protein sources

Bacteria are increasingly recognized as a promising source of single-cell protein (SCP) due to their rapid growth rates (20-30 minutes) and ability to utilize a diverse range of substrates for energy. Their biomass yield and protein content, which can reach up to 80%, are notably higher than those of other microorganisms used for SCP production.

Yeasts such as *Candida utilis*, *Yarrowia lipolytica*, and *Saccharomyces cerevisiae* are rich in protein, containing up to 55% protein content in their total biomass, making them potential protein sources for animal feed.

Microalgae are notable for their high content of essential fatty acids, vitamins, and minerals. The primary structure of their cell walls consists of cellulose, with smaller amounts of pectin, fucan, xylan, and mannan. Spirulina, *Arthospira platensis* is traditionally harvested from alkaline lakes, It has long been consumed by both humans and animals

Microbial protein can be obtained through **mixed cultures** for both solid-state and submerged fermentation, which offer several advantages over monocultures. The combination of different microorganisms allows for the optimization of metabolic pathways, enhancing protein yields and diversifying the nutrient profile of the product.

• Material and method

The research was guided by a systematic search protocol applied to leading academic databases, including Web of Science, Scopus, PubMed, and ScienceDirect. Search queries combined standardized descriptors and targeted keywords such as "microbial protein," "single cell protein," "nutrient recovery processes," and "bioconversion of food waste."

Microbial protein source	Impact on growth performance	Impact on health	Observations
Spirulina platensis	Positive effects on growth and feed efficiency	Improved immunity and disease resistance	High in protein, vitamins, and essential fatty acids.
Methylococcus capsulatus	Improved growth performance, meat quality	Enhanced intestinal health and reduced mortality	Used as a substitute for fishmeal in aquaculture diets.
Schizochytrium sp.	Improved growth and weight gain	Enhanced intestinal health	Rich in omega-3 fatty acids.
Corynebacterium glutamicum	Positive growth effects when replacing SBM	Increased immune responses, higher Ig levels	Safe for consumption; endotoxin-free.
Candida utilis (torula yeast)	Slightly reduced growth performance in poultry	Improved gut health, energy production	High in lysine but lacks sulphur amino acids.
Saccharomyces cerevisiae	Slight reduction in growth rate	Improved nutrient digestibility and intestinal morphology	Provides essential B-vitamins and bioactive compounds.
Methylophilus methylotrophus	Negative impact on growth performance in broilers	Improved intestinal health and microbial community	-
Desmodesmus sp.	Improved growth and feed efficiency		Source of protein and omega-3 fatty acids.

• Conclusions

This review highlights the growing need to explore sustainable alternatives to conventional protein sources in broiler nutrition, such as soybean meal, which, despite their nutritional adequacy, face limitations related to cost, availability, and environmental impact. Current biotechnological methods for microbial protein production, ranging from fermentation to biomass cultivation, have advanced considerably, enabling scalable and cost-effective outputs. Moreover, the inclusion of microbial proteins in broiler diets has shown positive effects on growth performance, nutrient utilization, and health markers, although the degree of benefit varies depending on the microbial strain and processing method.

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