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Dried Brewer's Yeast Byproduct as a Feed Product: A Review

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The article discusses the use of brewer's yeast and yeast extracts in animal feed. It describes the composition of brewer's yeast, including proteins, polysaccharides, B-vitamins, minerals, and nucleotides, as well as their effects on animal health and productivity. In particular, β-glucans found in the yeast cell wall exhibit immunostimulatory and anti-inflammatory properties, improving immune response and protection against pathogens. Additionally, the inclusion of yeast in poultry diets enhances growth, meat quality, and productivity by partially replacing fishmeal in the feed. The article also highlights the potential of yeast as an alternative source of vitamins, minerals, and proteins for animals. It is noted that while yeast is a promising component in the feed industry, further development of standard methods for quantifying its components is needed.

Keywords: brewer's yeast, composition, feed.

1. Introduction

Poultry production plays an essential role as a source of protein needed to meet the dietary needs of the ever-growing population. The rapid increase in global consumption of poultry meat and eggs requires the industry not only to scale up production but also to improve the feed base to enhance economic efficiency. The main limiting factors in animal feed production are the shortage, high cost, and low environmental sustainability of traditional raw materials. The anticipated sharp increase in meat demand in the coming years necessitates an active search for alternative sources of feed protein. Currently, a global shortage of protein feed for animals and poultry is observed, which reduces productivity and increases feed costs per unit of production. The use of alternative feed ingredients in poultry diets is becoming a key factor in the successful development of the poultry industry.

The use of industrial byproducts in animal feeding represents a valuable means for indirect food production (where Saccharo means "sugar," myces means "fungus", and cerevisiae means "beer" allowing for the efficient recycling of industrial waste [9]. In this context, the search for alternative protein sources is of particular importance.

Broiler poultry farming is one of the most efficient sectors in terms of feed conversion and growth rate; however, the high growth rates and nutritional needs place significant demands on feed composition. Optimizing feed rations becomes especially important in the context of rising prices for traditional feed components and the need to comply with sustainable and eco-friendly production standards.

Among the alternative feed ingredients suitable for poultry diets, dried brewer’s grain and dried brewer's yeast stand out. Brewer’s yeast is a “living” material composed of non-pathogenic microscopic fungi of the Saccharomycetes class, Saccharomyces cerevisiae

These microorganisms’ range in size from 6 to 10 microns (1 micron = one-thousandth of a millimeter) (Figure 1) [52].

Nevertheless, byproducts of the alcohol and brewing industries, such as brewer's grain, yeast, and post-distillation stillage, remain underutilized as sources of feed protein. One effective solution for addressing the protein deficit in poultry feed is the use of dried inactive brewer's yeast. The application of biologically active additives, such as brewer's yeast, can significantly improve the feed base and enhance production performance in poultry farming.

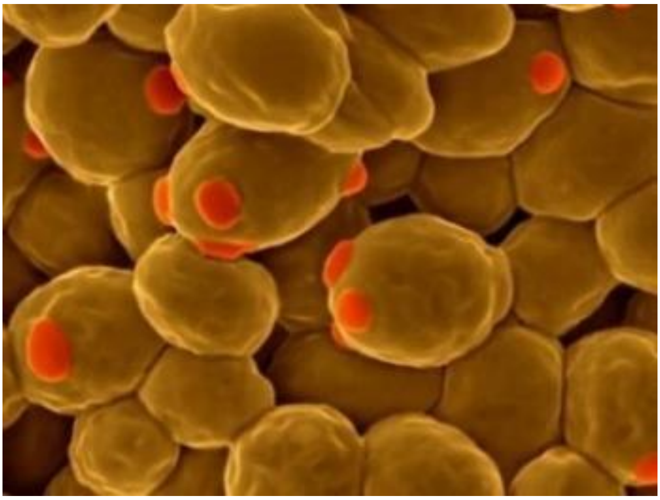

Figure 1. Brewer's yeast by-product

Brewer's yeast is rich in protein, essential amino acids, B vitamins, beta-glucans, and other biologically active components that can improve the metabolism and immunity of poultry, thereby boosting productivity and reducing the risk of diseases. In the context of current environmental challenges and the need to reduce antibiotic use in feed, brewer's yeast represents a promising alternative that can strengthen broiler resistance to pathogens and improve product quality.

Thus, researching and introducing feed additives based on brewer's yeast for broilers is an important task that can increase the efficiency and sustainability of poultry farming, ultimately impacting food safety and availability for consumers. In this context, the strategic objective remains the search for and adoption of alternative sources of feed protein, which requires the development and refinement of non-traditional technologies.

2. MATERIAL AND METHODS

The review summarizes the results of peer-reviewed scientific articles, research reports, and case studies focused on the impact of dried brewer’s yeast byproducts on chicken meat production. Literature searches were conducted across multiple databases, including PubMed, Scopus, Web of Science, and Google Scholar, using keywords such as "dried brewer's yeast," "chicken meat production," "poultry feed additives," "alternative protein sources," and "immunomodulation in poultry."

Data were extracted from selected studies using a systematic approach. Information was gathered for each article on sample size, chicken breed, experimental design, diet composition, and outcome measures, including performance and health metrics as well as feed efficiency. Qualitative and quantitative data were analyzed to identify trends, benefits, and potential gaps in the current knowledge regarding the use of brewer’s yeast byproducts in poultry feeding.

The review employs a narrative synthesis method, classifying findings into key thematic

areas:

- Nutritional Value of Brewer’s Yeast Byproducts: Studies were grouped to explore the protein content, amino acid profile, B vitamins, and bioactive compounds such as beta-glucans, and their impact on chicken health and productivity [9, 34].

- Impact on Growth and Feed Efficiency: Research on the influence of brewer’s yeast on growth rate and other performance indicators was analyzed.

- Health and Immunity Benefits: Literature assessing the immunomodulatory effects of brewer’s yeast components and their role in reducing the need for antibiotics was reviewed [47].

- Environmental Sustainability: Studies examining the feasibility of using brewer’s yeast and the environmental advantages of utilizing byproducts were included.

The aim of the research was to summarize and analyze existing data on the use of brewer’s yeast in broiler chicken feeding, with a focus on their composition and effects on poultry productivity and health.

The objectives included: summarizing information on the composition of brewer’s yeast by analyzing the content of protein, vitamins, amino acids, minerals, beta-glucans, and other bioactive substances that contribute to their value as a feed additive; assessing the impact of brewer’s yeast on broiler productivity based on studies examining their effects on weight gain, feed and conversion; compiling data on the effects of brewer’s yeast on immune parameters, disease resistance, and gut microbiota health; identifying limitations and risks related to dosage and the economic aspects of brewer’s yeast use.

These objectives aim to provide a comprehensive overview of the benefits and potential limitations of brewer’s yeast use, justify their role in poultry feeding, and identify pathways for further scientific research and practical implementation.

3. RESULTS AND DISCUSSION

The brewing industry, one of the largest sectors in the food industry, generates significant amounts of waste, including brewer's grain, yeast, post-distillation stillage, and sediment. These byproducts have a rich biochemical composition and can be utilized in feed products as well as in other industries. Beer production involves the creation of several byproducts and residues, such as grains, hops, and yeast [30].

Brewer's yeast, the second most significant byproduct of the brewing process, is a biologically active substance rich in various nutrients. It consists of Saccharomyces cerevisiae yeast left in the fermentation vats of malt wort after the fermented liquid has been removed. Typically, it is sold in dried form [53].

Comprehensive waste utilization in the brewing industry addresses several issues simultaneously: reducing waste volume, lowering disposal costs, decreasing greenhouse gas emissions, and producing valuable byproducts. The integrated processing of brewing waste reduces the amount of waste sent to landfills, thereby decreasing environmental pressure and extending landfill lifespan.

The use of organic fertilizers from waste, such as brewer's grain and yeast, enhances soil fertility and helps reduce dependence on chemical fertilizers [2, 51]. Converting waste into products with market value (e.g., feed, biofertilizers, biogas) increases production profitability through the recycling of waste [29].

Thus, integrated processing not only reduces the environmental impact but also fosters innovative approaches to the use of secondary resources [12].

Brewer's yeast is a rich source of protein, containing about 40-50%, making it an excellent source of amino acids, including essential ones such as lysine, methionine, threonine, and tryptophan, which play a key role in maintaining poultry productivity [45].

Brewer's yeast and spent grain are often used as feed ingredients due to their high protein, fiber, and amino acid content [28, 29]. Research has shown that adding brewery waste to the diet of animals, such as cattle and poultry, promotes growth and enhances productivity. The use of brewer's yeast as a feed supplement for poultry can improve immune status and metabolism due to its content of B vitamins and beta-glucans [34].

Spent yeast is inexpensive and can be obtained in areas where breweries are located. Breweries are often willing to supply it to farmers, viewing it as a better and more cost-effective disposal method. Dried brewer's yeast is also valued in poultry feeding because it promotes growth and health, thanks to its content of antioxidants, trace elements, and probiotic properties. Byproducts from beer production can be used as high-calorie protein-active feed additives in the diets of livestock and poultry [21,31].

Byproducts from brewing, such as probiotic additives and enzymes, find application in the food, pharmaceutical, and agricultural industries, opening additional sources of income [6]. Some components of waste, particularly yeast, can be used in the production of dietary supplements and fortified foods, as they contain a large number of vitamins, minerals, and proteins. Yeast extracts are used in the food industry as natural flavorings and taste enhancers.

Composting brewery waste allows for the creation of organic fertilizers that enrich the soil with nitrogen and phosphorus. A study by Shrestha et al. [40] notes that using compost from brewery waste improves soil fertility and increases crop yields.

Organic waste from the brewing industry, such as distillery spent grains, is a promising source for biogas production. In a study by [29], it was found that spent grain is an effective raw material for anaerobic digestion, yielding significant volumes of biogas. Moreover, this approach not only reduces waste but also lowers energy consumption costs.

Yeast waste is a rich source of antioxidants, such as glutathione, making it useful in pharmaceuticals and the production of dietary supplements [5, 9] noted that extracts from brewer’s yeast can be used as additives in products enriched with bioactive substances such as proteins and B vitamins.

Brewer’s yeast has found its application in cosmetics due to its high content of vitamins and antioxidants. Kordialik-Bogacka [22] reported that yeast extracts can improve skin health by moisturizing it and promoting regeneration. The use of yeast in cosmetic products supports the creation of environmentally friendly products, which is particularly relevant in the context of growing demand for natural cosmetics. In biotechnology, brewing waste is used to produce enzymes and as a nutrient medium for other microorganisms.

According to [32], yeast extracts from brewing waste serve as a nutrient medium for culturing bacteria and other microorganisms, making them useful for laboratory research.

Studies Franzoni, E., et al. [13] show that adding spent grain to construction materials enhances their thermal insulation properties. Brewer's waste can be utilized in the production of biocomposites and insulation panels, contributing to a reduced reliance on inorganic materials.

Yeast is widely recognized as a source of single-cell protein (SCP), also known as microbial protein, biomass, or bioprotein. The protein content of SCP from yeast ranges from 50 to 55%, which is comparable to the crude protein content of soybean meal.

Due to their high protein content (45-65%), yeast is considered an excellent alternative source of protein [17]. The chemical composition of dried brewer's yeast (DBSY) is similar to fish meal and contains protein hydrolysis products such as amino acids, peptides, and others, which are highly available and possess immunomodulatory properties. The nutritional composition of dried brewery spent yeast (DBSY) is presented in Table 1.

DBSY has a higher crude protein (CP) content (432 g/kg dry matter) and lower levels of acid detergent fiber (ADF), neutral detergent fiber (NDF), and crude fiber (CF).

However, unlike soybean meal, yeast is rich in B vitamins (thiamine, riboflavin, biotin, pantothenic acid, niacin), antioxidants (e.g., glutathione), and minerals (magnesium, phosphorus, potassium, zinc) [27].

Yeast is preferred over bacterial SCP due to its larger cells, ease of collection, and more balanced nutrient composition. The nutrients present in yeast support metabolic processes, strengthen the immune system, and enhance animal resistance to pathogens.

Patricia Fremu Chollom et. al. [36] in their studies, the proximate/nutritional composition of spent brewers' yeast (S. cerevisiae) was determined, where crude protein and crude fiber were found to be 40.52% and 4.31% on a dry basis, respectively (Table 1). Soybean has crude protein content of 38.00% and crude fiber of 5.01% These values are sufficiently close to suggest that spent brewers' yeast can substitute soybean. The metabolizable energy (ME) was 2606.07 kcal/kg, which also compares favorably with that of soybean (insert the value).

Table 1. Chemical composition of dry brewery spent yeast*

Feed	Parameters (g/kg DM)								EME (MJ/kg DM)
	DM	Ash	CP	CF	NDF	ADF	ADL	DOD	
DBSY	935	12.5	432	151	75.4	13.2	5.2	894.5	14.31

DM Dry-matter, CP- Crude protein, NDF - Neutral detergent fibre, CF - Crude fibre, ADF – Acid detergent fibre, ADL - Acid detergent lignin, DOMD - Digestible organic matter in the dry matter, EME - Estimated metabolizable energy, DBSY - Dry brewer spent yeast *[8].

In the study by Bacha et al. [3], it was noted that the presence of essential amino acids such as leucine, isoleucine, and valine in brewer's yeast makes it unique for use in animal feeding, including poultry, as they help improve growth and productivity by optimizing protein nutrition. The amino acid profile of spent brewer's yeast (Figure 2) revealed that it contains both essential and non-essential amino acids. Essential amino acids included leucine (8.42%), valine (6.07%), threonine (5.65%), isoleucine (5.37%), phenylalanine (5.30%), arginine (4.74%), histidine (2.93%), lysine (2.93%), and tyrosine (2.73%). Non-essential amino acids included glutamic acid (14.98%), aspartic acid (11.98%), alanine (7.26%), serine (5.75%), proline (4.84%), and glycine (4.83%). However, there were lower levels of cysteine, methionine, and tryptophan.

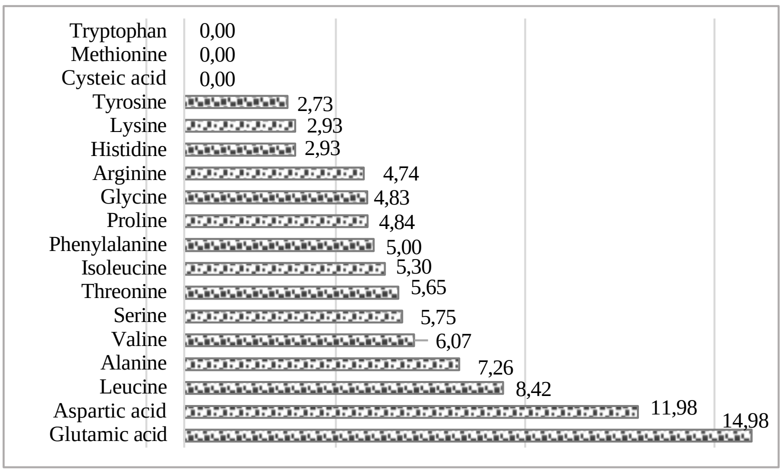

Figure 2. The content of some amino acids in dry brewer`s yeast, mg/kg [3]

These results compare favorably with the amino acids found in soybeans. However, spent yeast had higher levels of histidine, threonine, and valine compared to soybeans, while soybeans exhibited slightly higher values of arginine, lysine, methionine, and tryptophan than spent brewer's yeast [36].

Industrial yeast is becoming increasingly important as a source of enzymes, flavorings, essences, and proteins, and there is no reason why they could not also serve as sources of lipids.

Like other microorganisms, yeast contains various lipids, the content and composition of which can depend on growth conditions [37, 38] and/or genetics, making them suitable for the production of highly specific lipids. Moreover, yeast has several advantages over other microorganisms: they are eukaryotes, typically non-toxic, and have traditionally been used in the food industry.

According to Halas and Lastita [16], the lipid content of yeast varies from 7 to 15%, and the fatty acid composition is characterized by a high content of unsaturated fatty acids, with oxygen flow during cell culture being the parameter that most influences the fatty acid composition. The total lipid content of yeast cells is subject to various influences. However, it is possible to classify different yeasts based on their low, medium, or high lipid content (Table 2).

Table 2. Total cell lipid of various strains of yeasts [37]

Lipid (% cell dry WT)	Strain
Low (<5%)	Condida albicans C. lipolytica C.utilis Lipomyces starkey Rhodotorula glutinis Saccharomyces fragilis
Medium (5 to 15%)	Blastomyces dermatitidis C. lipolytica C. scottii C. tropicalis Debaromyces hansenii Endomycopsis vernalis Hanseniasporo valbyensis Hansenula anomala Histoplasma capsulatum L. starkeyi Mucor rouxii Pullularia pullulans R. glutinis R. graminis S. carlsbergensis S. cerevisiae
High (>15%)	B. dermatitidis Candida 107 Cryptococcus terricolus E. vernalis H. capsulatum H. duboisii L. lipofer L. sterkeyi R. glutinis

R. gracilis
R. graminis
S. cerevisiae Trigonopsis variabilis

This loose classification is not taxonomically significant, as there are overlaps, with members of the genus Candida appearing in all three groups [39].

The studies conducted by Blagovic et al. [4] showed that the total lipid content in brewer's yeast is 4.4% of the dry cell biomass. The relative proportions of neutral and polar lipid fractions, calculated based on results from silica gel preparative thin-layer chromatography (TLC), are 58% and 42%, respectively. The analysis of the neutral lipid fraction by TLC revealed the presence of mono-, di-, and triacylglycerols, squalene, lanosterol, ergosterol, sterol esters, and free fatty acids. Triacylglycerols, squalene, ergosterol, and sterol esters were quantified, and they accounted for 51% of the total lipids. The main characteristic of the neutral lipid fraction is the extremely high content of squalene (33% of total lipids, or 1.4% of dry cell biomass). Triacylglycerols and ergosterol each accounted for less than 10% of the total lipids [4].

The relative proportions of neutral and polar lipid fractions, calculated from the yields of silica gel preparative thin-layer chromatography, were 58% and 42%, respectively. The analysis of the neutral lipid fraction by TLC revealed the presence of mono-, di-, and triacylglycerols, squalene, lanosterol, ergosterol, sterol esters, and free fatty acids. Triacylglycerols, squalene, ergosterol, and sterol esters were quantified, accounting for 51% of the total lipids. The main characteristic of the neutral lipid fraction was an extremely high squalene content, which made up 33% of the total lipids, or 1.4% of the dry cell biomass. Triacylglycerols and ergosterol each accounted for less than 10% of the total lipids (Table 3).

Table 3. Mass fraction of the main classes of neutral lipids in total cell lipids and dry biomass of brewer's yeast

	w (cell lipids) / %	w (dry biomass) / %
Triacylglycerols	8.6	0.38
Squalene	32.6	1.43
Ergosterol	9.5	0.42
Sterol esters	0.7	0.03
Total	51.4	2.26

The yeast composition also includes important macro- and microelements such as potassium, phosphorus, magnesium, iron, zinc, and copper (Figure 3, 4), which are essential for growth, bone structure, and the optimal functioning of the immune system [33].

Brewer's yeast (mainly Saccharomyces cerevisiae) is a rich source of B vitamins and, therefore, holds high commercial value. Brewer's yeast is a significant source of vitamins such as thiamine (B1), riboflavin (B2), niacin (B3), pantothenic acid (B5), pyridoxine (B6), biotin, and folic acid. These vitamins play a vital role in metabolic processes required for cellular energy production and the maintenance of poultry health [20].

Yeast, a single-celled microorganism belonging to the fungal kingdom, has long been recognized for its pivotal role in various industrial processes, most notably in the production of alcoholic beverages such as beer [11, 18].

In addition to its application in fermentation processes, yeast has garnered scientific interest due to its rich composition, which includes not only proteins extracted as yeast extract but also valuable polysaccharides found within its cell wall [44].

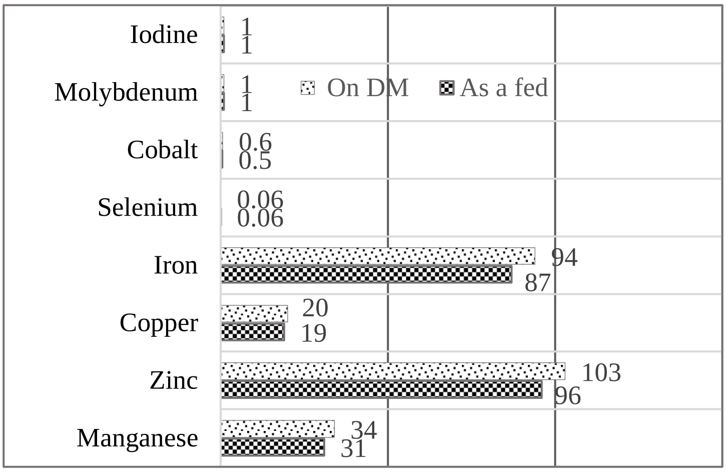

Figure 3. The content of some microelements in dry brewer`s yeast, mg/kg [33]

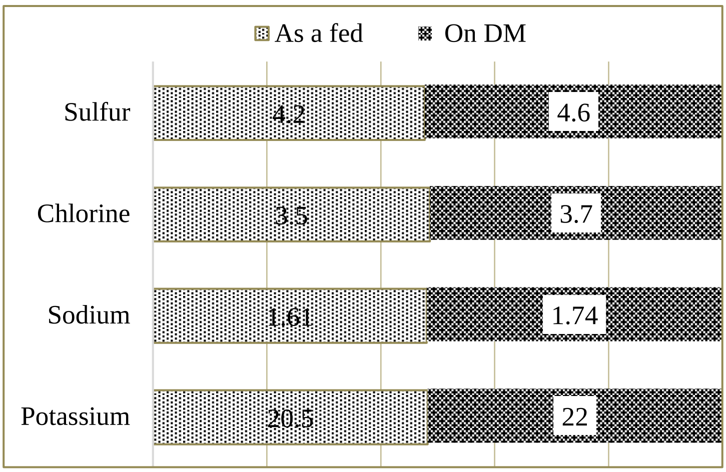

Figure 4. The content of some macroelements in dry brewer`s yeast, g/kg [33]

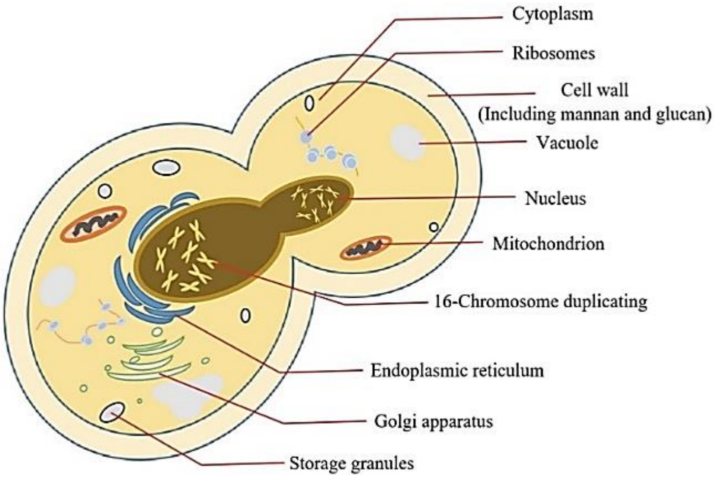

Figure 5. Schematic diagram of yeast structure [44]

Saccharomyces cerevisiae yeast contains high concentrations of β-glucans (6-7.7%) in its cell walls. Due to the physicochemical properties of β-glucans, such as solubility, viscosity, and gelling ability, they are considered beneficial food components for health protection [7].

Yeast extract is a complex product, with the main components being the cell wall material and the contents of the cells [49].

β-glucans are polysaccharides in the yeast cell wall that exhibit immunostimulatory and anti-inflammatory effects (Figure 5).

These compounds are capable of enhancing the immune response in poultry and protecting them from pathogens, which is especially important. Studies have shown that adding β-glucans significantly improves the weight of immune organs such as the spleen, Bursa of Fabricius, and thymus in broilers.

The addition of β-glucans also improves pathological changes associated with infections from E. coli, Campylobacter [14], and Salmonella (Sadeghi et al., 2013), which is beneficial for antibiotic-free farming [24, 43].

Brewer’s yeast also contains nucleotides, which contribute to the maintenance and restoration of cells, an important factor for tissues with high turnover rates, such as the intestinal epithelium. Nucleotides help improve nutrient absorption and strengthen the immune system [19].

Yeast also contains antioxidants, such as glutathione, which help reduce oxidative stress, protecting poultry cells from damage caused by free radicals. This contributes to improved productivity and health in broilers [50].

Yeast cell wall products modulate the host's immune response and reduce the load of intestinal pathogens in poultry [41, 25, 26]. Prebiotics prevent the colonization of poultry intestines by intestinal pathogens, thereby reducing competition between pathogens and host cells for nutrients [10]. Lectin receptors on bacterial pathogens bind with receptors containing D-mannose on intestinal epithelial cells. Mannose and mannan oligosaccharides (MOS) obtained from yeast cell walls act as trap receptors for binding bacterial lectins, preventing pathogen colonization [42]. Therefore, prebiotics derived from fungal cell walls have the potential to prevent or alleviate the impact of intestinal pathogens on poultry [41, 25, 10, 42].

According to research by Aghdamshahriar et al. [1], whole yeast can replace up to 60% of fish meal in poultry diets, positively affecting the meat quality of broilers. Studies show that adding yeast to poultry diets contributes to increased body weight and improved meat quality. For example, experiments conducted by Kumprechtova et al. [23] demonstrated that the addition of yeast-derived SCP improved feed conversion and increased growth rate in broilers. Thus, whole yeast and yeast biomass can be used as an alternative source of vitamins, minerals, and protein in poultry nutrition.

Despite the widespread use of yeast-containing additives and feed ingredients in the feed industry for decades, there are no standard analytical methods for quantitatively determining yeast and its biologically important chemical components. Unfortunately, there is limited information on the accuracy and application of practical methods for quantitatively determining yeast components for the feed industry.

Brewer's yeast is commonly used in the animal feed industry as a specialized amino acid, vitamin, and mineral supplement. Torula yeast (Candida utilis) also contains high concentrations of protein, minerals, and vitamins and is used as an additive in a wide range of processed food products [5].

4. CONCLUSION

- Brewer's yeast, including Saccharomyces cerevisiae, is a valuable source of proteins, B vitamins, lipids, minerals, and polysaccharides such as β-glucans, which play an important role in supporting animal health, improving growth, and productivity.

- Adding yeast to poultry diets enhances their immune response, helps protect against pathogens such as E. coli, Campylobacter, and Salmonella, and also promotes growth and improves meat quality. The β-glucans in the yeast cell wall have immunostimulatory and anti-inflammatory effects.

- Whole yeast and yeast biomass can replace traditional protein sources, such as fish meal, in poultry diets, improving feed conversion and increasing body weight in broilers.

- Despite the widespread use of yeast-based additives, there is a lack of standardized analytical methods for quantitatively determining their biologically active components, which limits their broader application in the feed industry.

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