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Meat Technology — Special Issue 64/2

www.meatcon.rs ▪ www.journalmeattechnology.com

UDK: 636.084.5

ID: 126636553

https://doi.org/10.18485/meattech.2023.64.2.40

Review paper

Live yeast cells in nutrition of monogastric animals

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ARTICLE INFO

Keywords:
Yeast
Animal nutrition
Health
Production performances

ABSTRACT

Yeast and yeast derivatives are used as nutrients and as feed additives. Live yeast cells (LYC) (*Saccharomyces cerevisiae*) belong to a group of potent microorganisms that are used as an additive in animal feed and represent an alternative to antibiotics that until recently were used in animal nutrition as growth stimulators. The role of yeast as a growth promoter is due mainly to mannanoligosaccharide and β-glucans, isolated from the outer cell wall of yeast, whose role is known in stimulating the body's immune response. Dietary supplementation with whole yeast or yeast cell wall at 1.0–1.5 g/kg can improve growth performance, improve digestion and absorption of nutrients by modulating gut structure, inhibiting pathogenic bacteria and lowering gut pH.

1. Introduction

The ban on the use of antibiotics as growth promoters in animal nutrition began in 2006 due to confirmed negative effects on human and animal health (*Kovitvadhl et al*., 2019). With the very hint of the need to stop using antibiotics as growth stimulators in intensive animal breeding, the need was to find alternative additives for animal feed, which will have a positive effect on production results and animal health, but without the negative effects associated with antibiotics (resistance to antibiotics, genotoxic and teratogenic effects, residues). As alternative solutions, additives, such as probiotics, prebiotics, phytobiotics, acidifiers and others, are of great importance. By using these additives, similar effects are achieved as when using antibiotics, with the advantages that they do not leave residues, nor do they have a withdrawal period. The positive effects of their use are based on the well-known importance of maintaining eubiotic relationships, because the balance in the micropopulation of the digestive tract enables efficient digestion and resorption of nutrients, increasing resistance to disorders caused by enteropathogenic bacteria. Diet can influence the maintenance of eubiosis in three ways: by including live microorganisms that become metabolically active after ingestion (probiotics), by including nutrients that contain indigestible ingredients and stimulate the growth and activity of desirable microbiota (prebiotics), or by using natural supplements with clearly demonstrated antibacterial properties (phytobiotics). The mentioned supplements enable the stimulation of animal growth by using their natural physiological potentials and mechanisms, providing the conditions for realizing the genetic potential of animals.

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Paper received August 9th 2023. Paper accepted August 30th 2023.
Published by Institute of Meat Hygiene and Technology — Belgrade, Serbia

2. Yeasts in feed

Yeasts are unicellular eukaryotic microorganisms that are classified according to the kingdom of fungi. Yeasts are considered facultative aerobes, which means they can survive in the presence or absence of oxygen. Yeast reproduction occurs under aerobic conditions, when yeast cells convert oxygen and sugars into carbon dioxide and energy, which enables their efficient growth and reproduction, through oxidative metabolism. There are about 100 different genera of yeasts and about 2000 different species of yeasts, but the importance for animal feed is on the following species: *Saccharomyces cerevisiae*, *Kluyveromyces marxianus*, *Candida utilis* and *Saccharomyces* var. boulardii (*Pang et al*., 2022).

Yeast as a nutrient is a rich source of proteins of high biological value, vitamin B complex, organic acids, trace minerals, growth factors and many other useful substances. When yeast is used as a feed additive as an alternative to antibiotic growth promoters, results vary depending on several factors, including yeast species, yeast product components, feed ingredients, animal categories, and differences in the animal's rearing environment (*Pang et al*., 2022).

Saccharomyces cerevisiae is most often used of the yeasts in the nutrition of ruminants, pigs and poultry. The positive influence of this yeast on production performance, development and intestinal health, improvement of immunity and improvement of meat quality has been proven.

Kluyveromyces marxianus is an ascomycete yeast, also known as *Candida kefyr.* It has often been used in trials examining the possibility of binding and controlling mycotoxins in animal feed.

Candida utilis has been shown to be a protein-rich microorganism that improves gut microbiota balance and facilitates host growth. *C. utilis* improves growth and reduces diarrhoea in weaned piglets.

Saccharomyces var. boulardii is a subspecies of *S. cerevisiae* and has, compared to other members of this genus, a higher survival rate, higher tolerance to bile salts, and better antioxidant properties under different temperatures and gastric acid conditions. *S.* var. boulardii is used in animal feed because of its good effects in preventing diarrhoea in young animals, improving the animal's immunity, improving intestinal function and improving production performance. In the diet of monogastric animals, *S. cerevisiae* and *S.* var. bourardii are the most often used yeasts (*Pang et al*., 2022).

Yeast and yeast derivatives can be used in nutrition in intensive livestock production. They can be added to feed as live yeast cells, yeast cell wall, purified cell wall components and yeast extracts after fermentation. These forms of added yeast differ in appearance, composition of biologically active components and their application in the production system. In addition, yeast cultivation conditions or fermentation conditions, as well as yeast strains, have a significant impact on the outcome of the final product and application results. It is necessary to understand the differences in these products due to the choice of yeast supplements.

Yeast cell walls are mainly composed of glucan (35~45%), mannanoligosaccharide (40~45%), protein (5~10%), chitin (1~2%), lipid (3~8%) and inorganic salt (1~3%). *Speranda et al*. (2008) reported that dietary supplementation of *S. cerevisiae* cell wall can promote the proliferation of lymphocytes, such as neutrophils, and improve their immune response. Polysaccharides contained in yeast cell walls have many biological functions, such as strengthening immunity, improving the antigenicity of pathogenic substances, alleviating stress and promoting growth and development. At the same time, yeast products have no residues, drug resistance and do not pollute the environment. Therefore, yeast cell walls can be used as natural and safe feed additives, and the main components of this product are mannanoligosaccharide and β-glucan.

Mannanoligosaccharide (MOS) can promote the development of the gastrointestinal tract of animals, regulate intestinal flora, improve animal immunity and improve animal growth performance. In addition, mannanoligosaccharide is resistant to high temperatures and maintains stable structure and function under high temperatures and high pressure food processing and pelleting conditions, which makes it also suitable for application as an animal feed additive.

β-Glucan has biological functions in the development of the gastrointestinal mucosa, balancing intestinal microorganisms, promoting the development of immune organs, increasing the body's immunity and improving production performance.

Yeast cultures with fermented metabolites can be added to animal feed. In addition to their nutritional role, they increase the activity of intestinal digestive enzymes, promote digestion and absorption and improve metabolic activities through their metabolites. Due to the complex composition of yeast culture, different strain sources, uncertain mechanism

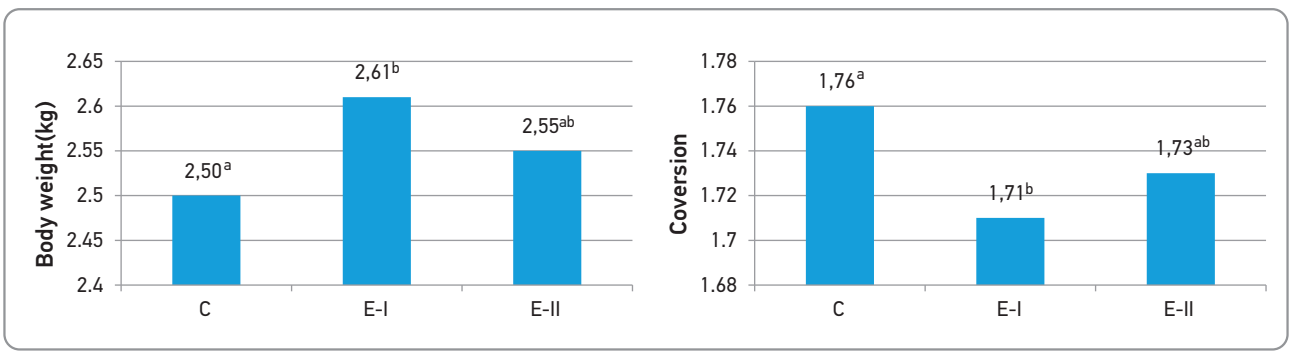
of action and different physiological environments of the gut, the effect of yeast culture produced by the same strain on different animals is different.

*Other yeast products***.** In addition to the listed main yeast products, selenized yeast and chromium yeast are also used in animal feed. Selenium-rich yeast as a highly bioavailable product has a unique role in regulating animal metabolism, improving animal health and increasing the serine content of meat and eggs compared to inorganic forms of the mineral added through feed (*Pang et al.*, 2022).

3. Live yeast cells (LYC) in feed

Live yeast cells (*S. cerevisiae*) are the source of one of the most potent microorganisms used as a supplement to animal feed (*Marković et al*., 2022; *Maksimović et al.*, 2022). They represent one of the alternatives for antibiotics that were used in animal nutrition until recently. Mannanoligosaccharide, isolated from the outer cell wall of yeast (*S. cerevisiae*), is most responsible for yeast's role as a growth promoter in animal nutrition. It has been proven that supplementing animal feed with whole yeast or yeast cell wall in the amount of 1.5–2 g/kg can improve the growth performance and meat gain in broilers (*Marković et al.*, 2022; *Maksimović et al.,* 2022). Also, the results of the research showed that the addition of yeast culture in the amount of 5 g/kg to the diet of pigs had a significant effect on the increase in body weight of pigs fed with this mixture, thanks to the improved absorption of nutrients from the digestive tract and the positive effect on the morphology of the intestinal villi. It is known that living yeast cells possess large amounts of polysaccharides, together with mannose and glucans, and their role in modulating the immune response of the body in interaction with various immunocompetent cells is recognised (*Marković et al.*, 2022; *Maksimović et al.,* 2022). In addition, the addition of live yeast cells to animal feed can improve digestion and absorption of nutrients from the intestinal tract by modulating the intestinal structure and inhibiting pathogenic bacteria in the intestines (*Trevisi et al.*, 2015). The role of living yeast cells is also reflected in the reduction of pH in the intestines, which leads to the creation of a wide range of organic acids that acidify the environment in the intestines, and thus, the consequent inhibition of pathogenic bacteria in the intestines is achieved (*Ogbuevu et al.*, 2019). It has been proven that the cell wall components of live yeast (especially β-glucan) have a role in stimulating the immune function of antibody synthesis in pigs and chickens (*Ding et al.*, 2019). Immune suppression, caused by infections that develop during intensive broiler breeding (most likely as a result of poor response to vaccines) has a huge negative economic impact on this production (*Umar et al.*, 2017). Atypical fowl disease (Newcastle disease) and infectious bursal disease are very serious broiler diseases that, apart from the fatal outcomes, have a significant negative impact on feed conversion (FCR) and lead to slow fattening of broilers (*Mahfuz et al.*, 2019). In addition to research previously conducted to examine the effect of live yeast cells on growth performance and gut microbiome of broilers, the role of *Saccharomyces cerevisiae* on antioxidant status and immune response in broilers remains a subject of further investigation. There are numerous studies on the positive impact of live yeast cells in pig feed under conditions of heat stress (*Mayorga et al.*, 2021).

Maksimović et al. (2022) examined the effect of adding different amounts (0.25 and 0.65 g/kg) of live yeast cell preparations to broiler feed (Ross 308) and determined the positive effect of the yeast



Legend: Means with the different superscript letter significantly differ at P<0.05

Figure 1. Production performances of broilers receiving diets containing different levels of yeast (*Saccharomyces cerevisiae*)

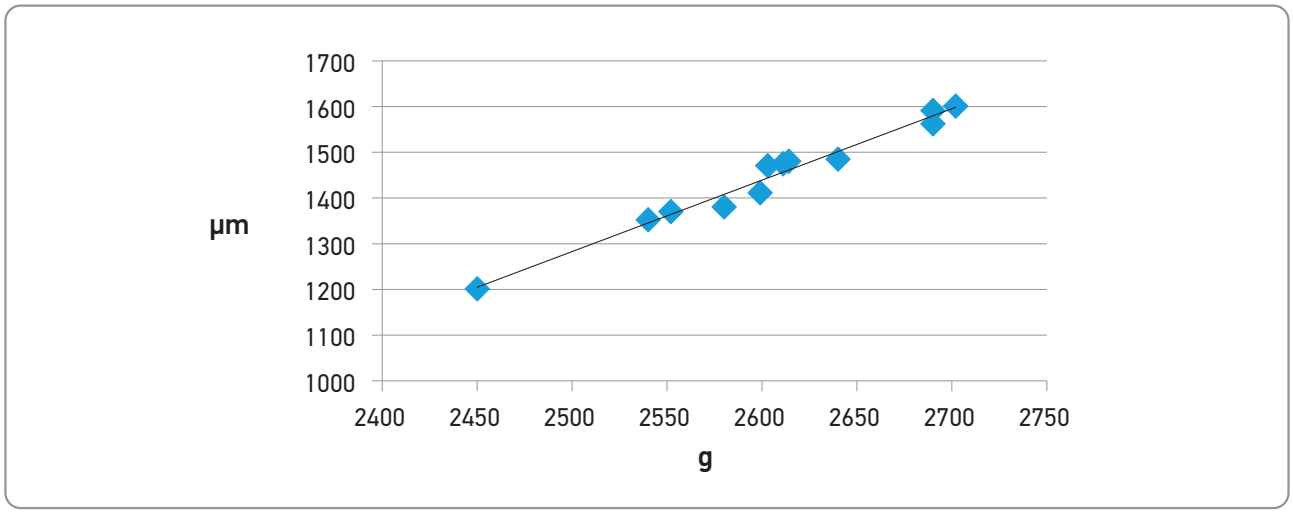
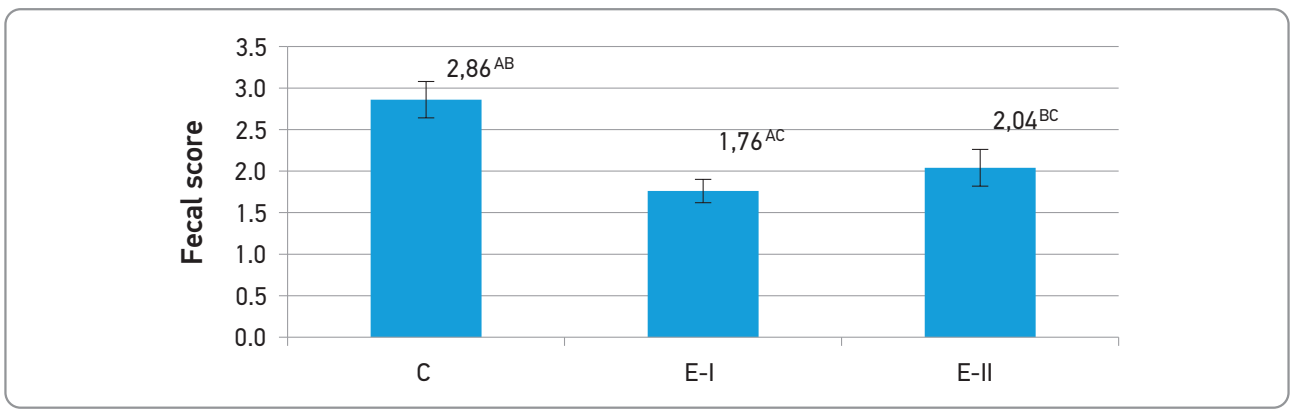


Figure 2. Correlation dependence of the final weight (g) of broilers receiving 0.25 g/kg yeast in diet (E-I) and the height of intestinal villi (µm) of the ileum



Legend: Groups with the same letters $^{A, B, C}$ are statistically different, $p<0.01$

Figure 3. Broiler faecal scores

on production performance, health status and production efficiency in broiler fattening (*Markovic et al.*, 2022). Each experimental group contained 90 animals housed in groups of 15 birds per pen in six repetitions (Figure 1).

The final weight of broilers and the height of the villi in the ileum were strongly positively correlated ($p<0.01$; $r=0.987$) statistically (Figure 2).

Assessment of excreta quality in each replicate was performed through visual faecal scoring. There were at least 2 independent evaluators and assessment was done twice a day (08.00 and 16.00 h) on days 7, 14, 21, 28 and 35. Scores ranged from 1 to 5: 1 = dry; well-formed excreta with characteristic white uric acid cover, 2 = mostly dry excreta with white uric acid cover, 3 = moist excreta with white uric acid cover, 4 = wet excreta with less white uric acid cover and droppings lose their shape, and 5 = extremely wet excreta with little to no white uric acid cover. Data were summarized for the overall excreta quality score for each treatment (Figure 3) (*Garcia et al.*, 2020). According to the results, positive effects of living yeast cells on the health condition, production results and morphometric characteristics of the broilers' intestines, and therefore on the economy of production, was confirmed. This indicates the nutritional, medical and economic justification of using living yeast cells in broiler nutrition.

4. Conclusion

Yeast and yeast products are used in animal feed with the aim of providing nutrients, having a probiotic role, stimulating animal growth and positively affecting animal immunity. A large number of scientific studies confirm that yeast and their derivatives can be good for the growth and health of animals, especially when the animals are housed in

poor animal hygiene conditions. However, there is still a need for additional information and research on the use of some yeast products. For some products and yeast derivatives, uneven product quality is apparent, and different batches of products have different nutritional values. Another possible problem is that there is no specific strain for one animal, and the same strain can act differently on different animals. Finally, there is a lack of recommendations on the application of yeast products in terms of quantity, type of yeast and preparation in different stages of production. Further research is needed to better understand the importance and possibilities of using yeast and its derivatives in animal nutrition.

Disclosure statement: No potential conflict of interest was reported by the authors.

Fundings: The study was supported by the Ministry of Science, Technological Development and Innovation of the Republic of Serbia (Contract number 451-03-47/2023-01/200143).

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