Journal of Animal Prod., 36(3), https://apm.reduc.edu.cu/index.php/rpa/article/view/e158

Technical Note

Algbiotics and Fungbiotics: New Groups of Nutraceutical Additives

Yordan Martínez Aguilar *, Román Rodríguez Bertot **,

*Faculty of Veterinary Medicine, University of Fondwa, Léogâne, Haiti.
**Center for Animal Production Studies, Faculty of Agricultural Sciences, University of Granma, Cuba.
Correspondence: ceoyordan@hotmail.com

Received: October 2024; Accepted: October 2024; Published: November, 2024.

INTRODUCTION

Currently, due to the high intensity of livestock production, changes in bacterial populations, dysbiosis, digestive diseases, immunosuppression, and decreased productive efficiency of animals are frequent (Abdelli *et al*., 2021). Due to these common problems, many producers and companies use growth-promoting antibiotics (GPA) in the diet or drinking water, either during critical stages or throughout the productive life of the animals (Dumont *et al.*, 2020).

The European Union and other countries have banned the use of GPAs (Vidovic and Vidovic, 2020). Several studies demonstrate that the indiscriminate use of GPAs increases the antimicrobial resistance of pathogenic strains, cross-resistance of other microorganisms, and causes microbial imbalance in the gastrointestinal tract of animals. Additionally, they can leave traces of chemical residues in animal products (Treiber and Beranek-Knauer, 2021; Glajzner *et al*., 2023).

However, after the ban on GPAs, there were several outbreaks of salmonella, colibacillosis, and necrotic enteritis in several countries of the European Union (McDevitt *et al*., 2006), which opened the debate on the use of other products to replace GPAs, preferably natural ones. The scientific community classifies natural products with a direct impact on animal production (especially in apparently healthy animals) into several groups, primarily those that can partially or completely replace GPAs. The most representative are probiotics, prebiotics, and phytobiotics (Wickramasuriya *et al*., 2024).

Citations (APA) Algbiotics and Fungbiotics: New Groups of Nutraceutical Additives (2024). *Journal of Animal Prod., 36*(3). https://apm.reduc.edu.cu/index.php/rpa/article/view/e158

ISSN 2224-7920

From the review of scientific literature and previous studies conducted by the research team, other less-studied natural products rich in secondary metabolites and beneficial chemical compounds that do not belong to the plant kingdom were detected. These products, such as fungi and algae, have shown positive effects on animal production even in small concentrations (Abdel-Wareth *et al*., 2024; Suberu *et al*., 2024). However, they are not yet classified into any specific group.

The purpose of this work is to define new nutraceutical groups, called "Algbiotics" and "Fungbiotics," as alternatives for the partial or total replacement of additives for animal production (GPA), with a positive impact on the well-being, prevention, and health of the host.

DEVELOPMENT

Since the 1950s, GPAs have been recommended in animal production, with greater emphasis on poultry and swine and, to a lesser extent, rabbits, ruminants, fish, and shrimp. The objective of using these subtherapeutic antibiotics was to reduce the proliferation of intestinal enterobacteria in young animals under different stressful conditions (El-Fateh *et al*., 2024). The results showed greater bacterial competitive exclusion and better feed efficiency, although whether there is a more marked anti-inflammatory impact of these synthetic products (GPA) is still debated due to the low concentration used, lower than the minimum inhibitory concentration to eliminate the most common enterobacteria (Nielwold, 2007).

Nutraceuticals are defined as active chemical or biological substances found as natural components in food ingredients (usually additives) or can be added to them. They are presented in a non-food matrix (pills, capsules, powder, among others) and, when administered in doses higher than those present in these foods, they exert a favorable effect on the health and well-being of the host. Therefore, nutraceutical products can prevent diseases and improve health conditions (Maskur *et al*., 2024).

In fact, probiotics are live microorganisms that can colonize and modify the intestinal microflora and/or cause microbial eubiosis, providing a benefit for the health and physiology of the host (Jiang *et al.*, 2024). Probiotics also modulate the anti-inflammatory response, antioxidant capacity, intestinal histomorphometry, gene expression of binding proteins, and intestinal protection. The most widely used are *Pediococcus pentosaceus*, *Lactobacillus casei*, *Enterococcus faecalis*, *Lactobacillus helveticus*, *Lactobacillus lactis*, *Lactobacillus salivarius*, *Lactobacillus plantarum*, *Enterococcus faecium*, and *Lactobacillus acidophilus* (Krysiak *et al*., 2021).

Moreover, sporulated bacteria of the division Firmicutes and the genus Bacillus, which are Gram-positive, have been frequently used in animal production as probiotics (Lee *et al*., 2019). Although these bacteria do not colonize the gastrointestinal tract, they produce enzymes and vitamins and have a positive response in animal production. The most commonly used strains are

B. cereus, B. subtilis, B. coagulans, B. polyfermenticus, *B. licheniformis, B. pumilus*, and *B. clausii* (Florido *et al*. 2017). Additionally, some live yeasts like *Saccharomyces boulardii* and *Saccharomyces cerevisiae* can induce microbial eubiosis and improve intestinal health, as well as produce vitamins and enzymes (Garcia-Mazcorro *et al*., 2020).

Thus, prebiotics are chemical compounds that selectively stimulate the growth of certain beneficial bacteria in the large intestine, mainly *Bifidobacteria* and *Lactobacilli*. Prebiotics improve the host's intestinal health by increasing the population of beneficial bacteria in the large intestine, which enhances the production of volatile fatty acids and the absorption of nutrients (Wlazło *et al*., 2021).

The most commonly used prebiotics are rich in fructo-oligosaccharides, α-galacto-oligosaccharides, transgalacto-oligosaccharides, β-glucans, mannan-oligosaccharides, and xylo-oligosaccharides. Thus, the use of prebiotics in the diet can prevent or reduce the incidence of colibacillosis, salmonellosis, or other digestive diseases. Additionally, they can modulate the immune system, anti-inflammatory response, antioxidant capacity, glucose levels, intestinal pH, and lipid metabolism (Zhu *et al*., 2021).

Phytobiotics, on the other hand, are plant-derived products used as additives in animal feed and as natural medicines. They encompass a wide range of plant-derived products such as flours, extracts, oleoresins, and essential oils that are added to animal feed to promote productive performance and improve the quality of products derived from these animals (Chodkowska *et al.*, 2024). They are rich in secondary metabolites synthesized by plants that serve non-essential functions.

These compounds participate in ecological interactions between plants and their environment. Unlike primary metabolites, secondary metabolites have a restricted distribution in the plant kingdom, sometimes to a single species or a group of them, depending on the edaphoclimatic conditions of the plants (Ivanova *et al*., 2024). The most common secondary metabolites include alkaloids, non-protein amino acids, steroids, phenols, flavonoids, glycosides, coumarins, quinones, tannins, and terpenoids, which have defensive functions against insects, bacteria, fungi, and others.

The highest concentrations of these chemical complexes are found in flowers, leaves, and seeds (Hafeez *et al*., 2024). Some phytobiotics used in small concentrations have bacteriostatic or bactericidal action, or inhibit the adhesion of pathogenic bacteria to the intestinal and urinary mucosa, as well as antioxidant effects by reducing reactive oxygen species (ROS) to free radicals, and anti-inflammatory, antifungal, and immune effects against pathogenic microorganisms or inflammatory processes (Cross *et al*., 2007; Rozbeh *et al*., 2013).

Algae are unicellular organisms that contain chlorophyll and perform photosynthesis, either forming colonies or presenting as multicellular organisms. They are found in various habitats on

Earth, including oceans, rivers, lakes, soils, and on the surface of plants and animals (Trentacoste *et al*., 2015). They are rich in nutrients such as amino acids, vitamins, fatty acids, phytosterols, minerals, dietary fiber, and secondary metabolites, including alkaloids, flavonoids, tannins, terpenoids, anthocyanins, and phenolic and cinnamic acids (Farvin and Sakulpong *et al*., 2015).

Studies indicate that algae act as bio-stimulants in animal response due to their chemical compounds (Bederska-Łojewska *et al*., 2017). Several companies, such as Olmix in France, have been producing natural products derived from algae for over 20 years for use in animals and humans. Martínez *et al.* (2019) showed that the inclusion of Chondrus crispus (red algae) in poultry diets reduced feed consumption and improved feed conversion, as well as increased carcass and breast yield and decreased abdominal fat, positively affecting the relative weight of immune organs.

Other studies have reported that the use of algae such as Spirulina platensis and Ascophyllum nodosum, which are rich in secondary metabolites and cell wall-associated compounds, increase the population of lactic acid bacteria due to their antimicrobial properties. These algae also modulate both cellular and humoral immunity in monogastric animals (Shanmugam *et al*., 2014). Considering all these benefits, the name for this new group of products has been suggested as "Algbiotics." This category is defined as derivatives from whole algae and/or their extracts rich in secondary metabolites or other beneficial chemical compounds. Their use as nutraceutical additives can have a positive effect on the well-being, prevention, and health of the host.

Fungi have been used in traditional Chinese medicine for their therapeutic properties, including antimicrobial, antitumor, anti-inflammatory, and antioxidant effects. Among the most notable fungi are *Lentinula spp*., *Agaricus spp*., *Hericium spp*., *Pleurotus spp*., *Fomitella spp*., *Flammulina spp*., *Cordyceps spp*., and *Ganoderma spp*. (Bederska-Łojewska *et al.*, 2017). These fungi are highly adaptable and are cultivated in greenhouses with specific substrates in China (Wang *et al*., 2012).

Due to their saprophytic nature, fungi are a rich source of secondary metabolites such as polysaccharides, triterpenes, and β-glucans (Ogbe and Affiku, 2012). Research has shown that Ganoderma lucidum improves growth and feed efficiency in rapidly growing poultry by increasing lactic acid bacteria in the cecum and modulating immunity (Martínez *et al*., 2022). Additionally, other studies indicate that fungi can reduce the number of fecal oocysts of *Eimeria tenella* and mitigate the effects of foods rich in aflatoxin B1 (Ogbe *et al*., 2009; Liu *et al*., 2020).

Based on these findings, the term "Fungbiotics" is proposed to refer to products derived from whole fungi or their extracts, which are rich in secondary metabolites and have positive effects as nutraceutical additives on the well-being and health of the host.

CONCLUSIONS

The classification of new groups of natural products rich in secondary metabolites, such as "Fungbiotics" and "Algbiotics," will contribute to the knowledge and funding of new projects. These groups focus on the nutraceutical effect of these products on animals of zootechnical interest, as well as on the discovery of new chemical compounds and biological functions in apparently healthy animals, even under stressful conditions. Additionally, their implementation could have a direct impact on consumer perception, allowing for the total or partial replacement of growth-promoting antibiotics with products derived from algae and medicinal fungi in animal feed.

REFERENCES

Abdel-Wareth, A. A., Williams, A. N., Salahuddin, M., Gadekar, S., & Lohakare, J. (2024). Algae as an alternative source of protein in poultry diets for sustainable production and disease resistance: present status and future considerations. *Frontiers in Veterinary Science*, *11*, 1382163. https://www.frontiersin.org/journals/veterinary-science/articles/10.3389/fvets.2024.1382163/full

Abdelli, N., Solà-Oriol, D., & Pérez, J. F. (2021). Phytogenic feed additives in poultry: achievements, prospective and challenges. *Animals*, *11*(12), 3471. https://www.mdpi.com/2076-2615/11/12/3471

Bederska-Łojewska, D., Świątkiewicz, S., & Muszyńska, B. (2017). The use of Basidiomycota mushrooms in poultry nutrition—a review. *Animal Feed Science and Technology*, *230*, 59-69. https://www.sciencedirect.com/science/article/abs/pii/S0377840117304492

Chodkowska, K. A., Barszcz, M., & Tuśnio, A. (2024). MicroRNA expression and oxidative stress markers in pectoral muscle of broiler chickens fed diets supplemented with phytobiotics composition. *Scientific Reports*, *14*(1), 4413. https://www.nature.com/articles/s41598-024-54915-y

Cross DE, Mcdevitt RM, Hillman K, Acamovic T. (2007). The effect of herbs and their associated essential oils on performance, dietary digestibility and gut microflora in chickens from 7 to 28 days of age. *Br. Poult. Sci*., *48*, 496-506. https://doi.org/10.1080/00071660701463221

Dumont, B., Puillet, L., Martin, G., Savietto, D., Aubin, J., Ingrand, S., & Thomas, M. (2020). Incorporating diversity into animal production systems can increase their performance and strengthen their resilience. *Frontiers in Sustainable Food Systems*, *4*, 109. DOI:10.3389/fsufs.2020.00109

El-Fateh, M., Bilal, M., & Zhao, X. (2024). Effect of antibiotic growth promoters (AGPs) on feed conversion ratio (FCR) of broiler chickens: A meta-analysis. *Poultry Science*, 104472. https://www.sciencedirect.com/science/article/pii/S0032579124010502

Farvin SK, Jacobsen C. (2013). Phenolic compounds and antioxidant activities of selected species of seaweeds from Danish coast. *Food Chemistry*, *138*(2-3), 1670-1681. DOI: https://doi.org/10.1016/j.foodchem.2012.10.078

Florido, G. M., Laurencio, M., Rondón, A. J., Pérez, M., Arteaga, F., Bocourt, R., & Beruvides, A. (2017). Methodology for the isolation, identification and selection of Bacillus spp. strains for the preparation of animal additives. *Cuban Journal of Agricultural Science*, *51*(2), 197-207. https://www.redalyc.org/pdf/1930/193057228005.pdf

Garcia-Mazcorro, J. F., Ishaq, S. L., Rodriguez-Herrera, M. V., Garcia-Hernandez, C. A., Kawas, J. R., & Nagaraja, T. G. (2020). Are there indigenous Saccharomyces in the digestive tract of livestock animal species? Implications for health, nutrition and productivity traits. *Animal*, *14*(1), 22-30. http://eprints.uanl.mx/23347/1/23347.pdf

Glajzner, P., Szewczyk, E. M., & Szemraj, M. (2023). Pathogenic potential and antimicrobial resistance of Staphylococcus pseudintermedius isolated from human and animals. *Folia microbiologica*, *68*(2). https://link.springer.com/article/10.1007/s12223-022-01007-x

Hafeez, A., Iqbal, S., Naz, S., Alhidary, I. A., Abdelrahman, S., & Selvaggi, M. (2024). Comparative effect of exogenous protease and phytobiotics on growth performance, nutrient digestibility, ileal histology and bone strength in broilers. *Journal of Applied Animal Research*, *52*(1), 2399933. https://www.tandfonline.com/doi/full/10.1080/09712119.2024.2399933

Ivanova, S., Sukhikh, S., Popov, A., Shishko, O., Nikonov, I., Kapitonova, E., & Babich, O. (2024). Medicinal plants: a source of phytobiotics for the feed additives. *Journal of Agriculture and Food Research*, 101172. https://www.sciencedirect.com/science/article/pii/S2666154324002096

Jiang, Z., Yang, M., Su, W., Mei, L., Li, Y., Guo, Y., & Wang, Y. (2024). Probiotics in piglet: from gut health to pathogen defense mechanisms. *Frontiers in Immunology*, *15*, 1468873. https://www.frontiersin.org/journals/immunology/articles/10.3389/fimmu.2024.1468873/full

Krysiak, K., Konkol, D., & Korczyński, M. (2021). Overview of the use of probiotics in poultry production. *Animals*, *11*(6), 1620. https://www.mdpi.com/2076-2615/11/6/1620

Lee, N. K., Kim, W. S., & Paik, H. D. (2019). Bacillus strains as human probiotics: characterization, safety, microbiome, and probiotic carrier. *Food Science and Biotechnology*, *28*, 1297-1305. DOI:10.1007/s10068-019-00691-9

Liu, T., Zhou, J., Li, W., Rong, X., Gao, Y., Zhao, L., ... & Ma, Q. (2020). Effects of sporoderm-broken spores of Ganoderma lucidum on growth performance, antioxidant function and immune response of broilers. *Animal nutrition*, *6*(1), 39-46. https://www.sciencedirect.com/science/article/pii/S240565451930188X

Martínez, Y., Ayala, L., Hurtado, C., Más, D., & Rodríguez, R. (2019). Effects of dietary supplementation with red algae powder (*Chondrus crispus*) on growth performance, carcass traits, lymphoid organ weights and intestinal pH in broilers. *Brazilian Journal of Poultry Science*, *21*(04), eRBCA-2019. https://www.scielo.br/j/rbca/a/5YpD8GfRQwKD8hYHfxPKLdf/?lang=en

Martínez, Y., Paredes, J., Avellaneda, M. C., Botello, A., & Valdivié, M. (2022). Diets with ganoderma lucidum mushroom powder and zinc-bacitracin on growth performance, carcass traits, lymphoid organ weights and intestinal characteristics in broilers. *Brazilian Journal of Poultry Science*, *24*(01), eRBCA-2021. https://www.scielo.br/j/rbca/a/Yc5ywY8PMbYRQqqKg3dpcZg/?lang=en

Maskur, M., Sayuti, M., Widyasari, F., & Setiarto, R. H. B. (2024). Bioactive Compound and Functional Properties of Sea Cucumbers as Nutraceutical Products. *Reviews in Agricultural Science*, *12*, 45-64. https://www.jstage.jst.go.jp/article/ras/12/0/12_45/_html/-char/ja

McDevitt, R. M., Brooker, J. D., Acamovic, T., & Sparks, N. H. C. (2006). Necrotic enteritis; a continuing challenge for the poultry industry. *World's Poultry Science Journal*, *62*(2), 221-247. DOI:https://doi.org/10.1079/WPS200593

Mohammadi Gheisar, M., & Kim, I. H. (2018). Phytobiotics in poultry and swine nutrition–a review. *Italian journal of animal science*, *17*(1), 92-99. https://doi.org/10.1080/1828051X.2017.1350120

Niewold, T. A. (2007). The nonantibiotic anti-inflammatory effect of antimicrobial growth promoters, the real mode of action? A hypothesis. *Poultry science*, *86*(4), 605-609. https://www.sciencedirect.com/science/article/pii/S0032579119441369

Ogbe, A. O., & Affiku, J. P. (2012). Effect of polyherbal aqueous extracts (Moringa oleifera, gum arabic and wild Ganoderma lucidum) in comparison with antibiotic on growth performance and haematological parameters of broiler chickens. *Res J Recent Sci ISSN*, *2277*, 2502. https://nutrinews.com/producto/mmi-s-olmix/

Ogbe, A. O., Ditse, U., Echeonwu, I., Ajodoh, K., Atawodi, S. E., & Abdu, P. A. (2009). Potential of a wild medicinal mushroom, Ganoderma sp., as feed supplement in chicken diet: effect on performance and health of pullets. *International Journal of Poultry Science*, *8*(11), 1052-1057. https://citeseerx.ist.psu.edu/document?repid=rep1&type=pdf&doi=0d25d19e515c81d0fde257de7baa9ad13cf79699

Rozbeh. Fallah., Kiani, A., & Azarfar, A. (2013). A review of the role of five kinds of alternatives to in-feed antibiotics in broiler production. *Journal of Veterinary Medicine and Animal Health*, *5*(11), 317-321. https://citeseerx.ist.psu.edu/document?repid=rep1&type=pdf&doi=573f532569850f0ebd203c80a51a5935839d1041

Shanmugam, N., Rajkamal, P., Cholan, S., Kannadasan, N., Sathishkumar, K., Viruthagiri, G., & Sundaramanickam, A. (2014). Biosynthesis of silver nanoparticles from the marine seaweed Sargassum wightii and their antibacterial activity against some human pathogens. *Applied Nanoscience*, *4*, 881-888. https://link.springer.com/article/10.1007/s13204-013-0271-4

Suberu, S. A., Isikhuemhen, O. S., Ogundare, T. E., Ekunseitan, D. A., & Fasina, Y. O. (2024). Benefits of Mushroom-Based Supplements on Growth Performance, Immunocompetence, and Meat Quality in Poultry. *Animals*, *14*(11), 1517. https://www.mdpi.com/2076-2615/14/11/1517

Treiber, F. M., & Beranek-Knauer, H. (2021). Antimicrobial residues in food from animal origin. A review of the literature focusing on products collected in stores and markets worldwide. *Antibiotics*, *10*(5), 534. https://www.mdpi.com/2079-6382/10/5/534

Trentacoste, E.M., Martinez, A.M., & Zenk, T. (2015). The place of algae in agriculture: policies for algal biomass production. *Photosynthesis Research, 123*(3), 305-315. DOI: https://doi.org/10.1007/s11120-014-9985-8

Vidovic, N., & Vidovic, S. (2020). Antimicrobial resistance and food animals: Influence of livestock environment on the emergence and dissemination of antimicrobial resistance. *Antibiotics*, 9(2), 52. https://www.mdpi.com/2079-6382/9/2/52

Wang, X. C., Xi, R. J., Li, Y., Wang, D. M., & Yao, Y. J. (2012). The species identity of the widely cultivated Ganoderma,'G. lucidum'(Ling-zhi), in China. *PLoS One*, *7*(7), e40857. https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0040857

Wickramasuriya, S. S., Ault, J., Ritchie, S., Gay, C. G., & Lillehoj, H. S. (2024). Alternatives to antibiotic growth promoters for Poultry: A bibliometric analysis of the research

journals. *Poultry Science*, 103987. https://www.sciencedirect.com/science/article/pii/S0032579124005662

Wlazło, Ł., Kowalska, D., Bielański, P., Chmielowiec-Korzeniowska, A., Ossowski, M., Łukaszewicz, M., & Nowakowicz-Dębek, B. (2021). Effect of fermented rapeseed meal on the gastrointestinal microbiota and immune status of rabbit (Oryctolagus cuniculus). *Animals*, *11*(3), 716. https://www.mdpi.com/2076-2615/11/3/716

Zhu, Y. T., Yue, S. M., Li, R. T., Qiu, S. X., Xu, Z. Y., Wu, Y., & Li, Y. (2021). Prebiotics inulin metabolism by lactic acid bacteria from young rabbits. *Frontiers in Veterinary Science*, *8*, 719927. https://www.frontiersin.org/journals/veterinary-science/articles/10.3389/fvets.2021.719927/full

AUTHOR CONTRIBUTION STATEMENT

Research conception and design: LFC, JABV; data analysis and interpretation: JABV, LFC, HJFB; redaction of the manuscript: LFC, JABV, HJFB.

CONFLICT OF INTEREST STATEMENT

The authors state there are no conflicts of interest whatsoever.